Fire injury analysis

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Abstract

In this paper we examine unintentional dwelling fire injuries during the period 2006 to 2016 in Merseyside, in the North West of England. Overall, it appeared that deprivation was a significant factor in unintentional fire injuries over the period studied, with 52% of fire injuries occurring in areas with the highest level of deprivation. Males and females appeared equally likely to be injured in an unintentional dwelling fire, however, males were twice as likely to be injured in an alcohol and drug related fire incident, or injured attempting to fight a dwelling fire than females. In terms of the age profile of those injured in unintentional dwelling fires, the group with the highest level of fire injuries was the elderly (29% of injuries), followed by those aged 25 – 45 (28% of injuries), then those aged 45 – 65 (23% of injuries), then young persons (aged up to 24) (20% of injuries).

Key words Fire Injury Analysis

1. Introduction

Numerous studies have indicated the high costs of fire injuries.[1,2,3] The number of unintentional dwelling fires in the UK has significantly reduced over the last decade,[4] however, when unintentional dwelling fires do occur, the likelihood of the fire causing a fatality or injury has not followed a similar decreasing trend.[5] This suggests that there is a need to examine the reasons for such in greater detail in order to be able to provide information to support appropriate fire injury prevention interventions. In the UK, from 2004, Fire and Rescue Services have had a statutory duty under the UK Fire and Rescue Services Act[6] to carry out

community safety interventions to reduce injury from unintentional dwelling fires. Typically, most unintentional dwelling fire injuries occur as a result of accidents involving cooking materials, smoker's materials, heating devices, and candles.[7] The likelihood of an unintentional dwelling fire injury can be significantly reduced by an early awareness of a fire, giving more time to safely leave a burning building. Unintentional dwelling fires concern events that can be considered preventable, rather than being considered accidental and due to chance.[39] Working smoke detectors can provide early warning of a dwelling fire, and for this reason the fitting and checking of smoke alarms is an integral part of home fire safety checks conducted by UK fire and rescue services.[8] Smoke alarms can alert residents to take care of a developing dwelling fire before calling the fire and rescue service. The English Housing Survey: Fire and Fire Safety, 2016-17 by the UK Ministry of Housing, Communities and Local Government[40] found that in the majority of households (75%) where an unintentional dwelling fire occurred, the fire was put out by someone in the household, or the fire went out by itself. Only a quarter (25%) of such fires were put out by a fire and rescue service, meaning that three quarters (75%) of unintentional dwelling fires in England may not be reported to a fire and rescue service. Fire safety improvements such as smoke detectors can also help mitigate many intentional fires, particularly ones not aimed at causing bodily harm.

It is important to establish the nature and distribution of unintentional dwelling fires within the area covered in order for fire and rescue services to target fire safety interventions effectively.[9] Fire injury prevention strategies need to be targeted towards high-risk community groups in order to optimise impact, and this requires accurate, up-to-date community specific information.[10] A study based in Manchester in the UK identified that there can be significant differences in domestic fire injury risk between different community groups within an area.[7] In terms of householders responding to an unintentional dwelling fire, previous research had identified that a functioning smoke alarm reduces the risk of fire injuries, however, when householders attempt to put the fire out themselves there can be increased risk of slight burns.[41] Since the preventive actions by fire and rescue services such as information and education efforts are costly, it is therefore important to attempt to ensure that such activities are appropriately targeted.[11] Recognising population-specific dwelling fire injury vulnerabilities can lead to a reduction in fire deaths and injuries, in particular, although the oldest are more likely to die in an unintentional dwelling fire, those in the middle-age group are more likely to be injured in a dwelling fire.[12] The UK Home Office analysis of 2018/19 dwelling fires in England stated that overall, per million, there were 4.5 fire-related fatalities. The fatality rate was highest among older people at 7.8 per million for those aged 65 to 79, and 17.3 per million for those aged 80 and over. The fatality rates for age bands 54 and less were all below 5 per million.[43] In England the death and injury rates for children under 15 had declined from 1995-2004.[44] Lower fire death and injury rates for children under 15 were also observed in a US study.[42] Analysing fire statistics and data based on fire investigations can inform approaches for different preventive measures to be targeted effectively.[13]

In this paper we present a detailed analysis of fire injuries during the period 2006 to 2016 in Merseyside, in the North West of England. Merseyside covers an area of 645 km^2, and in the 2011 UK census (the mid-point of the study period) had a population of 602,087.[45] Merseyside is also one of the most deprived areas in England, with 31.8% of the population living in areas with the highest level of deprivation (IMD decile 1). The Indices of Multiple Deprivation (IMD) decile[38] is a scale ranging from 1 which denotes the 10% most deprived areas in England to 10 which denotes the 10% least deprived areas. In terms of housing in the Merseyside area, 60% of the housing is in Council Tax band A (which covers properties with a value of up to

£40,000)[47]. The average house price in Merseyside is £130,000[47] compared to an average house price in England of £284,000.[48]

The originality of the research reported in this paper is the detailed analysis of the circumstances associated with unintentional dwelling fire injuries by age, gender, and level of deprivation, the types of housing in which fire injuries occurred, and the types of injuries associated with unintentional dwelling fires.

2. Literature review

2.1 Fire injuries

Various researchers have credited recent reductions in dwelling fire incidents and injuries with being due in part to the growing preventative role of fire and rescue services and other partner organisations within local communities.[14,15,16] In England between April 2019 and March 2020 there were 4,531 non-fatal casualties from unintentional dwelling fires, including those who received first aid (1,450) and those who were advised to seek precautionary checks (1,172). Of the non-fatal fire casualties requiring hospital treatment (1,909), the largest category of fire injury was 'overcome by gas or smoke' (913; 48%) followed by 'burns' (385; 20%) and 'other breathing difficulties' (297; 16%). All other fire injury categories combined comprised the remaining 16 per cent of injuries.[17]

Smoke inhalation during unintentional dwelling fire incidents is a major cause of injuries and deaths.[18] A fire will consume available oxygen within a room, slowing the burning process, leading to incomplete combustion, resulting in carbon monoxide being released into the air in the room. Toxic gases may also be released from certain burning objects, such as hydrogen cyanide from burning plastics and phosgene from vinyl materials. Reducing oxygen levels in a room can also impair judgement and potentially lead to unconsciousness and death. Very heated air in the room may burn the respiratory tract.[19] Unintentional dwelling fire burn injuries can be far worse for the elderly since these can be complicated by co-morbidities, and may typically require increased healing time and medical care compared to younger adults,[20] and burned elderly individuals are also at a higher risk of death than younger individuals.[21] Individuals living in the highest levels of deprivation are more like to have higher burn injury severity in terms of burn size and have inhalation injury.[22]

2.2 Fire injury costs

Unintentional dwelling fire burns injuries in the UK add to the pressures on NHS burns services. The complexity and rarity of burn injuries makes delivering burns care a specialised NHS service, requiring expert multi-disciplinary teams in specialised burn services.[3] Burns injuries can be among the most expensive traumatic injuries to manage, generating a substantial health economic impact to the NHS.[1] In 2017 more than 40 admissions to NHS burns services were classified as extremely severe, with such burns costing more than £95,000 each to treat.[2] The estimated mean NHS cost of burns wound care per patient per year is approximately £17000 per burn, ranging from £12000 to over £40000. In the year 2018 / 2019 the total cost of burns care provided by the NHS was approximately £4.5m.[1]

Smoke inhalation injuries are a complex clinical problem, as injured pulmonary tissue has to be protected from secondary injury from to resuscitation, mechanical ventilation, and

infection. The management of toxin exposure from fire smoke inhalation may be complex, especially in terms of carbon monoxide and cyanide exposure.[23] The UK NHS does not however, specifically record the costs solely associated with smoke inhalation injury. In cases where the patient does not actually suffer a burn but does have an inhalation injury, the primary diagnosis would be likely to be: Pulmonary oedema due to chemicals, gases, fumes and vapours; Upper respiratory inflammation due to chemicals, gases, fumes and vapours, not elsewhere classified; Other acute and subacute respiratory conditions due to chemicals, gases, fumes and vapours. All of these are generally classified as Inhalation, Lung Injury or Foreign Body which includes other injuries to the lungs, so the national average cost of this category would not be indicative of the cost of the treatment of a smoke inhalation fire injury where the patient does not suffer burns.[24]

2.3 Fire injury prevention

In terms of unintentional dwelling fire injury prevention, fire and rescue services have informed and educated the public with regard to the risk of fire injury from cooking fires,[25] smoking,[26] attempting to tackle fires themselves,[27] and the effects of alcohol and drugs.[28] The reach of such information and education can be increased by the use of social media compared to other forms of distribution.[29] Home fire safety checks can reduce the likelihood of unintentional dwelling fire injuries by advising householders of escape routes in the event of fire and checking or installing smoke detectors.[30,8] Partnerships with other agencies can help to reduce the underlying causal factors in unintentional dwelling fire injuries, for example in terms of NHS programmes for smoking cessation,[31] alcohol management,[32] and drug addiction,[33] and NHS and social services support for those with mental health difficulties.[34]

Overall, research into unintentional dwelling fire injuries has tended to focus on fatal dwelling fire injuries, rather than examining overall patterns and trends in dwelling fire injuries.[35] Few studies attempt to map the entire spectrum of unintentional dwelling fire related injuries in a defined population. The originality of the research reported in this paper is the detailed analysis of the circumstances associated with unintentional dwelling fire injuries in terms of age, gender, type of housing and level of deprivation over a ten year period in a UK fire and rescue service.

3. Research method

The research method adopted was exploratory data analysis of fire injury data for Merseyside Fire and Rescue Service in the UK between 2006 and 2016. The analysis of unintentional dwelling fire injuries was undertaken by examining the different circumstances recorded for unintentional dwelling fire injuries during 2016 to 2016 in the county of Merseyside in England, and deprivation data from the UK Office for National Statistics. This involved analysing the overall pattern of unintentional dwelling fire injuries, and analysis of the distribution of unintentional dwelling fire injuries by age, gender, and type of housing and level of deprivation of areas in which such injuries occurred, and also the distribution of the types of injuries sustained during unintentional dwelling fire incidents.

The research questions posed by the research reported in this paper were:

- What types of fire injuries occur in unintentional dwelling fires?

- Who is most at risk of unintentional dwelling fire injuries in terms of age and gender?

- Where do unintentional dwelling fire injuries occur in terms of housing type and level of deprivation?

These are important research questions, given the social and economic costs of unintentional dwelling fire injuries, and the need for fire and rescue services to better understand the nature of unintentional fire injuries in order to effectively target fire prevention activities in times of decreasing fire and rescue service budgets in the UK. It is essential that fire and rescue services and other organisations concerned with residential fire safety have accurate information regarding the types of households at greatest risk of dwelling fires, to ensure ever limited resources are targeted towards such households.[16] The originality of the research presented is the detailed analysis of unintentional dwelling fire injury circumstances recorded by a UK fire and rescue service in terms of age, gender, type of housing, and level of deprivation in order to inform fire injury prevention strategies.

A limitation of the research undertaken was the availability of data for analysis, since only limited data regarding the individuals involved in a fire is typically recorded in unintentional dwelling fire (ADF) records. For each unintentional dwelling fire in the UK, the circumstances of the fire are recorded by a fire officer. However, in some instances such data might be recorded in an 'unknown', or 'other' category. In addition, UK Office for National Statistics Indices of Multiple Deprivation (IMD) decile level data was only available at the Lower Layer Super Output Area[36] level of geography or above. A Lower Layer Super Output Area contains between 1000 and 3000 residents representing between 400 and 1200 households. In addition, the number of unintentional dwelling fire injury incidents and the factors associated with fire injury incidences are not static, with the demographics of populations in an area changing over time. A further limitation to the analyses undertaken concerned potential limitations regarding the generalizability of the research findings to other UK fire and rescue services and beyond, since the area covered by the fire and rescue service concerned, Merseyside Fire and Rescue Service, included some of the most deprived areas in England.

4. Fire injury analysis results

The pattern of the number of unintentional dwelling fire incidents over the period 2006 to 2016, in Merseyside in the UK is shown in Figure 1.

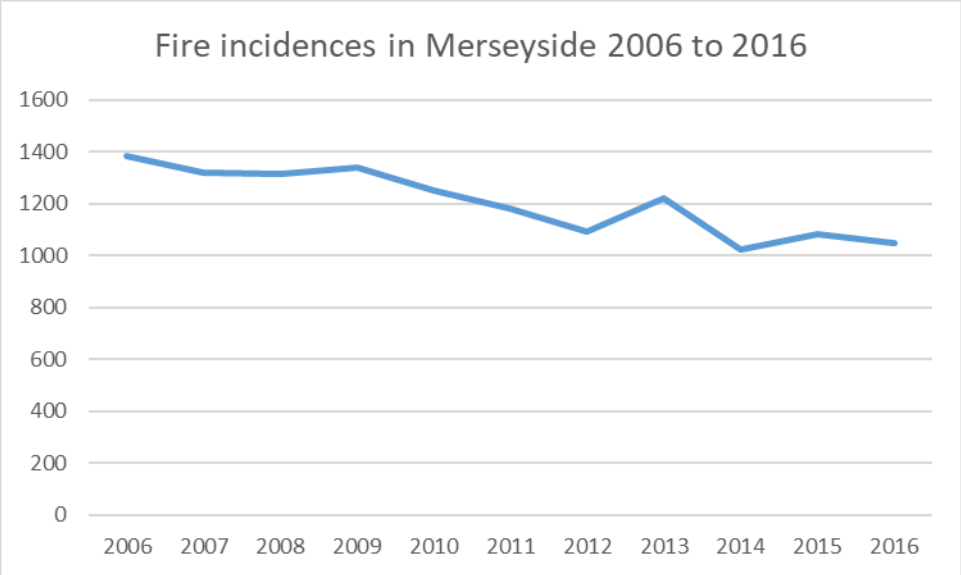

Figure 1. Unintentional dwelling fire incidents over the period 2006 to 2016, in Merseyside England.

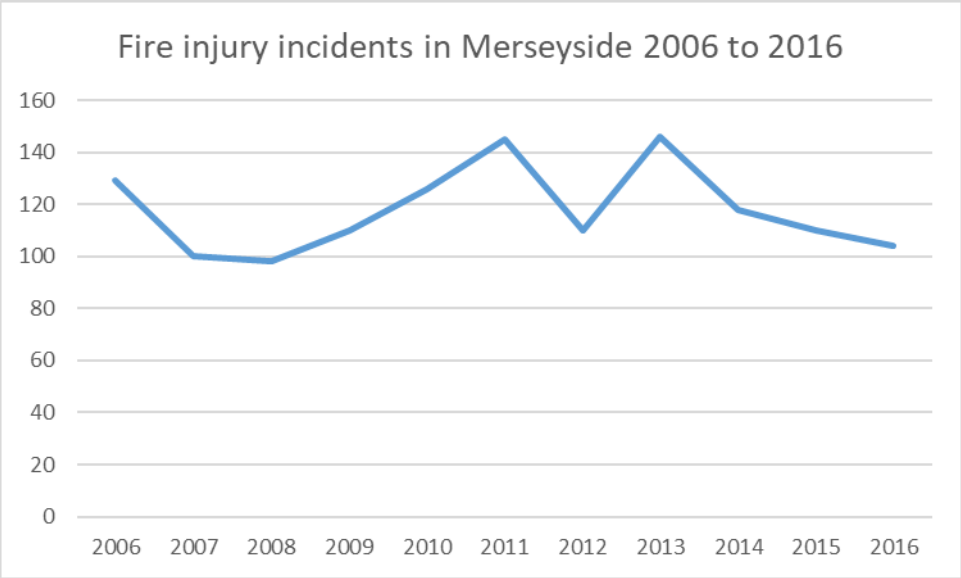

Figure 2. Unintentional dwelling fire injury incidents over the period 2006 to 2016, in Merseyside England.

Figure 1 and Figure 2 show that although the number of unintentional dwelling fire incidents had significantly reduced over the period studied, there had not really been a similar level of reduction of fire injuries. A particular aspect of the trends in unintentional dwelling fire incidences and unintentional dwelling fire injuries was that the likelihood of a given unintentional dwelling fire incident involving a fire injury had increased slightly over the time period (2006 to 2016) in the area studied by 6.5% from 2006 to 2016. In 2006 there were 129 fire injuries out of 1384 fire incidences (9.3% of fire incidences resulting in injury), whereas in 2016 there were 104 fire injuries out of 1049 fire incidences (9.9% of fire incidences resulting in injury).[37] Of the 1309 unintentional dwelling fire incidents in which fire injuries occurred over the period studied, 19.5% of such injuries were sustained by householders fighting such fires, and alcohol and drug related unintentional dwelling fire injury incidents constituted 13% of such injuries. Figure 3 shows unintentional dwelling fire fatality incidents over the period 2006 to 2016 in Merseyside England.

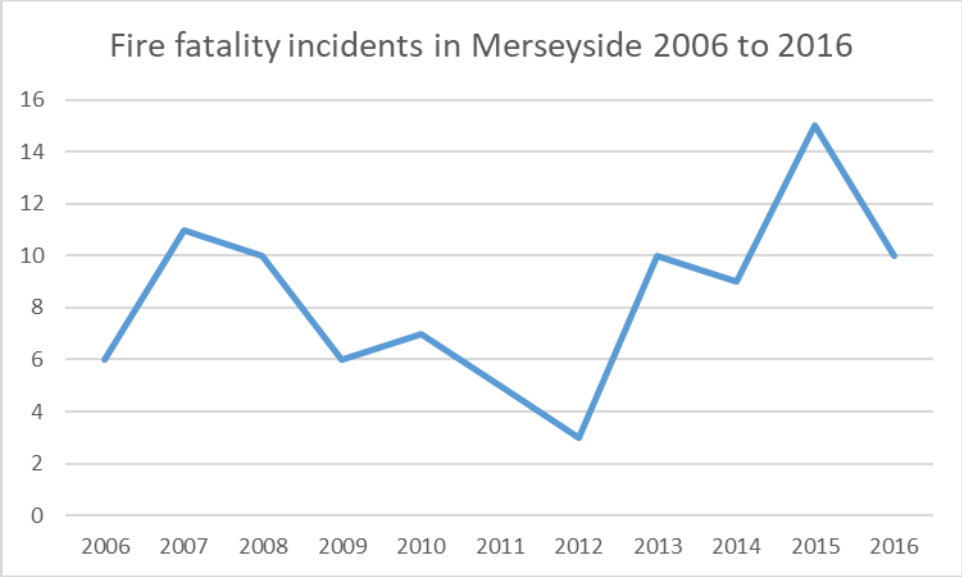

Figure 3. Unintentional dwelling fire fatality incidents over the period 2006 to 2016, in Merseyside England.

4.1 Types of unintentional dwelling fire injuries

Figure 4 shows the numbers of the different types of unintentional dwelling fire injuries in Merseyside between 2006 and 2016.

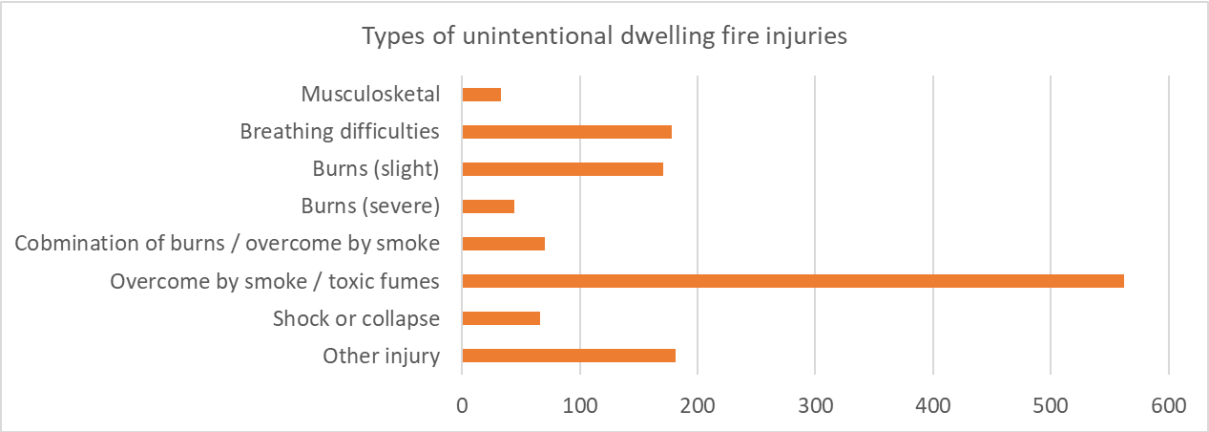

Figure 4. Types of unintentional dwelling fire injuries in Merseyside 2006 to 2016

This indicated that the majority of unintentional dwelling fire injuries involved being overcome by smoke or toxic fumes, followed by breathing difficulties (and other injuries), then slight burns. Overall slight burns accounted for 13% of the unintentional dwelling fire injuries over the period studied. For unintentional dwelling fire injuries sustained by householders fighting the fire themselves, slight burns accounted for 32% of such injuries. Slight burns injuries occurred equally between males and females, however, there were more severe burns injuries to males (27 injuries), compared to females (17 injuries). Overall, burns injuries appeared to be more likely to affect younger people as shown in Figure 3, whereas smoke injuries were more relatively evenly spread, apart from children and very old, as shown in Figure 4.

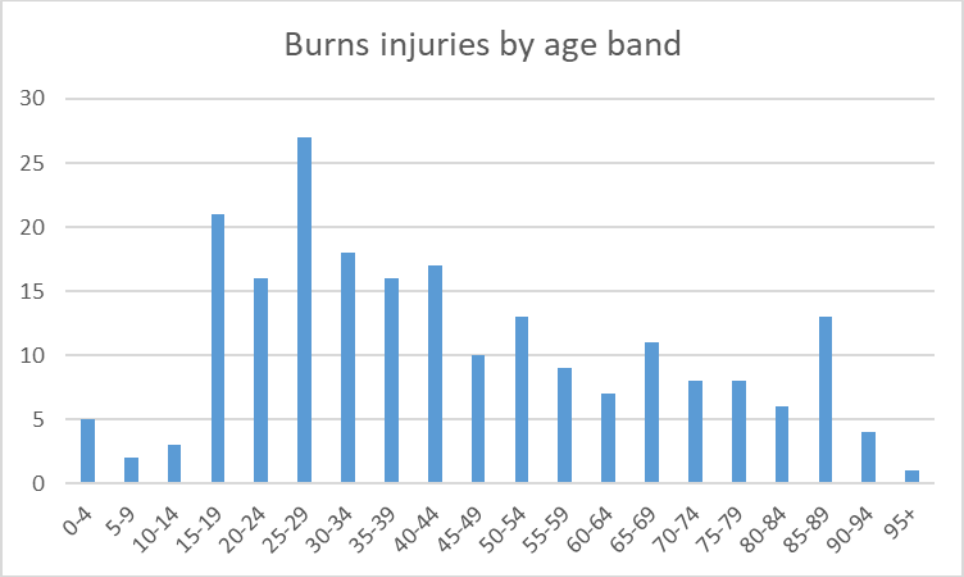

Figure 5. Unintentional dwelling fire burns injuries by age in Merseyside 2006 to 2016

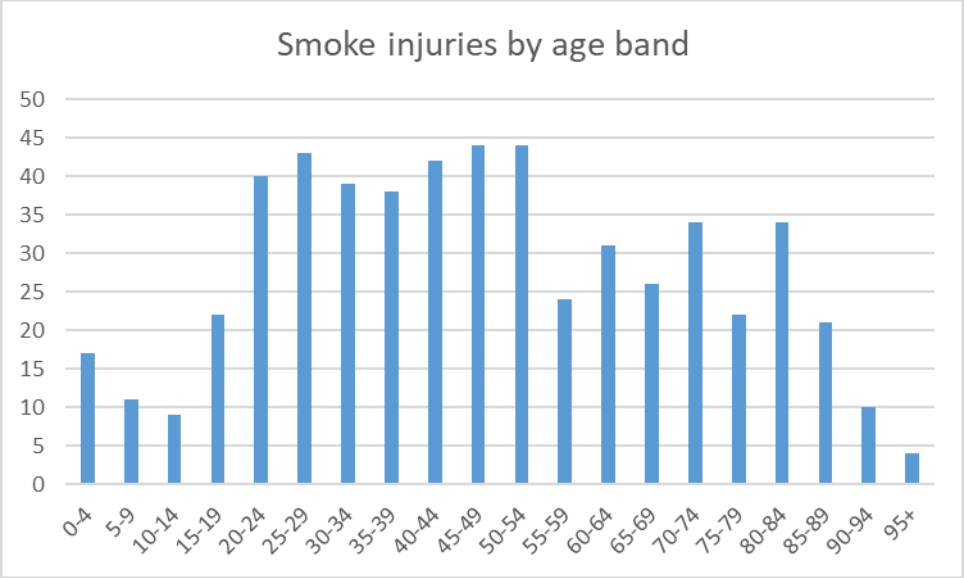

Figure 6. Unintentional dwelling fire smoke injuries by age in Merseyside 2006 to 2016

4.2 Unintentional dwelling fires injuries by age and gender

Figure 7 shows the overall distribution of unintentional dwelling fire injuries by age in Merseyside over the period studied.

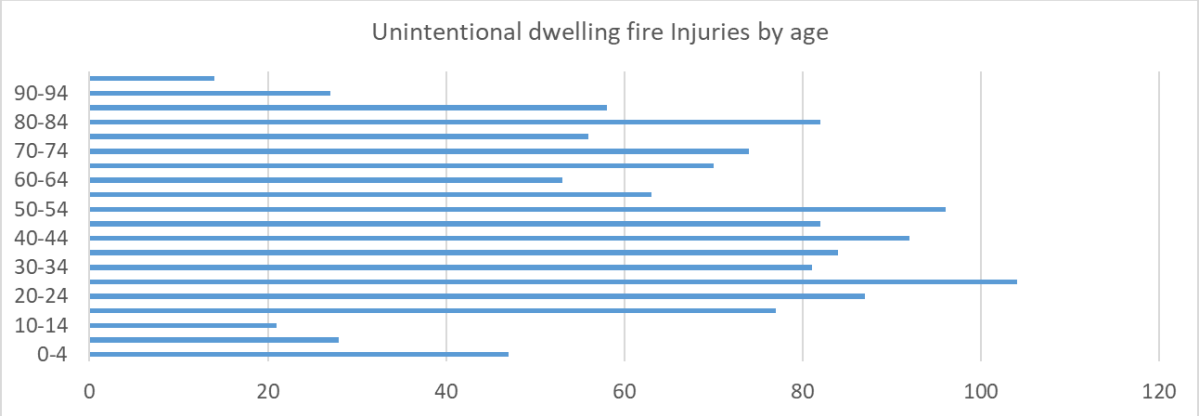

Figure 7. Unintentional dwelling fire injuries by age in Merseyside 2006 to 2016

This appeared to indicate that the number of unintentional dwelling fire incident injuries was largest amongst the elderly (those aged 65+) accounting for 29% of injuries, followed by those aged 25 – 45 (28% of injuries), then those aged 45 – 65 (23% of injuries), then young persons (aged up to 24) (20% of injuries). The breakdown of the population of Merseyside by age band in 2016[48] is shown in Figure 8.

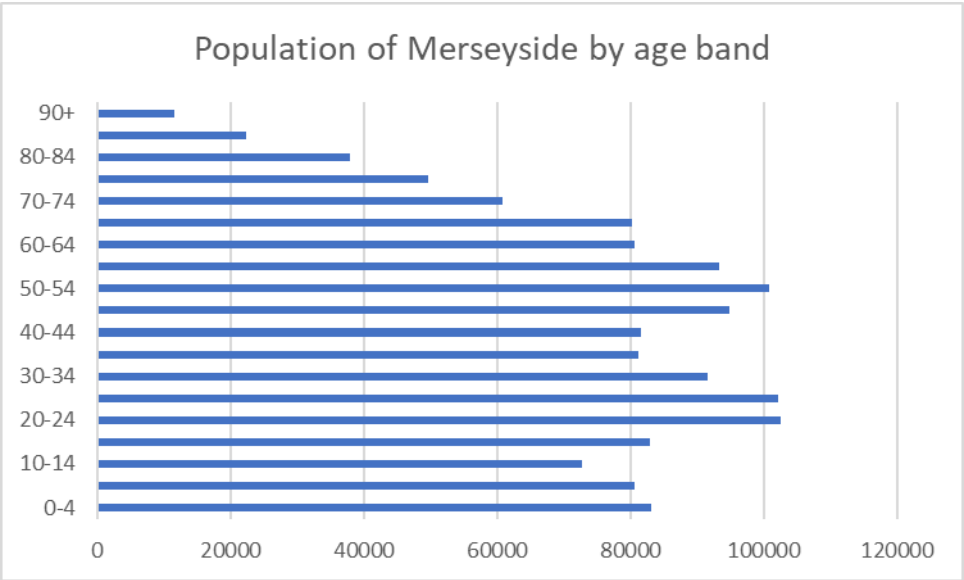

Figure 8. Population of Merseyside by age band

Figure 9 shows the distribution of unintentional dwelling fire injuries by gender in Merseyside 2006 to 2016.

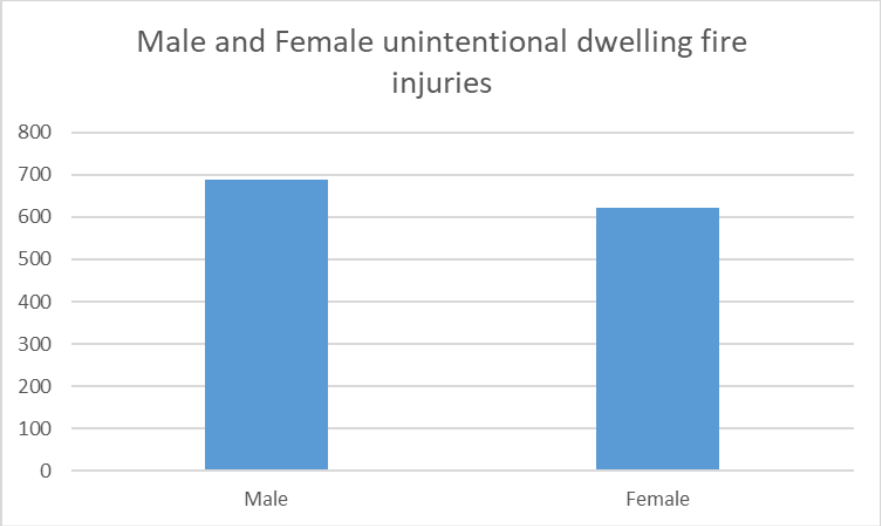

Figure 9. Unintentional dwelling fire injuries by gender in Merseyside 2006 to 2016

Over the period studied, in terms of overall number of unintentional dwelling fire injuries, the ratio of male to female fire injuries was 1.1 to 1. For alcohol and drug related unintentional dwelling fire injury incidents the ratio of male to female injuries was 1.9 to 1, and for injuries sustained by householders fighting an unintentional dwelling fire, the ratio of male to female injuries was 2.0 to 1. In 2020 in England, 62% of NHS hospital admissions related to alcohol were for males compared to 38% for females[46] giving a ratio of 1.6 to 1.

Figure 10 show the distribution of unintentional dwelling fire incident injuries by age and gender over the period studied.

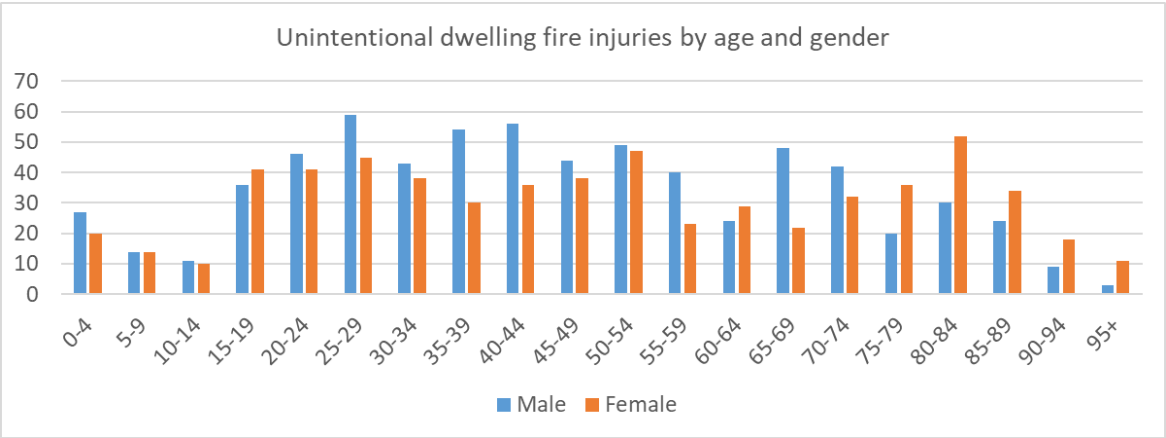

Figure 10. Unintentional dwelling fire injuries by age and gender in Merseyside 2006 to 2016

This appeared to indicate that the ratio of male to female unintentional dwelling fire injuries was highest amongst those aged 25 to 45, and 65 to 75, however, for those aged 75+ there was a higher ratio of female to male unintentional dwelling fire injuries, which relates to the higher number of females aged 75+ (72,030) compared to the number of males aged 75+ (49,571) in the Merseyside area in 2016[49], a ratio of 1.5 to 1.

4.3 Location of unintentional dwelling fire injuries

The location of unintentional dwelling fire injuries during the period studied is shown in Figure 11.

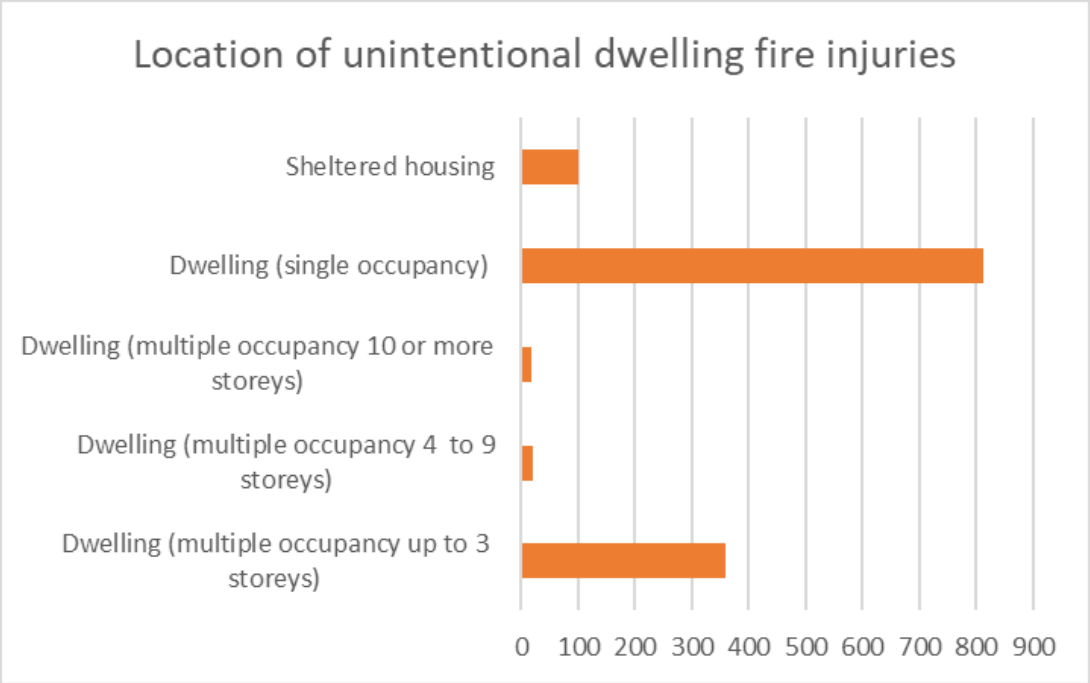

Figure 11. Unintentional dwelling fire injuries by type of housing in Merseyside 2006 to 2016

This indicated that over the period studied the majority of unintentional dwelling fire injuries occurred in single occupancy dwellings, followed by multiple occupancy dwelling of up to three storeys.

The level of deprivation for the Lower Level Super Output Area[36] in which the unintentional dwelling fire injuries occurred is shown in Figure 12. The level of deprivation shown is the Indices of Multiple Deprivation (IMD) decile.[38]

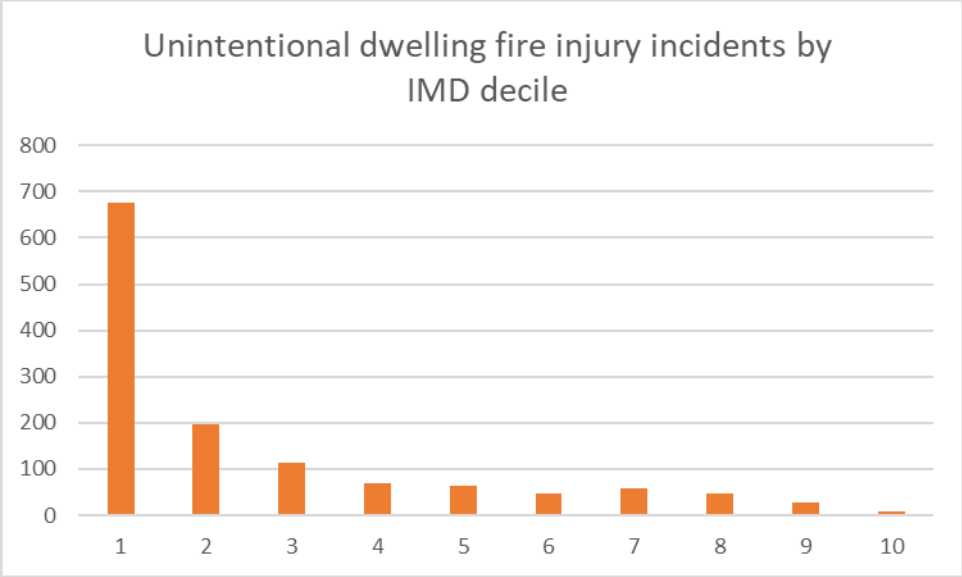

Figure 12. Unintentional dwelling fire injuries by level of deprivation in Merseyside 2006 to 2016

The majority (52%) of unintentional dwelling fire injuries occurred in the most deprived areas of Merseyside. In terms of alcohol and drug related fire injuries over the period studied, 70% of such injuries occurred in areas with the highest level of deprivation. The distribution of unintentional dwelling fire injuries by IMD decile closely matched the distribution of the IDM decile Lower Level Super Output Areas within Merseyside as shown in Figure 13.

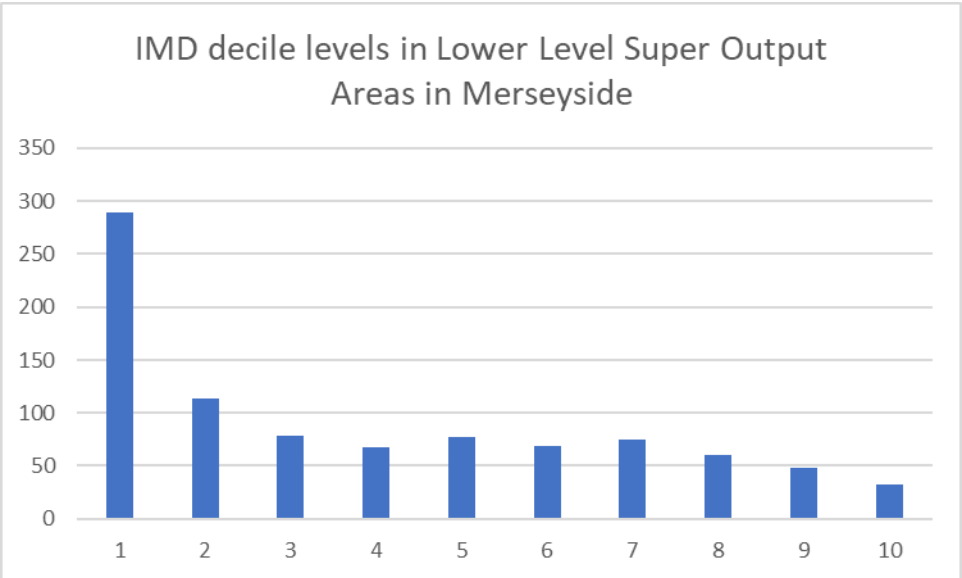

Figure 13. Levels of deprivation in Lower Level Super Output Areas in Merseyside

Conclusion

The originality of the research reported in this paper is the detailed analysis of the circumstances associated with unintentional dwelling fires injuries over a ten year period (2006

to 2016) recorded by a UK fire and rescue service. This is an important research topic since fire injuries have both a social and economic impact, and understanding the nature and distribution of unintentional dwelling fire injuries can support more targeted fire injury prevention approaches, which is especially important in times of reducing fire and rescue service budgets. In particular, the analysis presented in this paper provides an analysis of the different unintentional dwelling fire injury risk levels for different social groups in terms of age, gender, type of housing and level of deprivation.

Deprivation appeared to be a significant factor in unintentional dwelling fire injuries over the period studied, with 52% occurring in areas with the highest level of deprivation, and 70% of alcohol and drug related fire injuries occurring in areas with the highest level of deprivation. The number of unintentional dwelling fire incident injuries was largest amongst the elderly (those aged 65+), followed by those aged 25 – 45, then those aged 45 – 65, then young persons (aged up to 24). The numbers of unintentional dwelling fires and fatalities in Merseyside was also largest amongst the elderly (those aged 65+) during the period studied.[14] In England as a whole in 2015 to 2016, the numbers of unintentional dwelling fire incidents, injuries and fatalities was also largest amongst the elderly (those aged 65+).[50]

The overall ratio of male to female unintentional dwelling fire injuries was one to one, however, for alcohol and drug related unintentional dwelling fire injury incidents and fire injuries sustained by householders fighting an unintentional dwelling fire, the ratio of male to female injuries was two to one. Over the period studied the majority of unintentional dwelling fire injuries occurred in single occupancy dwellings, followed by multiple occupancy dwelling of up to three storeys.

A deeper understanding of the characteristics and behaviours of those injured in unintentional dwelling fires can support appropriate targeting of fire prevention measures such as home fire safety checks, and web and social media based fire safety messages concerning behaviours that can lead to increased fire injury risk. It is hoped that the research undertaken into unintentional dwelling fire injuries may be of use to other UK Fire and Rescue Services, and to other Fire and Rescue Services worldwide, in terms of understanding the age, gender, type of housing, and level of deprivation circumstances associated with unintentional dwelling fire injuries, and how such information can be used for appropriately targeting fire injury prevention initiatives. In terms of practical unintentional dwelling fire injury prevention, public information and education with regard to the risk of fire injury from cooking fires, smoking, attempting to tackle a fire, and the effects of alcohol and drugs can be effective, and the reach of such information and education can be increased by the use of social media compared to other forms of distribution. Appropriately targeted home fire safety checks can reduce the likelihood of unintentional dwelling fire injuries by advising householders of escape routes in the event of fire and checking or installing smoke detectors. Partnerships with other agencies can assist in reducing underlying causal factors associated with unintentional dwelling fire injuries, in terms of smoking cessation, alcohol management, and drug addiction treatment programmes.

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