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An analysis of fatal unintentional dwelling fires investigated by London Fire Brigade between 1996 and 2000

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Abstract

London is a large capital city with a population of approximately seven million people. It shares many problems with other large cities around the world, including deaths due to fire. Many of these fire deaths can be linked to social problems such as poor housing, loneliness, illness, etc.

Data from the London Fire Brigade Real Fire Library—a unique database of information collected from real fire incidents by dedicated teams of fire investigators operating in the Greater London Area has been used to obtain a range of statistics about fatal fires and fire death victims for the 5-year period from 1996 to 2000. Most deaths occurred in unintentional dwelling fires. The statistical information has therefore been analysed to identify the main factors involved as to why people die in unintentional dwelling fires and see what lessons can be learnt from these deaths.

Common risk factors identified in the unintentional dwelling fire deaths investigated include smoking, alcohol, old age, disability, illness, living alone, social deprivation and not having a working smoke alarm fitted. Comparisons are also made with the results found from other studies and measures for preventing unintentional dwelling fire deaths are examined.

Keywords: Fatal fires; London; Fire investigation; Risk factors; Accidental ignition

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1. Introduction

In common with many other large cities around the world, London has a range of architecture and building types, both old and new and has a vast social and cultural diversity of people living within its boundaries. It also shares many of the same problems as other major international cities, including the tragic loss of life due to fire. The lessons learnt from investigating such fire deaths in London should therefore be of relevance to a wider international audience.

Residential dwelling fires kill on a regular basis. The spectacular fires requiring detailed research account for far fewer deaths and occur infrequently. We need to reduce the regularly occurring deaths. It is vitally important that data is collected about such real fires. They are usually straightforward and generally do not need a great deal of sophisticated science to be understood.

In London, a London Fire Brigade (LFB) Fire Investigation Unit is required to attend all incidents where one or more fire fatalities have occurred. Since 1994, the data collected by the fire investigators at the scene of each fire incident they attend has been entered into a database known as the Real Fire Library (RFL) [1,2]. For fatal fires information is also collected into the Library from the inquest held into the death, which provides additional details about the victim, including age, sex and cause of death. The inquest can also provide details relating to the percentage of carboxyhaemoglobin in the victim's blood and important information about any pre-existing medical, mental and physical conditions that the victim might have had at the time of the fire.

LFB fire investigators have recorded details of a total of 381 fatal fires and 418 fire deaths in the RFL in the 5-year period between 1996 and 2000. The number of deaths per year for the size of population is similar to that of a country like Denmark. Table 1 shows a breakdown of the fatal fires by the type of property

Table 1
Number of fatal fires and deaths recorded in the RFL, 1996–2000 by the purpose group type of the property in which they occurred

Purpose group title	Number of fatal fires	Number of fire deaths
Residential—dwellings	322	358
Mobile property	19	19
Outdoor and other property	18	18
Residential—institutional	5	5
Shop and commercial	3	4
Residential other	4	4
Assembly and recreation	4	4
Storage and other	3	3
Industrial	1	1
Car parks	1	1
Not specified	1	1
All	381	418

Table 2
Fatal dwelling fires and deaths recorded in the RFL, 1996–2000 by cause of fire

Most likely cause	Number of fatal fires	Number of fire deaths
Unintentional	259	279
Deliberate	48	61
Other	15	18
All	322	358

purpose group in which they occurred. Clearly, the majority of fire deaths—358 or almost 86% of the total—occurred in residential dwellings. In contrast, a relatively small number of fire fatalities, 22 deaths or 5% of the total occurred in "other building" purpose group types. The remaining 9% of deaths either occurred in mobile property, out of doors or in other miscellaneous types of property.

A breakdown of the 358 dwelling fire deaths recorded in the RFL between 1996 and 2000 in terms of the cause of the fire is shown in Table 2. It is evident that the majority of fatalities in dwelling fires—279 deaths or 78% of the total—were due to fires that were started unintentionally, while 61 deaths (17%) resulted from fires that were set deliberately. Over half of the deliberate fire fatalities (36 deaths) were caused by the intentional application of a naked flame, while 15 deaths were due to suicide and 8 deaths were caused by an item being pushed through a letterbox.

Since the majority of fire deaths occurred in unintentional dwelling fires the focus of the rest of this paper is on the fatalities resulting from this type of fire. The data in the RFL has been used to provide statistical information on fatal unintentional dwelling fires in terms of:

(a) the fire characteristics,
(b) the fire death victims, and
(c) the location of the fire.

The statistical information has then been analysed to try to identify the main factors involved as to why people die in unintentional dwelling fires and to examine the implications for reducing the number of fire deaths. Some comparisons are also made with the results of other fatal fire studies focusing on similarities and differences in patterns.

2. The fire characteristics

2.1. *Source of ignition*

Nearly half of the fatal unintentional dwelling fires (121 fires or 47% of the total 259) had a cigarette, cigar or tobacco as the source of ignition (Fig. 1) and were responsible for 131 fatalities. Cooking appliances and candles also featured strongly,

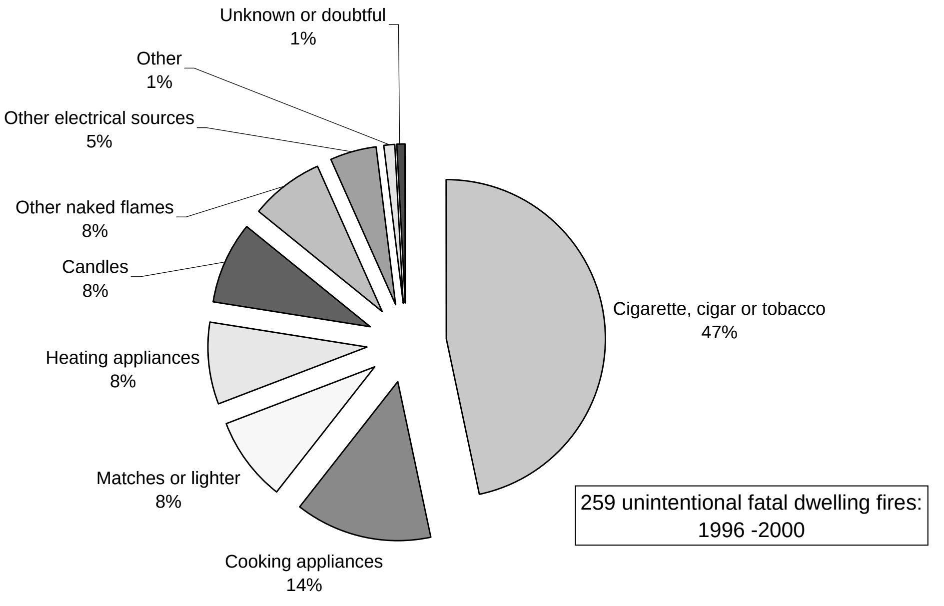

Fig. 1. Unintentional fatal dwelling fires by source of ignition.

accounting for 14% (36 fires) and 8% (21 fires) of the total, respectively. In comparison, other electrical sources were only responsible for 5% of the fatal incidents (12 fires).

Table 3 provides a breakdown of the number of unintentional fatal dwelling fires in terms of the defect, act or omission that caused the fire and the most frequent sources of ignition associated with a particular cause. Almost half of the fires (46%, $n = 259$) were caused through the careless disposal of an item (usually of cigarettes, cigars or tobacco). There were also a significant number of fatal fires caused through the misuse of a cooking appliance (typically leaving a chip pan unattended), placing an article too close to a heat source (primarily heating appliances and candles) or due to a person getting too close to a heat source (mainly cooking appliances).

In a Northern hemisphere city like London, it is likely that people would generally spend more time at home during the winter. An increase in activities like smoking, cooking and the use of heating appliances might therefore be expected during the winter months. This seasonal variation would appear to be reflected in the number of fatal unintentional dwelling fires that occurred due to different ignition sources (Fig. 2). The number of fatal fires started by cigarettes, cigars or tobacco was highest in the winter (43 fires) and was significantly lower during the summer (17 fires). A similar pattern was also exhibited by fires started by cooking appliances with 13 fatal fires recorded in the winter (but only 2 in the summer) and heating appliances with a significantly higher number of fatal fires in the winter (13 fires) than for the other seasons. The number of fatal fires started by candles appears to have been significantly lower during the summer (only one fire) than for the other seasons.

Table 3
Unintentional fatal dwelling fires by the defect, act or omission that caused the fire

Cause of unintentional fatal dwelling fire	Number of fires	% of fires
Careless disposal	118	46
Cigarette, cigar or tobacco	100	
Matches or lighter	10	
Other careless action	46	18
Cigarette, cigar or tobacco	18	
Candles	10	
Misuse	25	10
Chip pan fire	10	
Other cooking appliances	6	
Article too close to heat source	21	8
Heating appliances	8	
Candles	7	
Person too close to heat source	14	5
Cooking appliances	11	
Children playing with fire	9	3
Electrical fault or defect	7	3
Other	16	6
Doubtful or unknown	3	1
All unintentional fatal dwelling fires	259	100

Note: The most common ignition sources are also listed for some causes (indented).

The unintentional fatal dwelling fires started by cigarettes, cigars or tobacco were reasonably well spread over the whole day, with a slightly lower number between 9 am and 12 midday (Fig. 3). The number of fires started by the other ignition sources was also relatively evenly distributed over the course of the day.

2.2. Type of material first ignited

Around 23% of unintentional fatal dwelling fires (58 incidents) first involved bedclothes (bedding, pillows, blankets, etc.) while 20% (52 fires) had upholstered furniture as the first material ignited (Fig. 4). There were also a relatively large number of fatal fires (42 incidents) where an item of clothing was the first material ignited.

Fig. 5 shows the number of unintentional fatal dwelling fires by both the first material ignited and the source of ignition. This data suggest that there is a strong link between those fatal fires started by cigarettes, cigars or tobacco and where the first material involved was bedclothes (38 fires) or upholstered furniture (41 fires).

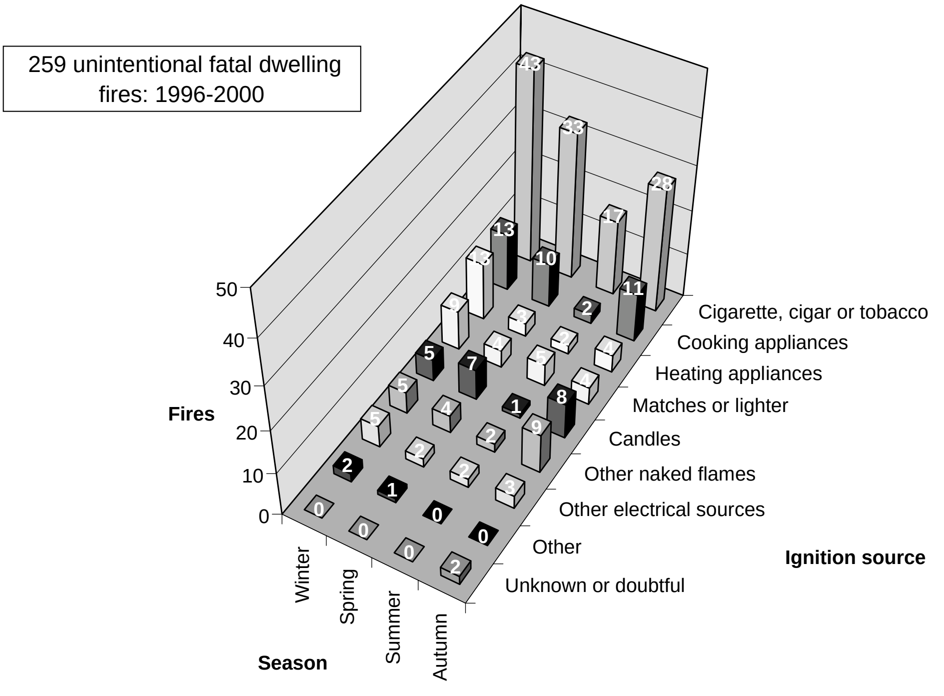

Fig. 2. Unintentional fatal dwelling fires by season and ignition source.

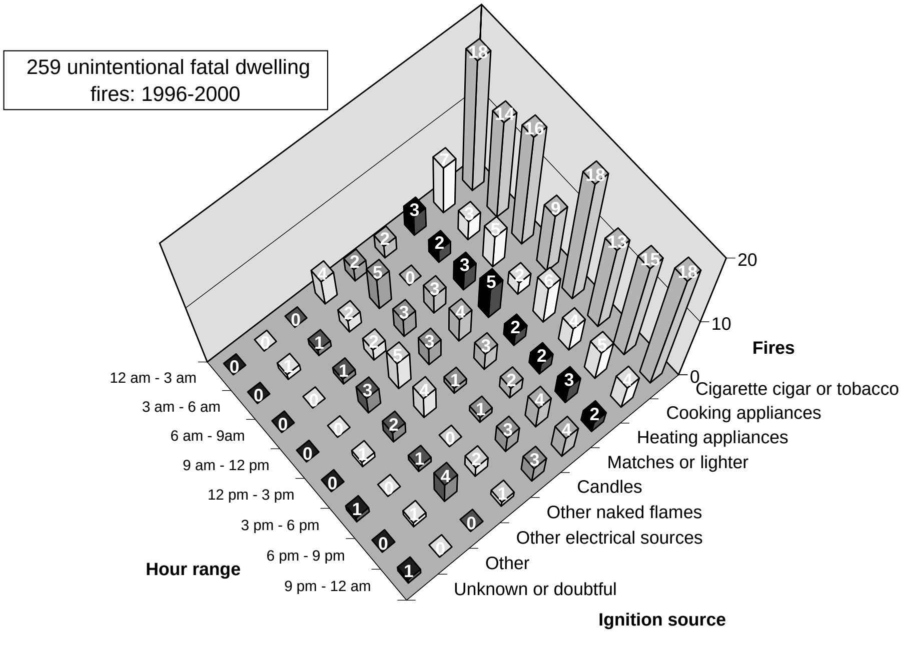

Fig. 3. Unintentional fatal dwelling fires by hour range and ignition source.

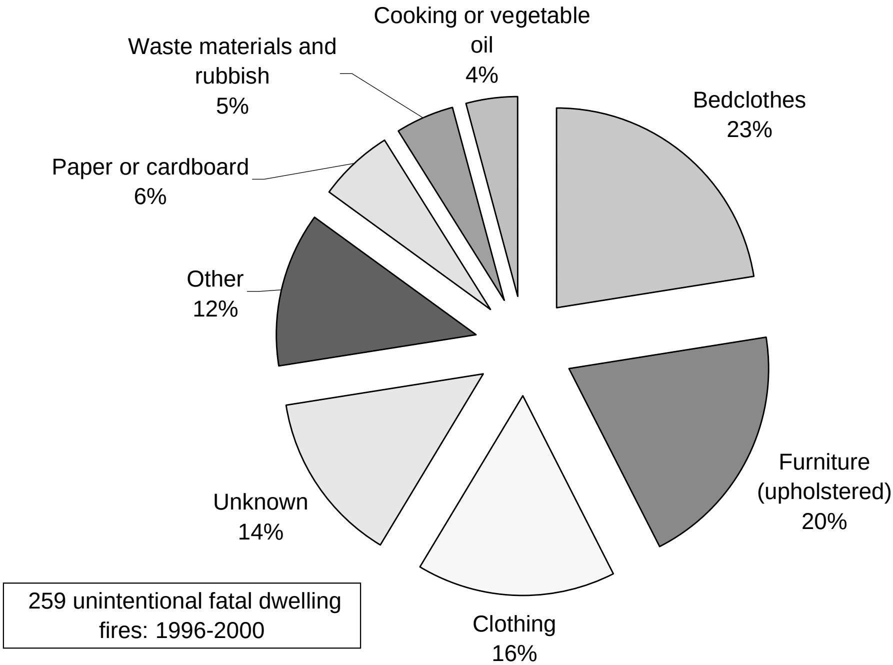

Fig. 4. Unintentional fatal dwelling fires by the first material involved in the fire.

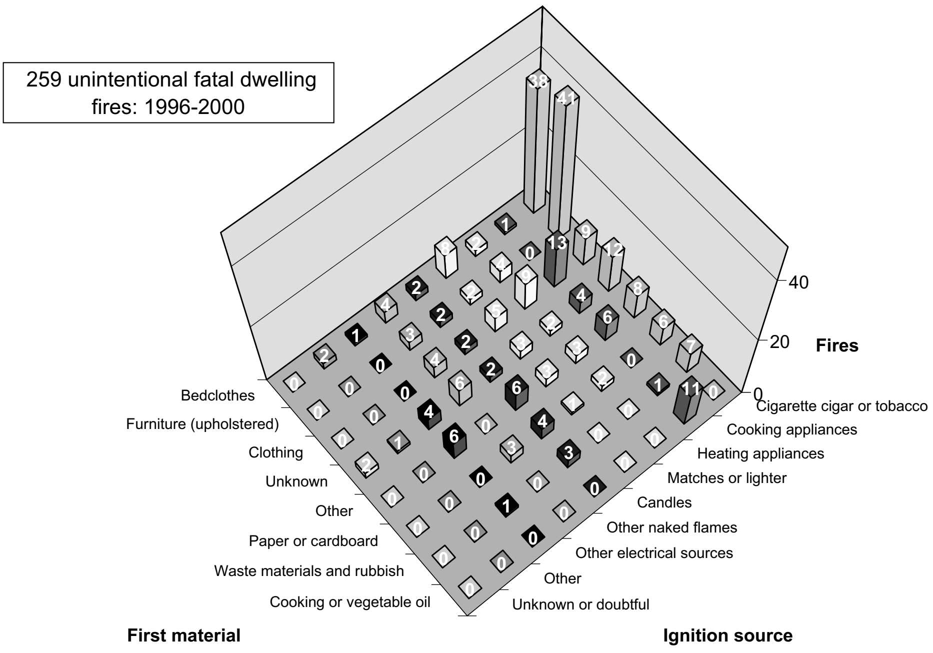

Fig. 5. Number of unintentional fatal dwelling fires by the first material ignited and source of ignition.

Table 4
Number of deaths per incident and number of incidents

Number of deaths per incident	Number of incidents	Total number of deaths
1	244	244
2	12	24
3	2	6
5	1	5
All	259	279

There were also a number of fatal fires involving clothing which were started by heating or cooking appliances (9 and 13 fires, respectively).

2.3. Number of deaths per incident

The majority of incidents involved a single death, while there were a small number of incidents, which involved two, three or in one case five fatalities (Table 4).

3. Fire death victims

3.1. Age of victim

Well over half of the unintentional dwelling fire deaths (158 = 57%, $n = 273$) involved persons who were aged 60 years or above, as shown in Fig. 6 (note that age was not specified for 6 of the 279 victims). In comparison, relatively few unintentional dwelling fire deaths were suffered by persons under the age of 20 (23 = 9%, $n = 273$).

The number of fire deaths involving elderly people is of even greater significance when population demographics are taken into account. Fig. 7 shows both the distribution of unintentional dwelling fire deaths by the age of the victim and the population age distribution for Greater London, estimated for 1998 [3]. It is evident that while the population distribution tails off above 35 years of age, the number of deaths increases significantly for the older age groups. Thus, relative to the number of persons in each age range, there are a far higher number of fire death victims in these older age groups. There were also a relatively high number of deaths in the 0 years and 1–4 years age ranges, but far fewer fire death victims aged between 5 and 19 years old.

The increase in the number of deaths with age is also reflected in the unintentional dwelling fire death rate (shown in Fig. 8 and Table 5) in terms of the number of fire deaths per million population (pmp) per year occurring in each age group (with an additional male/female breakdown). These results show that the death rate was significantly higher for persons who were aged 80 years or above than for any of the other age groups and suggest that the fire death rate for adults increases

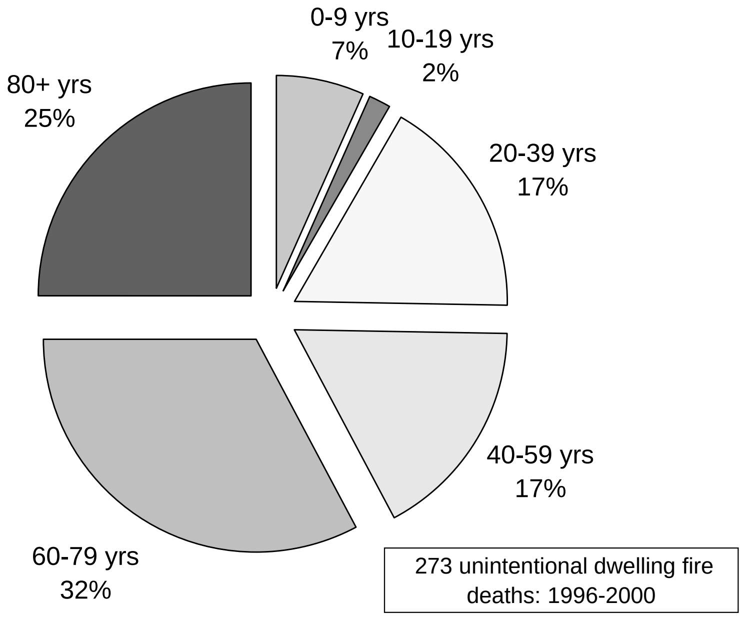

Fig. 6. Unintentional dwelling fire deaths by age of victim.

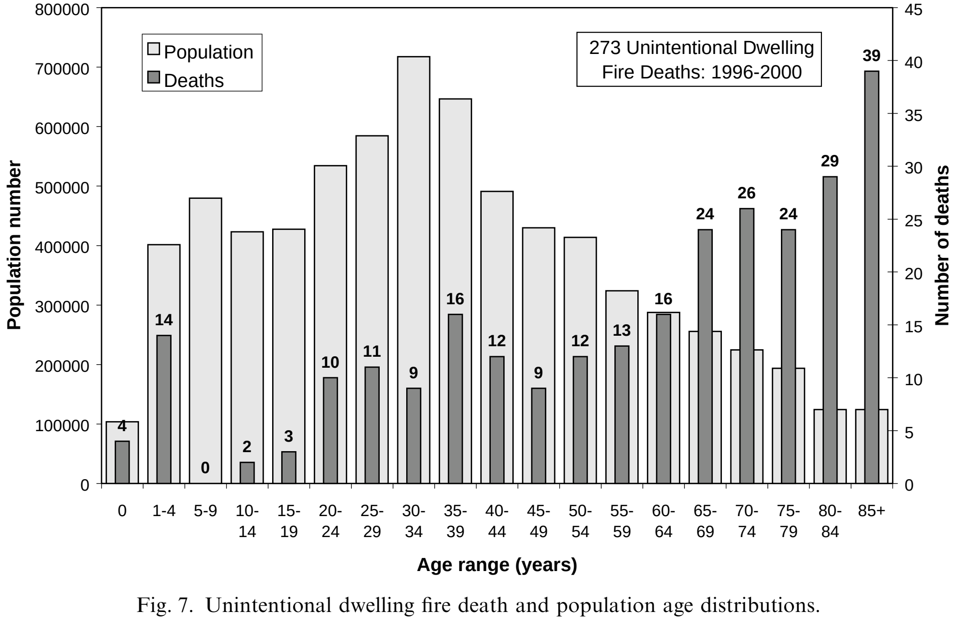

Fig. 7. Unintentional dwelling fire death and population age distributions.

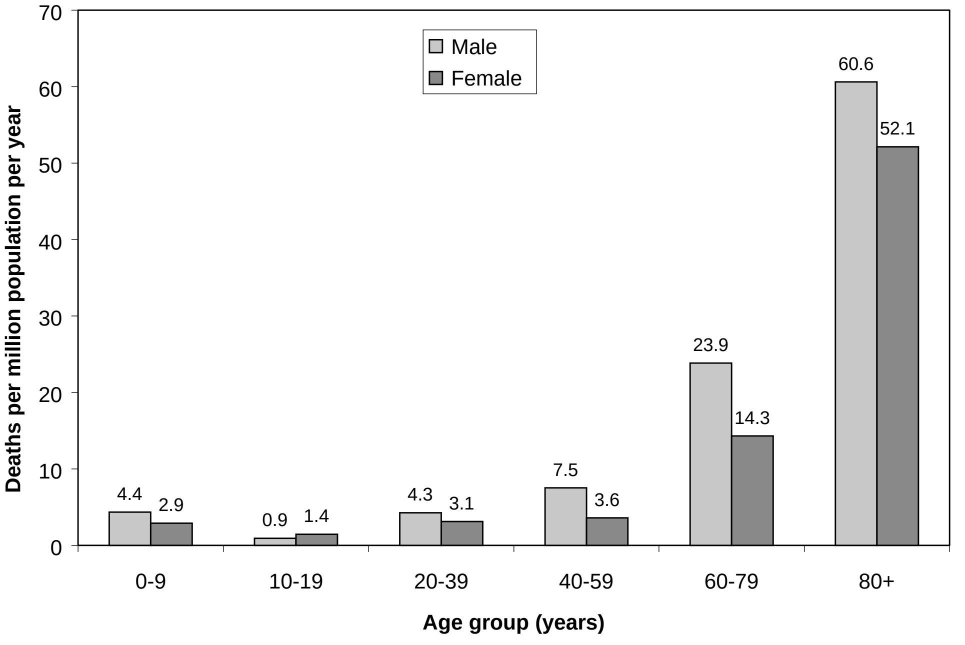

Fig. 8. Death rate due to unintentional dwelling fires (pmp per year) by age group and sex.

Table 5
Number of deaths and death rate due to unintentional dwelling fires by age group and sex of victim

Age group (years)	Number of fire deaths			Annual death rate (pmp per year)		
	Male	Female	All	Male	Female	All
00–09	11	7	18	4.4	2.9	3.7
10–19	2	3	5	0.9	1.4	1.2
20–39	27	19	46	4.3	3.1	3.7
40–59	31	15	46	7.5	3.6	5.5
60–79	53	37	90	23.9	14.3	18.7
80+	23	45	68	60.6	52.1	54.7
Unknown	3	3	6	—	—	—
Total	150	129	279	8.4	7.1	7.8

approximately exponentially with age. It is also apparent that the unintentional death rate in dwelling fires was higher for males than for females in most of the age groups.

A cigarette, cigar or some other form of tobacco was the dominant source of ignition for fires where the victim was aged 20 years or above (Fig. 9), and in particular for the older age groups of 60–79 years (43 deaths) and 80+ years (30

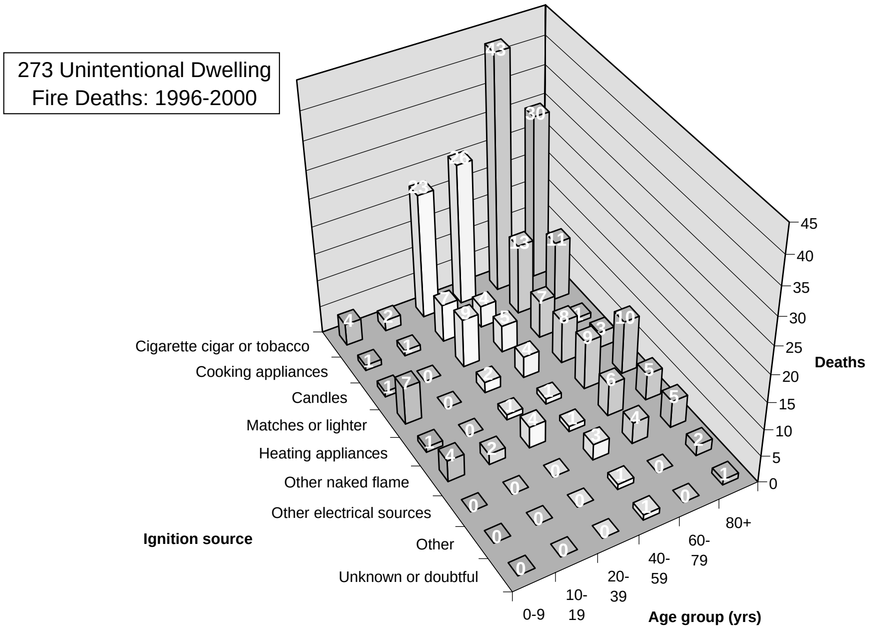

Fig. 9. Unintentional dwelling fire deaths by source of ignition and age group.

deaths). Cooking and heating appliances were also responsible for fires that resulted in a number of deaths in the older age categories.

There were a significant number of fire fatalities involving clothing in both the 80+ years and 60–79 years age groups (16 and 19 deaths, respectively), but relatively few in the remaining age categories (Fig. 10). Bedclothes and upholstered furniture were the most frequent first materials ignited for fatalities in the 20–39 and 40–59 years age groups. There were also a relatively large number of fire fatalities involving bedclothes and upholstered furniture with victims belonging to the 60–79 and 80+ years age groups.

The number of unintentional dwelling fire deaths follows a periodic cycle over the course of the year, with more than three times the number of deaths in winter months (November–February) than in the summer months (June–August) as shown in Fig. 11. Most of this seasonal variation in the number of fatalities occurred in those aged 60 years and above.

In terms of the time of day when the fire occurred, for the 80+ years age group the number of deaths peaked in the late morning between 9 am and 12 midday (14 deaths), although the fatalities would appear to spread across the day (Fig. 12). In comparison, the 60–79 years age group displayed more variation over the course of the day, with peaks in the numbers of fatalities between 12 midnight and 3 am (15 deaths), 12 midday and 3 pm (15 deaths) and 6 and 9 pm (20 deaths). The 40–59 years age group had a higher number of fatalities in the later part of the day from

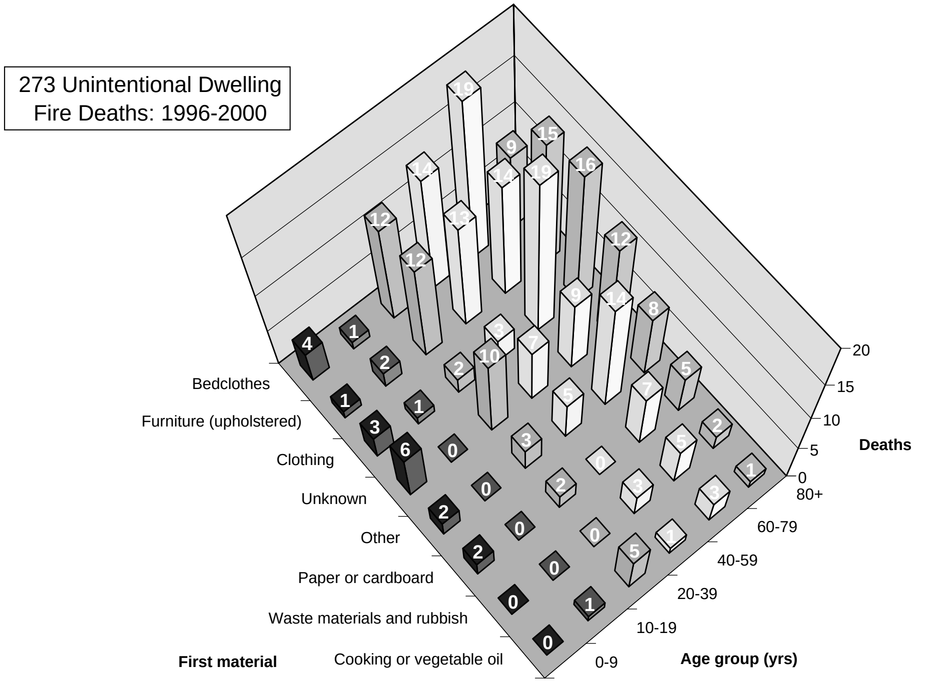

Fig. 10. Number of unintentional fire deaths in dwellings by the first material ignited and age of victim.

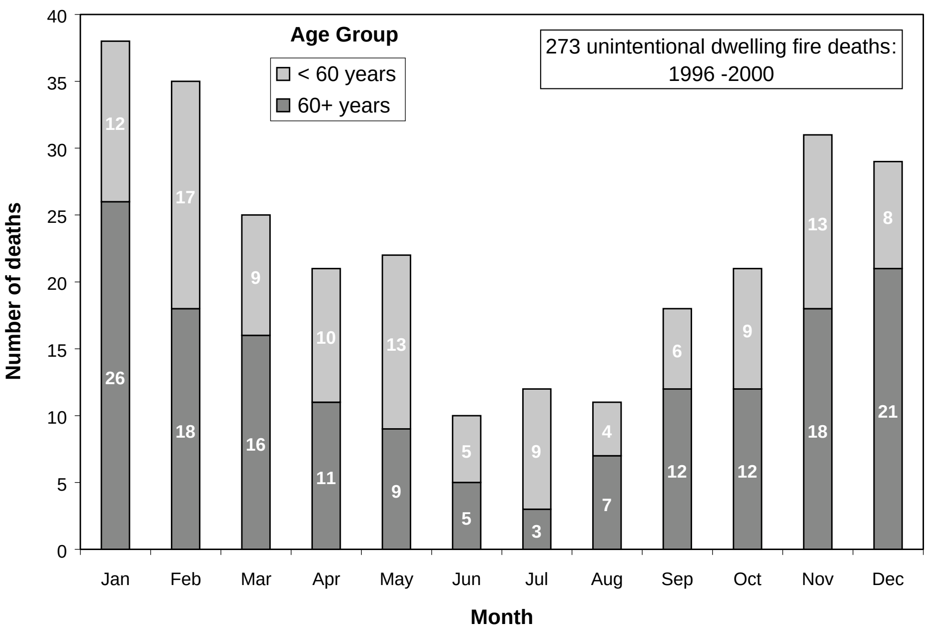

Fig. 11. Unintentional dwelling fire deaths by month and age group of victim.

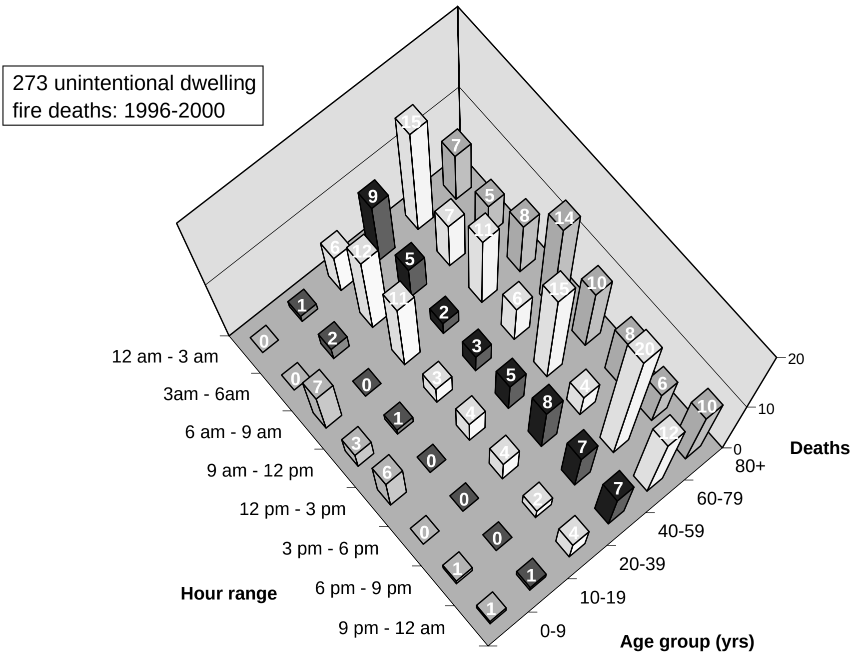

Fig. 12. Unintentional dwelling fire deaths by hour range and age group of victim.

3 pm to 3 am. In contrast, the 20–39 years age group had a much higher number of deaths during the early hours and morning from 3 to 9 am than during the rest of the day. Finally, for the youngest age group of 0–9 years, most of the fatalities occurred during the morning and afternoon from 6 am to 3 pm.

3.2. Alcohol

Of the unintentional dwelling fire victims, 58% (162, $n = 279$) were tested for the presence of alcohol (as shown in Fig. 13). Of these, 40% (65, $n = 162$) had blood alcohol concentrations (expressed in mg of alcohol per 100 ml of blood) in excess of the legal limit for driving in the UK (80 mg/100 ml), while 24% (39, $n = 162$) would have been highly intoxicated at their time of death (i.e. in excess of 200 mg/100 ml of blood).

Table 6 provides a breakdown of the number of intoxicated victims by age group and sex. Over two-thirds (24 deaths, $n = 34$) of the male fire death victims aged between 20 and 59 years that were tested for alcohol were intoxicated. In contrast, few of the victims who were intoxicated were aged 80 years or above.

The number of unintentional dwelling fire deaths by the blood alcohol concentration measured in the victim's blood stream and time of day when the fire occurred is shown in Fig. 14. For the victims where no alcohol was measured in

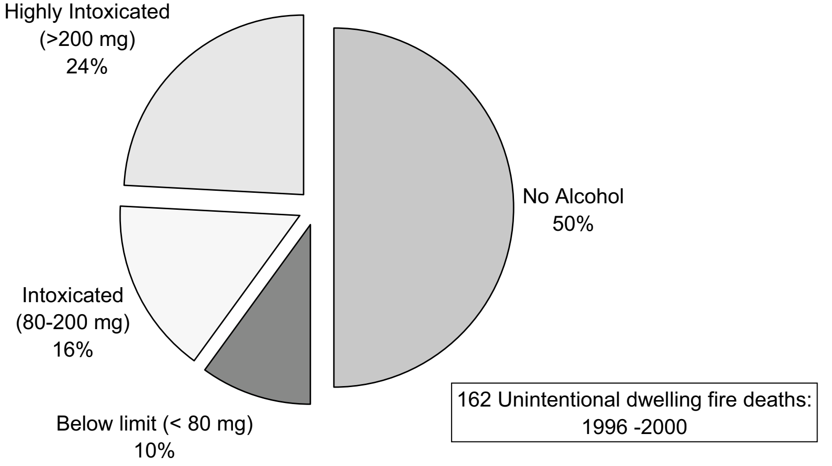

Fig. 13. Unintentional dwelling fire deaths by victims blood alcohol concentration.

Table 6
Number of deaths due to unintentional dwelling fires where the victim was intoxicated and tested for alcohol by age group and sex of victim[a]

Age group (years)	Number of intoxicated victims (BAC >80 mg/100 ml)		Total number of victims tested for alcohol	
	Male	Female	Male	Female
00–09	0	0	4	4
10–19	1	0	1	1
20–39	10	5	15	17
40–59	14	7	19	12
60–79	13	9	29	24
80+	1	4	10	24
Unknown	0	1	1	1
Total	39	26	79	83

[a] Based on 162 unintentional dwelling fire deaths where the victim's blood alcohol concentration was measured.

the bloodstream, the majority of deaths occurred during the day between 6 am and 9 pm. In contrast, the number of deaths for those victims who were "highly intoxicated" peaked in the hours around midnight with 7 fatalities recorded from 9 pm to midnight and 12 fatalities between midnight and 3 am. The number of fire deaths involving victims who were "intoxicated" also had a peak in the hours between midnight and 3 am (6 deaths) but had an additional peak in the early evening from 6 to 9 pm (6 deaths).

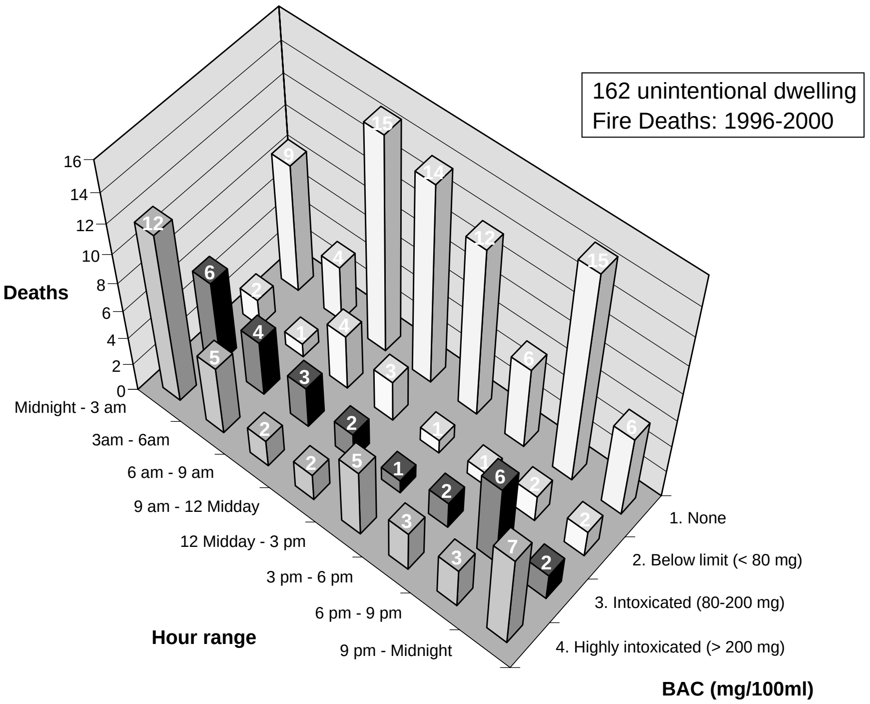

Fig. 14. Unintentional dwelling fire deaths by hour range and blood alcohol concentration measured in the victim's blood.

3.3. Occupation of the victim

As might be expected from the analysis of the victim's age more than half of the unintentional fatal dwelling fire death victims were retired, while nearly 8% were children (Table 7). There were also a significant number of the victims that were unemployed (14%). Of the victims that were aged between 20 and 59 years, 38% were also unemployed (35 deaths, $n = 92$).

3.4. Personal circumstances of the victim

In many cases the fire investigator has recorded detail about the victim's personal circumstances. Since such observations are made at the investigator's disgression, incidents where the victim's circumstances have not been specified will be effectively indistinguishable from cases where the victim has no special circumstances. Nevertheless, the results still give an indication of common problems and provide a lower bound on the frequency with which particular circumstances occur.

In approximately one-third of the unintentional dwelling fire deaths (91 fatalities) the victim's personal circumstances mention that they were alone (i.e. either that they lived alone or that they were alone at the time when the fire occurred).

Table 7
Occupation of unintentional dwelling fire death victims

Occupation group[a]	Number of deaths	% of deaths
Retired	151	54
Unemployed	40	14
Child	22	8
Home-maker	10	4
Service & sales[a]	9	3
Associate professional[a]	6	2
Student	5	2
Managers & senior officials[a]	4	1
Machine operators[a]	3	1
Elementary occupations[a,b]	3	1
Trades worker[a]	3	1
Secretarial & admin[a]	2	1
Professional[a]	2	1
Unknown	19	7
All unintentional fatal dwelling fires	279	100

[a] Occupation groups based on international standard classification of occupations ISCO-88.
[b] For example labourers, cleaners, caretakers, porters, etc.

Table 8
Personal circumstances of unintentional dwelling fire death victims[a]

Personal circumstances of victim	Number of fire deaths	Types of condition mentioned
Alcohol problem	17	Heavy drinkers, alcoholics, alcoholic vagrants
Asleep	9	Intoxicated, smoking in bed or chair
Disabled	58	Arthritis, bedridden, chairbound, frail, infirm, blind or partially sighted, physically disabled, stroke victim, MS, hip replacement, deaf
Ill health	17	Heart condition, epilepsy, diabetic, HIV positive, influenza or cold (could not hear fire or smell smoke), emphysema
Mental illness	15	Dementia, depression, schizophrenic, mentally handicapped, Alzheimers, senile dementia
Social outcast	1	Eccentric bag lady

[a] Based on 117 unintentional dwelling fire deaths where the victim's personal circumstances were noted.

At least 21% of the unintentional dwelling fire death victims (58 fatalities) had some form of physical disability, which may have restricted their mobility (see Table 8). Specific types of condition mentioned included arthritis, strokes, infirmity and frailty, and blindness or partial sight. Around 6% of the victims (17 fatalities)

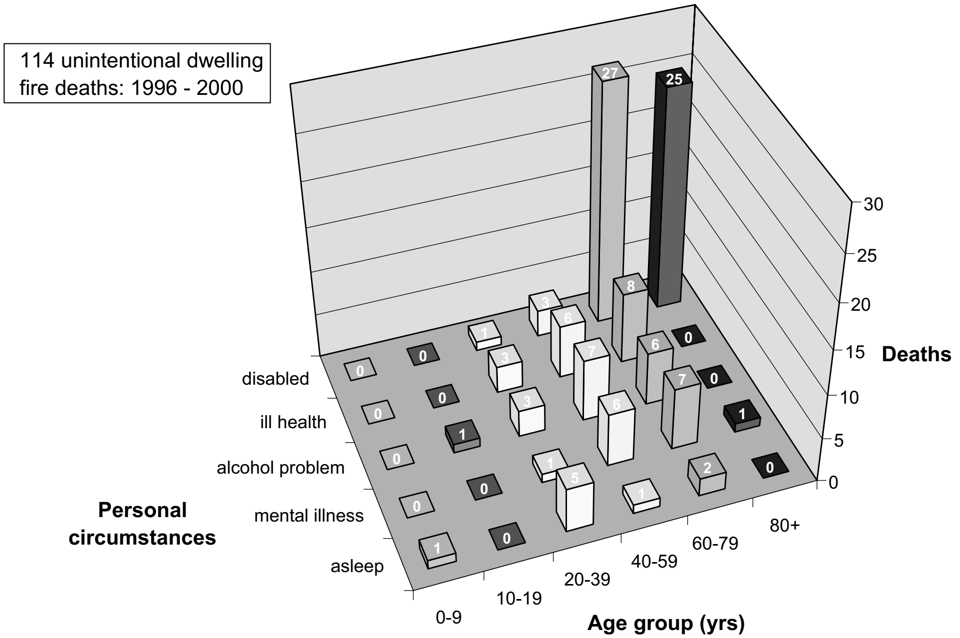

Fig. 15. Number of unintentional dwelling fire deaths by the victim's personal circumstances and age group.

were described as having had an alcohol problem (e.g. heavy drinkers, alcoholics, etc.), while a similar number were suffering through ill health at the time of the fire (e.g. heart condition, epilepsy, diabetes, etc.). In addition, 5% of the unintentional dwelling fire victims (15 fatalities) suffered from mental illness or handicap. Specific conditions mentioned included depression, schizophrenia, Alzheimer's and other forms of dementia.

As might be expected, the majority of victims suffering with a disability were in the older age groups of 60–79 and 80+ years (Fig. 15).

3.5. *Illegal drugs or medication*

A small number of the unintentional dwelling fire death victims (16 fatalities) were noted to be using drugs or medicines at the time of the fire (Table 9). A variety of different substances were recorded including several involving sleeping or anxiety tablets and anti-depressants. Note that these results are only indicative since, as with personal circumstances, unknowns are indistinguishable from cases in which no illegal drugs or medication were used.

3.6. *Cause of death*

The most frequent cause of death recorded was being overcome by smoke inhalation accounting for 42% of the total or 117 fatalities (see Table 10). The

Table 9
Types of drugs or medicine that were involved in fatal unintentional dwelling fires

Type of drug or medicine involved	Number of deaths[a]
Sleeping tablets and anxiety	5
Diazepam/Valium	4
Benzodiapede	1
Anti-depressants	3
Amitriptyline	1
Prozac	1
Otherwise unspecified	1
Khat (Amphetamine)	1
Cannabis	1
Heroin	1
Methadone	1
Anti-epileptic treatment	1
Paracetamol	1
Diuretics	1
Sustonen injection	1

[a] Based on 16 deaths where the involvement of drugs or medicine was specified.

Table 10
Unintentional dwelling fire deaths by cause of death[a]

Cause of death	Number of fire deaths	% of fire deaths	Types of condition mentioned
Smoke inhalation	117	42	
Inhalation of fire fumes	101	36	Carbon-monoxide poisoning
Asphyxia	8	3	
Bronchial pneumonia	8	3	
Burns	53	19	Shock due to burns
Smoke inhalation and burns	69	25	
Other	20	7	Heart disease, stroke, injuries from fall
Not specified	20	7	
All	279	100	

[a] Based on 279 unintentional fire deaths in dwellings.

majority of these cases (36%) were attributed to general inhalation of fire fumes, with carbon-monoxide poisoning also being mentioned specifically. In a smaller number of these cases the cause of death was either asphyxia (3%) or bronchial pneumonia (3%). A further 19% of deaths (53 fatalities) were attributed to burns alone (death from shock due to burns was also mentioned), while 25% of deaths (69 fatalities) were due to both smoke inhalation and burns. There were also a number of cases with ‘‘other’’ causes of death, including jump injuries incurred whilst escaping from fire.

A similar number of deaths occurred in the room of fire origin (115 fatalities) as took place once the victim was taken to hospital (105 fatalities). The remaining 21% (59 fatalities) occurred in other locations such as rooms outside that where the fire originated, outside the dwelling or in the ambulance.

3.7. Carboxyhaemoglobin level measured in the fire deaths victims' blood

54% of the unintentional dwelling fire victims (151, $n = 279$) were tested for the presence of Carboxyhaemoglobin (% COHb) as shown in Fig. 16. Of these, nearly a third (48, $n = 151$) had fatal levels of COHb saturation measured in their blood (in excess of 50% COHb), indicative of death by smoke inhalation (see Fig. 16), while a further 46% (69, $n = 151$) of victims had % COHb level in excess of the 15% saturation level which is considered to be the limit of safe exposure.

It has also been suggested that high levels of alcohol in the bloodstream may increase susceptibility to smoke inhalation producing high levels of % COHb [1]. There were a number of deaths where the victim was intoxicated or highly intoxicated and also had high % COHb levels present in their bloodstream (see Fig. 17).

3.8. Reason why the victim was found adjacent to the fire

In 39% of cases (110 deaths) the victim was not found adjacent to the fire. The remaining 61% of victims were found adjacent to the fire for a variety of reasons.

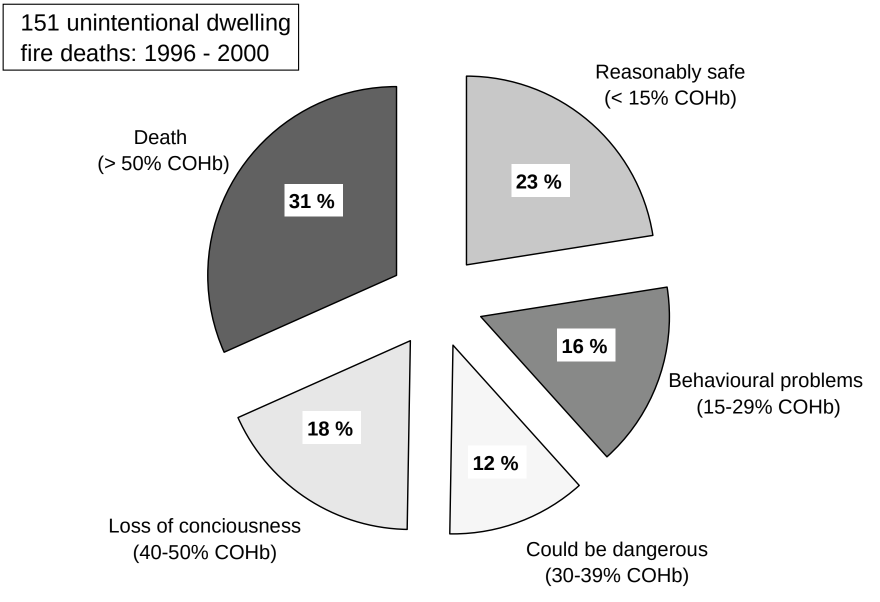

Fig. 16. Unintentional dwelling fire deaths by the % COHb saturation level measured in the victim's bloodstream.

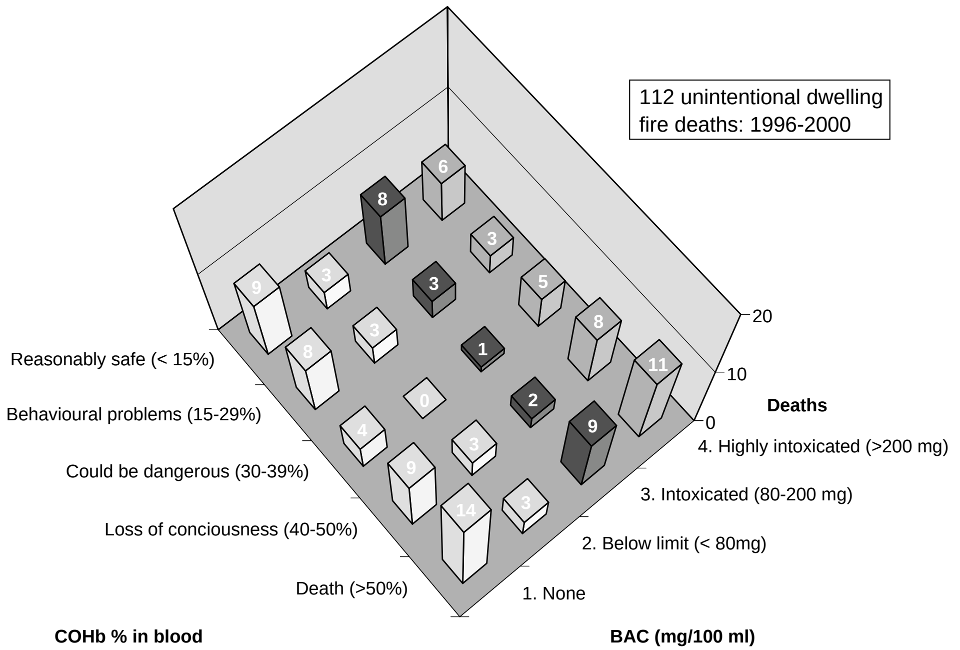

Fig. 17. Unintentional dwelling fire deaths where the cause of death involved smoke inhalation by the % COHb saturation level and blood alcohol concentration measured in the victim's bloodstream.

The most frequently cited explanations for why the victim was found next to the fire were that they were "disabled" (28 deaths), "trapped" by the fire (24 deaths), had their "clothing set on fire" (22 deaths), were "overcome" by smoke (20 deaths) or were "intoxicated" by alcohol or other drugs (19 deaths). Less common reasons given were that the victim was "asleep" (15 deaths), because of an "explosion" (6 deaths), or because the victim was an "infant" (5 deaths). Only 4 deaths adjacent to the fire were attributed to the victim fighting the fire, although this may also be covered in part by other explanations, e.g. "overcome" or "trapped" while fighting the fire.

3.9. *Smoke alarms*

Data indicating whether a smoke alarm was fitted or not, was recorded for 171 of the 279 unintentional dwelling fire deaths, the results of which are shown in Fig. 18. For 77% of these fire deaths (131, $n = 171$) a smoke alarm was not fitted, while an alarm was fitted in the remaining 23% of cases (40, $n = 171$). The figure also shows a further breakdown of those cases where an alarm was fitted in terms of whether the smoke alarm actually operated or not. In around a third of the cases (14, $n = 40$) where a smoke alarm was fitted the alarm failed to operate because the battery was either missing or flat. In the remaining cases (26 deaths) the smoke alarm operated but a fatality still occurred. Table 11 shows a breakdown of the probable reason why

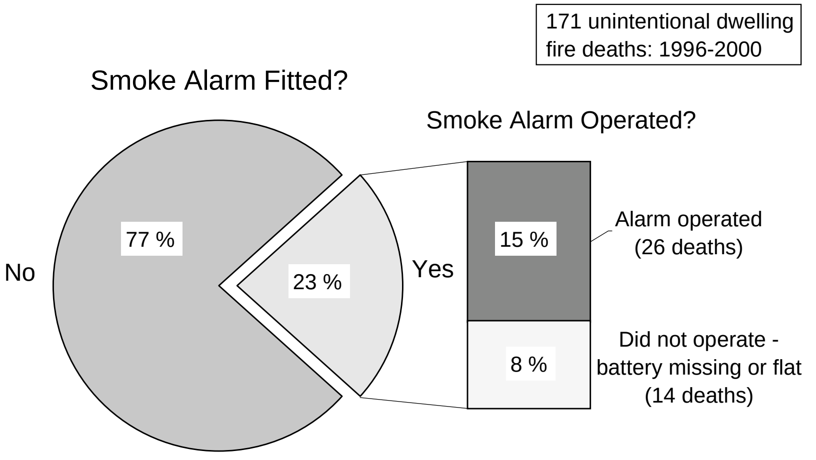

Fig. 18. Unintentional dwelling fire deaths by whether a smoke alarm was fitted.

Table 11
Probable reasons why fatal fire victims failed to escape in cases where the smoke alarm operated[a]

Probable reason why the victim failed to escape	Number of deaths
Disabled or infirm	9
Clothing was on fire	6
Intoxicated by alcohol	5
Mentally ill	2
Drug user	1
Ill health	1
Heart attack	1
Infant	1

[a] Based on 26 deaths where a smoke alarm was fitted and operated.

the fatal fire victim failed to escape for those cases where the smoke alarm did operate. In the majority of cases the victim was either suffering from some form of disability or infirmity (9 deaths), had an item of clothing set on fire (6 deaths) or was intoxicated by alcohol (5 deaths).

4. Location of the fire

4.1. Room in which fire originated

The room in which the fire originated was recorded for 75% (196, $n = 259$) of the unintentional fatal dwelling fires (see Fig. 19). Of these, a third (64, $n = 196$) originated in the living room, while 29% (57, $n = 196$) of the fires started in the bedroom and 20% (40, $n = 196$) originated in the kitchen. Over half the deaths from

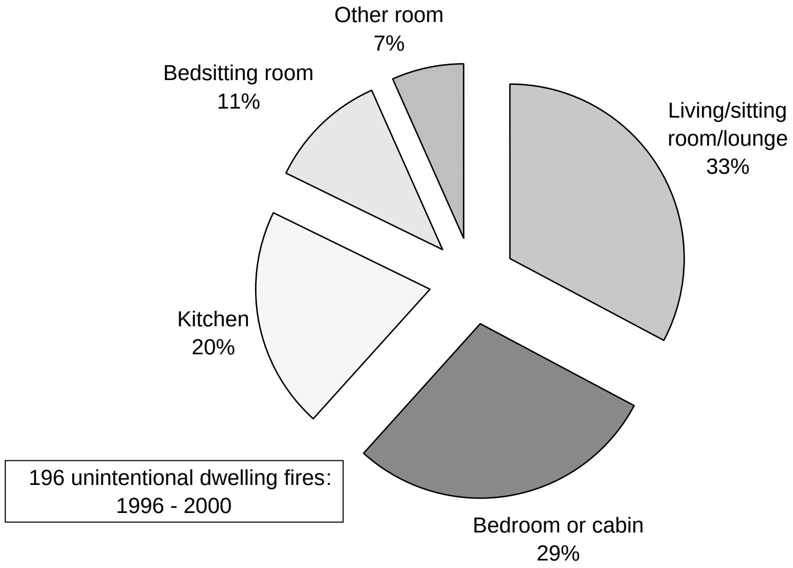

Fig. 19. Unintentional dwelling fire deaths by the room of fire origin.

fires originating in a living room, bedroom or bedsitting room were due to cigarettes, cigars or tobacco.

4.2. Dwelling type

Nearly half of the fatalities recorded (134, $n = 279$) occurred in purpose built flats (apartments), while a further 13% (36 deaths) happened in converted flats. 22% of deaths (62 fatalities) occurred in terraced houses, while 13% (37 fatalities) took place in semi-detached houses. In comparison, relatively few fatalities due to unintentional fires (4 deaths) occurred in detached houses.

A comparison between the numbers of unintentional dwelling fire deaths in each type of dwelling and the number of such dwellings in the Greater London Authority area [3] suggests that there were a relatively high number of deaths in purpose built flats in relation to the number of such dwellings (Fig. 20). Similarly, there were comparatively few deaths in detached houses in relation to the number of such houses. These observations are confirmed by the annual unintentional fire death rates found for each dwelling type, listed in Table 12. The death rate for purpose built flats, at 2.67 deaths per 100,000 dwellings per year is significantly higher than that found for the other dwelling types, while the death rate for detached houses, at 0.54 deaths per 100,000 dwellings per year is relatively low. These results could also have a social significance, since the dwelling type could be considered a de facto measure of the relative affluence of the victim (i.e. a greater number of flats are located in the more socially deprived areas of London).

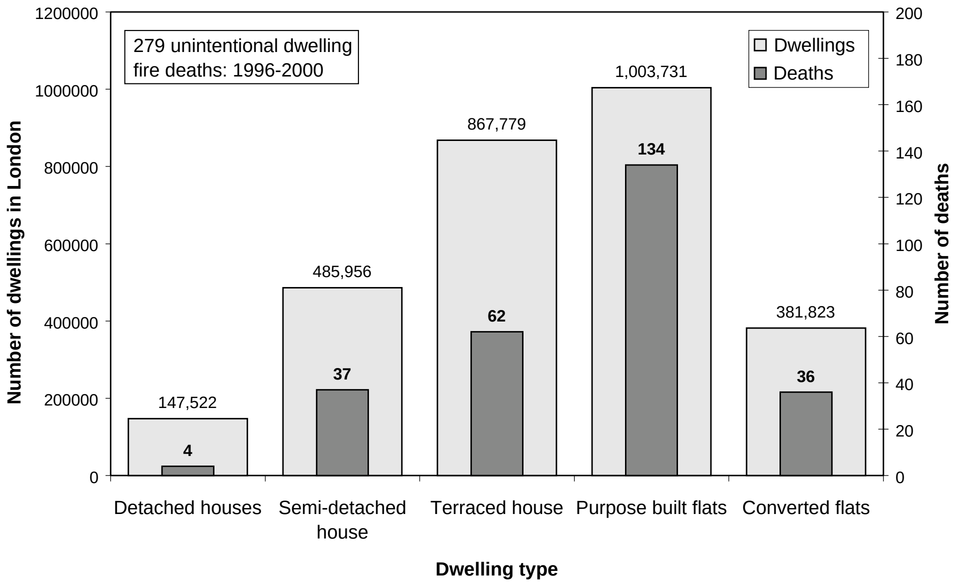

Fig. 20. Comparison between the number of unintentional dwelling fire deaths and the number of dwellings of each type in London.

Table 12
Annual unintentional fire death rate for different types of dwelling

Dwelling type	Annual fire death rate per 100,000 dwellings per year[a]
Detached houses	0.54
Semi-detached house	1.52
Terraced house	1.43
Purpose built flats	2.67
Converted flats	1.89

[a] Number of dwellings based on 1991 Census data, Office for National Statistics.

4.3. Relationship between social deprivation and the death rate from unintentional dwelling fires

The UK Department of the Environment, Transport and the Regions (DETR) has developed an index to measure the relative levels of local deprivation across the 354 local authority districts of England which includes the 33 local authority administrative areas (boroughs) of Greater London. The index compiled in 1998 was based upon 12 indicators covering unemployment, low income, health, education, crime and housing [4]. Fig. 21 shows the results of plotting the unintentional dwelling fire death rate against the DETR deprivation index for each of the London boroughs. The plot and calculated correlation coefficient, R, value of 0.54, suggests that a moderate degree of correlation exists between the level of the

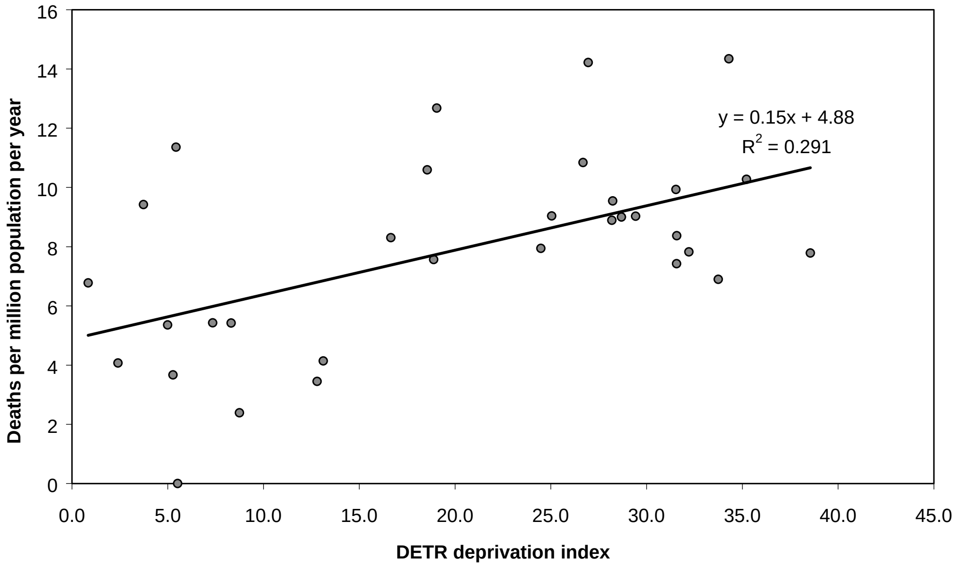

Fig. 21. Plot of the death rate from unintentional dwelling fires against the DETR deprivation index for each London Borough.

deprivation and the rate of unintentional dwelling fire death as expressed by the fitted linear regression line. Of course each borough represents a mixture of socio-economic types and the deprivation provides only an average broad-brush measure of deprivation across the borough as a whole. It would, therefore, seem likely that a higher degree of correlation might be attained if deprivation and fire death rate were to be compared over a more local area scale.

To test this, the analysis was extended to the smaller area "electoral ward" level using an approach similar to that used by Duncanson et al. in New Zealand [5]. Each of the local authority administrative areas (boroughs) of Greater London is divided into a number of electoral wards (containing a median of 9200 people). On the basis of a ranking by the ward-level index of multiple deprivation score (in this case using the updated DETR deprivation index compiled in 2000 [6]) each of the London wards were assigned into ten deprivation deciles, with the scale running from 1 to 10. Thus, a value of 10 indicates that a ward is in the most deprived 10% of wards in London, while a value of 1 indicates that a ward is in the least deprived 10% of wards in the capital.

Table 13 shows the number of unintentional dwelling fire deaths that occurred in London between 1996 and 2000 at each (ward-level) decile of social deprivation and indicates that the number of deaths is higher in the more socially deprived areas. While 30% of these deaths occurred in the most deprived 20% of wards only 11% of the fatalities occurred in the least deprived 20%.

The annual death rate from unintentional dwelling fires (pmp per year) for each ward-level deprivation decile were calculating by scaling the number of deaths by the

Table 13
Number and percentage of unintentional dwelling fire deaths occurring in London 1996–2000 at each ward-level decile of social deprivation

Ward-level decile of deprivation	Number of fire deaths (%)[a]
1	16 (6%)
2	15 (5%)
3	26 (9%)
4	20 (7%)
5	22 (8%)
6	25 (9%)
7	34 (12%)
8	37 (13%)
9	43 (15%)
10	41 (15%)
Total	279

[a] Percentages do not add to 100% due to rounding.

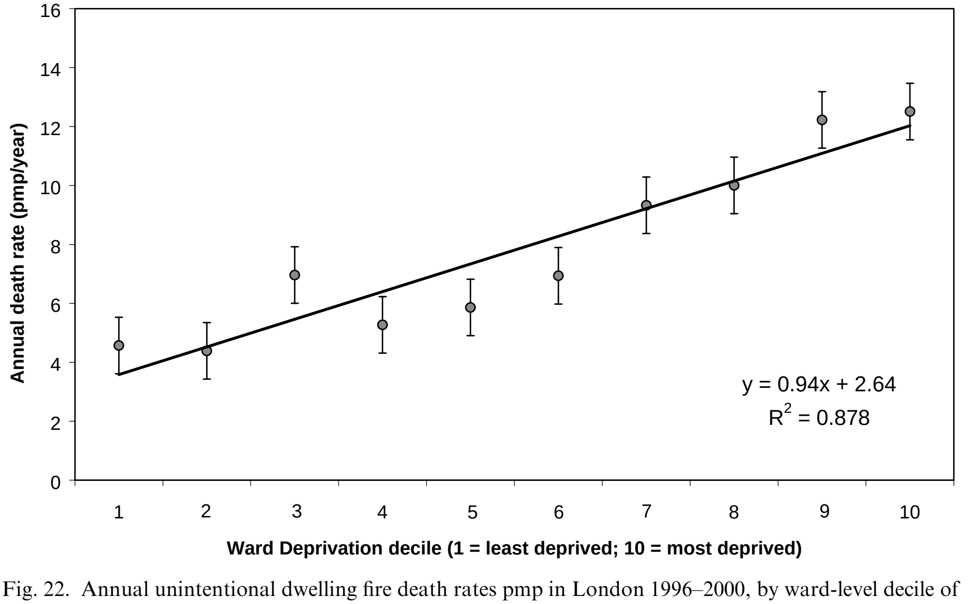

Fig. 22. Annual unintentional dwelling fire death rates pmp in London 1996–2000, by ward-level decile of social deprivation.

total population in the wards at each level of deprivation (found by using the Oxford University population estimates for wards in England, mid-1998 [7]). Fig. 22 shows the results of plotting the unintentional dwelling fire death rate against the ward-level decile of deprivation. The unintentional dwelling fire death rate clearly increases significantly with increasing social deprivation decile. The calculated correlation coefficient, R, value of 0.94 also confirms that a high degree of correlation exists between the deprivation decile and unintentional dwelling fire death rate at ward-level.

A measure of the relative risk of death due to unintentional dwelling fires at different deprivation levels can be calculated by finding the ratio between the rate at a given level of deprivation and the rate in the least deprived decile. Thus, the relative risk between the tenth (ward-level) decile of deprivation and the least deprived (ward-level) decile was 2.7, with 95% confidence intervals between 1.5 and 4.9 (RR 2.7; 95% CI 1.5–4.9). The relative risk between the ninth (ward-level) decile of deprivation and the least deprived (ward-level) decile was also 2.7, with 95% confidence intervals between 1.5 and 4.8 (RR 2.7; 95% CI 1.5–4.8). Since this confidence interval does not include the value 1, the increased risk of death due to unintentional dwelling fires shown by the two most deprived ward-level deciles is statistically significant and unlikely to have occurred by chance.

5. Discussion

5.1. Comparisons between death rates from different sources of injury

Table 14 shows a comparison between the annual death rates (pmp) resulting from unintentional fatal dwelling fires and other common sources of unintentional fatal injury in the UK. The table also gives the annual number of deaths and the chance of dying (per year) from injuries inflicted by a given source.

The annual death rate from all fires in London, at 12 pmp, was almost identical to that found for fire deaths in UK as a whole (11 pmp for 1998), while the annual

Table 14
Death rate and chance of dying from selected sources of unintentional injury in the UK

Source of unintentional fatal injury	Number of deaths (per year)	Annual death rate (pmp)	Chance of dying (per year)
Fire (London)[a]	84	12	1 in 86,000
Fire (UK)[b]	668	11	1 in 91,000
Unintentional dwelling fire (London)[a]	56	8	1 in 128,000
Vehicle crashes (UK)[c]	3599	60	1 in 17,000
Fatal falls (UK)[d]	1925	32	1 in 31,000
Railway crashes (UK)[e]	33	0.6	1 in 1,800,000

[a] Based on RFL data for London: 1996–2000 and using the 5 year average for annualised figures.

[b] Home Office Fire Statistics UK, 1998 data.

[c] Department of the Environment, Transport and the Regions: "Road Accidents Great Britain: 1997 The Casualty Report".

[d] Department of Trade and Industry: "Avoiding slips, trips and broken hips—accidental falls in the home". DTI 2000. Annualised figures based on average over 3-year period 1995–1997.

[e] Department of the Environment, Transport and the Regions: "Railway accident casualties by type of accident, 1999/2000".

death rate due to unintentional dwelling fires in London was 8 pmp. In comparison, the chances of dying in either a vehicle crash or fatal fall were both significantly higher. However, the chances of dying in an unintentional dwelling fire were still 10 times higher than those of dying in a railway crash.

5.2. Comparisons with other data

A large number of international studies into fatal fires have been undertaken. Some comparison between the results found for London and for these other studies will now be drawn.

5.2.1. Smoking

A third of *all* the fatal fires (127 fires = 33%, $n = 381$) and nearly half of the fatal unintentional fires that occurred in dwellings (121 fires = 47%, $n = 259$) investigated in London were started by smoking materials (cigarette, cigars or tobacco). Many other international studies have identified smoking as the most common cause of fatal fires. For example:

(i) In Denmark, 51% of fatal unintentional house fires were caused by tobacco smoking. Fires caused by smoking materials also accounted for most of the five-fold increase in the number of fatal fires that had occurred in the previous 30 years [8].
(ii) In a UK study, the most common cause of fatal fires was found to be smoking materials (41% of *all* fatal fires in the sample), in the majority of cases igniting upholstery and soft furnishings and bedding material [9].
(iii) In the State of Victoria, Australia, Brennan [10] found that the primary cause of the unintentional fatal residential fires in the sample studied was smoking related, often involving the careless disposal of cigarettes (42% of cases).

Smoking materials have also been identified as the leading cause of unintentional home fire deaths in the USA [11]. A study made by the NFPA, found that nearly 25% of all of the fire fatalities in the United States in 1995 were caused by inappropriate use or disposal of smoking materials [12]. Baker [13] also observed that cigarettes were the leading cause of residential fatal fires in the USA, causing twice as many deaths as the next most important cause. In a study made in North Carolina (USA), Runyan et al. [14] observed that ignition by smoking materials occurred five times more frequently in fatal residential fires than in non-fatal residential fires. Ballard et al. [15] compared fatal and non-fatal unintentional fire injuries in Washington State (USA) and concluded that smoking was an important underlying risk factor, producing an increased likelihood of fire injury in households whose occupants were smokers.

Why should smoking be the most common cause of fatal fires? By their very nature cigarettes are a ready ignition source, particularly if not handled carefully or if incorrectly disposed. They can also smoulder unnoticed on a sofa or chair while the occupants go to sleep, subsequently producing toxic carbon monoxide and/or making the transition into a flaming fire with potentially fatal consequences.

5.2.2. Candles

Nearly 6% of *all* the fatal fires (22 fires, $n = 381$) and 8% of the fatal unintentional fires that occurred in dwellings (21 fires, $n = 259$) investigated in London were started by candles. Candles were also found to be a relatively common source of fatal fires in Denmark where they caused 9% of fatal unintentional house fires [8]. Similarly in Victoria, Australia, 7% of the unintentional residential fatal fires were caused by candles (5 out of 74 incidents, where the cause was known) [10].

However, candles were less commonly cited as a source of ignition of fatal fires in other studies. For example in the UK, candles accounted for only 2% (7 fires) of the 381 fatal fires in the sample examined by Geering between 1994 and 1995 [9].

These differences may be attributable to a growing trend in candles being used as a lifestyle product in the UK. Greater awareness of the problem has also lead to a more thorough investigation of fires that might previously have been attributed to a defective appliance (e.g. television), but which were in fact due to a candle being placed directly on top of the appliance casing [16]. Fires resulting from night-light candles being placed directly onto television sets are also less common in the United States and Japan because the television casings used there contain halogen additives that inhibit ignition. These cannot be used in Europe because of waste disposal regulations.

Such candle fires typically occur because a candle has been left unattended, been used incorrectly (e.g. placed directly on an unsuitable surface such as plastic television top or acrylic bath) or because a manufacturing defect has caused the candle to burn abnormally.

5.2.3. Electrical faults and defects

Only 3% of the fatal unintentional fires that occurred in dwellings (7 fires, $n = 259$) investigated in London were due to electrical faults or defects. Similarly in Denmark, Leth [8] found that most of the fatal unintentional house fires were caused as a result of human error with only 4% being caused by technical malfunctions, while in the State of New Jersey (USA), only 3% of the fatal house fires in the sample (4 fires, $n = 148$) were caused through electrical faults [17].

However, some other studies have found electrical faults to be a more common (higher proportion) source of fatal fires. Brennan [10] found that malfunctioning electrical appliances and other electrical faults were responsible for 14% of the unintentional residential fatal fires sampled in the State of Victoria, Australia. In the UK sample examined by Geering [9], 8% of all the fatal fires (29 fires) were attributed to electrical faults. Nearly half of these (14 fires) were due to electric blankets, while in comparison in London there was only one fatal fire investigated in the 5 year period examined that was caused by an electric blanket. It is possible that this may reflect the positive effect of recent safety campaigns in the UK warning against the dangers of leaving electric blankets on overnight, the introduction of more modern designs of blanket with safety features providing a thermal cut-out in the event of a fault developing and the greater use of over-blankets which are not subjected to so much 'wear and tear' as under-blanket models.

5.2.4. Children playing with fire

Only 3% of the fatal unintentional fires that occurred in dwellings (9 fires, $n = 259$) investigated in London were started by children playing with fire (i.e. matches and lighters), resulting in 10 deaths.

Some other studies have also found that children playing with fire were responsible for only a relatively small proportion of fatal fires. For example, Brennan [10] found that only four unintentional residential fatal fires, where the cause was known (5% of the sample), were started by an unsupervised child playing with fire in Victoria, Australia (although these four fires were responsible for 12 fatalities). In the UK, Geering [9] also concluded that fires started by children "did not account for a significant proportion of the sample" comprising just 4% of fatal fires.

However, such fires are of greater significance if the age of the victims is taken into account. In London, eight of the victims of fires started by children playing were under 5 years old, making it the leading cause of unintentional fatal dwelling fire deaths for children in this age range (i.e. causing 44% of fire deaths involving children aged 0–4 years old). Squires and Busuttil [18] who examined 168 child deaths in 118 house fires in Scotland between 1980 and 1990 also found that in the 0–5 years age group, a high percentage of the deaths (40%) occurred in fires started as a direct result of the actions of children.

In contrast, studies in the USA have attributed a higher proportion of fatal fires to children playing with fire. In New Jersey (USA), Barillo and Goode [17] found that 7% of the fatal house fires (where the cause was known) were started by children, in most cases playing with matches or lighters and it has been estimated that children playing with fire may cause up to 10% of fatal house fires in USA [19]. It is also the sixth highest cause of fire death in the USA and the leading cause of fire death involving those under the age of 6 years [20].

Such incidents have been linked to increases in the number of single parent families and the consequent problems in supervision: "Children of lone mothers have especially high death rates in the UK with injuries accounting for 60% of the deaths of these children." [21]

5.2.5. The very young and elderly

Over half of the fatal unintentional fire death victims in London were aged over 65 years old. There was also a relatively high number of deaths involving infants' aged less than 5 years (7% of victims). The annual death rate due to an unintentional dwelling fire in London also increases significantly with age. In comparison with the average (for the London populace as a whole) the annual death rate was twice as high for those aged between 60 and 79 years and around seven times as high for persons aged 80 years or more.

The very young and elderly have also been identified as high-risk, vulnerable groups in a number of other international studies. For example:

(i) In Denmark almost half of the victims were over the age of 65 years, while 6% were children under the age of 5 years [8].

(ii) In Japan almost half (48%) of the total residential fire death victims were aged 65 years or older, while 9% of victims were aged 5 years or younger [22].
(iii) In the state of Victoria, Australia, 10% of unintentional residential fire fatalities in the sample examined were children aged 0–4 years while 41% were aged 65 years or above [10].

Children and the elderly also represented a disproportionate percentage of fatal fire victims in the New Jersey (USA) sample examined by Barillo and Goode [17]. However, in this case, a far greater proportion of the fatal fire victims in New Jersey (nearly 22%) were aged 10 years or under than in London (7%, $n = 418$). This difference is reflected in the fire fatality rate (based upon *all* fatal fires) for under eleven's which in New Jersey (using 1990 census data) was approximately 20 pmp per year compared to a much lower rate of around 6 pmp per year found for London. On the other hand, only around 18% of fatal fire victims in New Jersey were aged 70 years or above in comparison to 43% in London. In this case, the corresponding fire fatality rate for the over 70s in New Jersey was approximately 25 pmp per year compared to a higher rate of around 32 pmp per year for London.

A survey by the NFPA in the USA found similar results, reporting that while children aged five and under made up 9% of the country's population, they accounted for 19% of home fire deaths and that youngsters faced twice the risk of the general population [11]. By comparison, in London, children aged five and under also made up 9% of the population but accounted for only 7% of dwelling fire deaths.

The higher fire death rate of pre-school children in the United States compared to Japan has been noted previously by Sekizawa [22], and would also appear to be true in comparison to other countries in Western Europe and Australia. Fahy [23] has suggested that the higher rate found in the USA may be at least partly attributable to a greater incidence of single parent families in the United States resulting in more children being left either unattended or unsupervised.

The significant rise in the fire death rate with increasing old age observed in London is also comparable with that found in other studies. In Japan the death rate for those aged 65+ years was 4.5 times as high a risk as the average (for the population as a whole), while those aged 75+ years were eight times as high a risk than average [22]. Similarly, in the USA the fire death rate of 65+ years olds was twice that of the national average, rising to three times the average for the 75+ years and four times the average for the 85+ years age groups [24].

Why are so many of the unintentional dwelling fire death victims elderly? The elderly tend to be more accident prone, being both more likely to start a fire and be in close proximity to it. They often suffer from infirmity or disability, have slower reactions and are less likely to be able to escape from a fire unassisted. They are also more likely to succumb to smoke inhalation and burn injuries and less able to cope with shock. The effect of age on life expectancy is illustrated by the Baux formula which states that if the victim's age added to the percentage body burns exceeds 100 the chances of their survival are low [25].

5.2.6. Fire deaths incidence by timing of fire

When taken together the starting times of the fatal fires investigated in London were relatively evenly distributed over the course of the day, with roughly equal numbers occurring during both the night and day.

The UK sample of fatal fires examined by Geering [9] shows a broadly similar pattern to London, but with a higher percentage of fires occurring during the morning from 6 am to Midday (32% compared to 23% in London). There were also a lower percentage in the afternoon from Midday to 6 pm (19% compared to 25% in London) and evening from 6 pm to Midnight (21% compared to 28% in London).

However, some other international studies have found that fatal fires start more frequently during the night. In New Jersey, the majority (51%) of fatal fires had an onset time between the hours of 11 pm and 7 am compared to only a third (32%, $n = 381$) of the fatal fires in London [17]. Similarly, an NFPA study in the USA also found that half of all fatal fires in the home were reported between 10 pm and 6 am compared with 41% (131, $n = 322$) of fatal dwelling fires in London [11]. Elsewhere, in the State of Victoria, Australia, 81% of the unintentional fatal residential fires in the sample started at 'night' between the hours of 8 pm and 8 am [10]. By comparison, only around half (48% = 125, $n = 259$) of the unintentional fatal dwelling fires investigated in London occurred between 8 pm and 8 am.

One possible explanation for these differences could be due to variations in the proportion of fire death victims belonging to vulnerable groups. In Japan, Sekizawa [22] has identified two fire death patterns, based upon the time of day when the fire occurred: 'vulnerable' groups, i.e. elderly, disabled or infants dying in day-time fires (in many cases where the victim was left alone) and other 'non-vulnerable' groups perishing through fires occurring during the night. These patterns are also apparent in the London data, with a higher frequency of victims in the more vulnerable 0–4 years and 80+ years age groups resulting from fires occurring during the day-time, (the 60–79 years age group is split roughly 50–50 between day and night) and other age groups showing more fire deaths during the night-time. As a result when the two groups are taken together they even out producing broadly similar numbers during the day and night. However, the USA and Australia samples have a lower proportion of fires involving the elderly than London and so as a result the 'non-vulnerable' groups pattern may be more dominant, giving rise to a higher percentage of night-time fires.

Nearly half (49% = 126, $n = 259$) of the fatal unintentional dwelling fires investigated in London occurred during the winter months (November–February). Other studies have shown a similar seasonal variation in the number of fire fatalities. In the UK the sample of fatal fires examined by Geering [9] had a higher number of fatal fires during the winter (although some fluctuations were apparent perhaps as a consequence of only using data for a single year). Similarly, the fatal fire death rate in Denmark was highest in the winter months [8]. In New Jersey (USA) fatal fires were also found to be more common during the winter months, reflecting an increased use of central or portable heating systems [17].

In the USA as a whole, Hall [11] found that most home fire deaths occurred in the winter months of December–February. He also found that smoking and heating equipment caused a similar share of fatal fires during these months. By way of comparison, although the majority of unintentional fatal dwelling fires caused by heating appliances in London occurred during the winter, these were still far fewer in number than those started by smoking materials in the same period.

The increase in the number of deaths during the winter can be attributed to people spending more time inside during the colder and wetter winter months, possibly with higher smoking and drinking levels. Usage of cooking and particularly heating appliances would be higher at this time of year. It is also possible that hospitalised victims (particularly the elderly) would be more vulnerable to infection and less likely to survive during the winter months.

5.2.7. *Living alone*

At least one-third of all the victims of fatal unintentional dwelling fires that were investigated in London lived alone or was alone at the time of the fire. Similar findings have been made by some other studies. In Denmark, Leth et al. [8] observed that most (57%) victims of fatal unintentional fires lived alone. Sekizawa [22] also found that more than half of the residential fire death victims were living alone or had been left alone at the time of the fire in Japan.

Why? Persons living alone would be less likely to discover a fire and have no one else on hand to raise the alarm or help him or her to escape.

5.2.8. *Disability, ill health or mental illness*

At least 21% of the victims of unintentional dwelling fire deaths in London were reported as suffering from some form of disability or infirmity, while at least 6% of the victims were suffering through ill health and a further 5% had some form of mental illness. As would be expected, the majority of those victims suffering from disability were elderly while at least a third of the elderly unintentional fatal dwelling fire victims in London (aged 60+ years) suffered from some form of disability.

Other international studies have also found that disability is a significant risk factor in fatal fires. In Denmark, Leth et al [8] found that approximately one-fifth of the victims of fatal unintentional fires received disablement pensions, while two-thirds (66%) of the elderly victims (aged over 66 years) were disabled. In Japan, Sekizawa [22] found that elderly bedridden persons aged 65 years or above had over 40 times the average residential fire death rate of the general population, while handicapped persons showed five times the average death rate. Runyan et al. [14] also found that 21% of fatal fires involved disabled person's in North Carolina (USA).

Why? As a consequence of disability, infirmity or illness a person would find much greater difficulty in escaping in the event of fire. In many cases the disabled are also restricted to spending their time in a bed, or chair, making ignition by cigarettes more likely. Those suffering from mental illness might also be more likely to start a fire or have problems in escaping.

5.2.9. Alcohol

Nearly a quarter (65, $n = 279$) of *all* of the unintentional dwelling fire death victims in London and 40% (65, $n = 162$) of those tested for alcohol, were intoxicated (i.e. had blood alcohol concentrations in excess of the legal UK driving limit of 80 mg/100 ml). Furthermore, almost a quarter (24% = 39, $n = 162$) of those victims that were tested, were *highly* intoxicated at the time of the fire, with concentrations in excess of 200 mg/100 ml. Other international studies have also made similar findings and identified alcohol as an important risk factor in fatal fires. For example, in Denmark, 35% of *all* the unintentional fire victims were intoxicated at the time of the fire, while 26% were chronic alcoholics [8]. Similarly in Japan, Sekizawa noted that around 20% of *all* the residential fire death victims were drunk at the time of the fire. In North Carolina, USA, Runyan et al. [14] concluded that the risk of death was greatest in those fires involving alcohol-impaired persons, while in a subsequent study Marshall et al. [1998] found that 53% of the adult fatal fire victims who had their blood alcohol measured were intoxicated (i.e. more than 100 mg/100 ml).

In the state of Victoria, Australia, about 70% of the unintentional residential fire death victims aged 18–74 years, and around half of those aged over 75 years in the sample examined by Brennan were tested for the presence of alcohol [10]. Around half of those victims tested were intoxicated, with blood alcohol concentrations in excess of 100 mg/100 ml. Almost three-quarters (74%) of the intoxicated victims were male while males in their early 20s and 40–50 years of age were shown to be particularly at risk. By comparison in London, 60% of the intoxicated victims' were male, while 66% (10, $n = 15$) of the male victims' tested in the 20–39 years age group and 74% (14, $n = 19$) in the 40–59 years age group were intoxicated. Brennan also found that drinking was not a factor in the fires involving victims aged over 75 years. Elder et al. [26] examining fatal dwelling-house fires in Scotland between 1980 and 1990 reported similar results, concluding that compared to victims under 75, those aged over 75 years were significantly less likely to have alcohol detected in their blood. Once again London shows a similar pattern with only 15% (5, $n = 34$) of the elderly victims aged 80+ years that were tested being found to be intoxicated.

Why? Alcohol intoxication impedes decision making, reduces the ability to move and prevents waking, delaying effective escape in the event of fire. It can also impair judgement making a fire more likely, e.g. smoking whilst under the influence and subsequently falling asleep or carelessly disposing of the cigarette, leaving cooking unattended, etc.

5.2.10. Smoke alarm

Based upon the case where it was recorded nearly 80% (131, $n = 171$) of unintentional dwelling fire deaths investigated in London occurred in dwellings that were not fitted with a smoke alarm. In a third of those deaths where an alarm was fitted, it failed to operate due to a missing or flat battery (14, $n = 40$). Other studies have found similar results. In the UK, Geering [9] found that 57% of the households in the sample examined did not have a working smoke alarm and when one was found almost half did not work most often due to missing or flat batteries.

Strathclyde Fire Brigade reported that in 80% of fatal fire incidents occurring in Glasgow between 1991 and 1992 a smoke alarm was either not fitted or not working [27], while a smoke alarm operated in just five of the 94 fatal unintentional dwelling fires in sample studied by Brennan [10] in Victoria, Australia.

These results are consistent with other studies that have suggested that fatal fires are less likely to occur in dwellings that are fitted with an operational smoke alarm. In the USA, Hall [28] found that smoke alarms reduced the risk of death by 40% and that in one-third of homes fitted with smoke detectors that reported fires the detectors did not work. Similarly, in North Carolina (USA), Marshall et al. [29] observed that there was a significantly decreased risk of dying in a home fitted with a functioning smoke detector.

5.2.11. Social deprivation

The data suggests that even at the broader borough level in London, a degree of correlation exists, between the level of social deprivation and the death rate due to unintentional fires in dwellings, while a strong correlation was found between the deprivation decile and unintentional dwelling fire death rate at ward-level in London. It was also reflected in the annual unintentional dwelling fire death rate in the most deprived (ward-level) decile of social deprivation being observed to be significantly higher than the rate in the least deprived decile (RR 2.7; 95% CI 1.5–4.9).

Other international studies have also found evidence of an association between the level of social deprivation and the incidence of fatal fires [5,30]. For example, in the UK, Roberts has observed that the risk of fire is strongly related to the type of housing with the risk being greatest to those living in the poorest council houses or temporary accommodation [31]. Roberts and Power have also noted that house fire deaths exhibit the greatest social economic gradient of any cause with children in social class V (the most deprived) being 16 times more likely to be killed by fire than those in social class I (the least deprived) [32].

In the USA, based upon a study in Baltimore, Mierley and Baker [33] found that the ‘‘fire death rates were highest in census areas where property rental values were low’’ and that ‘‘socio-economic factors are amongst the best predictors of fire rates at the neighbourhood level’’. Similarly in the State of Washington, Ballard et al. [15] reported that households experiencing fires generally had lower incomes and were frequently less well educated. In Toledo, OH, Gunther [34] found that ‘‘fire rates for children playing were 14 times higher in the low-income inner city than in the high-income tracts and that smoking causes were over eight times higher in the inner-city areas.

Duncanson et al. [5] made a detailed study of the relationship between socio-economic deprivation and fatal unintentional domestic fire incidents in Aotearoa, New Zealand (1993–1998). A deprivation score is available for each census meshblock (a geographical unit containing a median of 90 people) in New Zealand, providing a measure of socio-economic deprivation at a small area level. The scale runs from 1 to 10 with a value of 10 indicating that the meshblock belongs to the most deprived 10% of areas in New Zealand, and a value of 1 indicating that the meshblock belongs to the least deprived 10%. Comparing rates of fatal incidents at each level of deprivation, they found that the annual rates of fatal unintentional fire incidents in the most deprived decile of social deprivation were significantly higher than rates in the least deprived decile (RR 5.6 95% CI 1.9–16). These results show a similar pattern to those found for the analysis of ward-level deprivation deciles in London, although the magnitude of the rate ratio between the highest and lowest decile would appear to be higher in New Zealand. This could be at least partly attributable to the analysis in New Zealand being performed at a finer area scale (i.e. ward-level with a median of 9000 persons in London versus meshblock level with a median of 90 persons in New Zealand).

Why? The correlation is probably a reflection of the association between social deprivation and other high-risk factors, e.g. low income and elderly, physically disabled, ill, mentally ill, prevalence of smoking and drinking, etc. Those with low income are also more likely to engage in higher-risk activities, e.g. in the winter old people who either cannot afford a central heating system at all or cannot afford to heat the whole house, might instead use a space heater to heat just a single room

5.3. Prevention of unintentional dwelling fire deaths

From the results of the analysis of fatal fires it is clear that many of the same factors emerge repeatedly, time after time and that a number of vulnerable, high-risk groups can be identified (e.g. smokers, very young, elderly, etc.). In order to reduce the number of unintentional dwelling fire death in the future fire prevention strategies need to target these vulnerable groups and the circumstances most likely to result in a fatal fires occurring.

5.3.1. Smoking

Smoking materials were responsible for causing the majority of unintentional fire deaths that occurred in dwellings, for all age groups, most commonly as a result of careless disposal and igniting bedclothes or upholstered furniture. There are a number of measures that could be used to try to prevent such deaths.

One possibility is the use of advertising campaigns warning against the dangers of fires caused by smoking, particularly under the influence of alcohol. Unfortunately, such campaigns can be difficult to target and are often ignored by those most at risk.

Almond [35] relates that in the UK, surveys showed that while broad based advertising campaigns were readily taken up by those who needed them least, the elderly and low-income groups were far less likely to adopt the measures (“Fire safety advice is most often ignored by those who need it most”).

The use of smoking-aprons, particularly by the elderly, bedridden and infirm could also prevent cigarettes igniting clothing and furniture, but again may prove difficult to implement in practice.

In the UK much effort has focused on reducing the flammability of furniture, mattresses and clothing (e.g. fire retardant foams in furniture have been compulsory since 1992). However, there are limits to what such programmes can achieve with many households still containing older, unmodified furniture (i.e. over 10 years old) especially those in the more socially deprived areas and amongst the most vulnerable groups.

Perhaps the measure with the greatest potential for reducing the number of smoking related fire deaths would be the introduction of *fire-safe* cigarettes [36]. Fire-safe cigarettes have a reduced propensity for starting a fire when carelessly discarded or left unattended and will either go out quickly when set down or will not generate enough energy to cause a fire. By changing the manufacture of the cigarette including using less dense tobacco, reducing the cigarette diameter or reducing the porosity of the cigarette wrapper, a fire-safe design with self-extinguishing properties can be achieved. The technology to produce fire-safe cigarette designs has existed for at least 10 years, but tobacco manufacturers have been reluctant to introduce them because of development costs, lack of an accepted testing standard, possible loss of market share and risk of admitting legal liability for past cigarette fire-related injuries and fatalities [37].

In 2000, New York State passed the USA's first law requiring the establishment of a fire-safety standard such that all cigarettes sold in the state must pass a fire-safety code, while a fire-safe cigarette act has also been proposed at a national level in the USA. A Bill has also been introduced into the New Zealand Parliament seeking a fire-safety standard for cigarettes. However, currently no such legislation is planned in the UK.

In response to legislative requirements one major tobacco manufacturer has developed cigarettes that are less likely to ignite certain fabrics than conventional types. By using rings of ultra-thin paper applied on top of traditional cigarette paper which act as "speed-bumps" to slow down the rate of burning, the cigarette will be more likely to extinguish if left unattended. Once again while the technology is being made available for the US and New Zealand markets there are currently no plans to introduce it into the UK.

5.3.2. The elderly

The results show that the elderly, especially those living alone and suffering from physical disability, infirmity or mental illnesses were particularly at risk of dying in an unintentional dwelling fire. Such fire deaths were concentrated during the day, reaching a peak over lunchtime (for victims' aged 80+ years) and during the evening (among victims' aged 60–79 years). The fatalities in this age group also frequently involved smoking materials, heating and cooking appliances (often igniting items of clothing) and primarily occurred during the winter months. While alcohol intoxication was an important factor in many of the deaths involving victims aged between 60 and 79 years, few of the very elderly victims aged 80+ years were intoxicated at the time of the fire.

The increasing elderly population in London as elsewhere means that this problem is of growing concern. One possible initiative to reduce the number of such deaths would be community programmes distributing and arranging visits by fire-safety officers to highlight the dangers of fire to the elderly (such as wearing loose fitting clothing while cooking or getting too close to heating equipment). It is also important to target any carers or helpers the elderly person may have, to help communicate the potential fire risks. Other possible initiatives could include ''neighbourhood watch'' of potential victims, particularly in the winter months (e.g. fire-stoppers who check on old people) and issuing personal alarms to potential victims (linked to a central monitoring point) designed to indicate the presence of any fire problem.

5.3.3. The very young

Many of the deaths involving the very young were started as a consequence of children playing with fire. Such results highlight the importance of keeping lighters and matches out of the reach of children and indicate problems with child supervision, especially around breakfast, lunch and dinner times when the parent may be occupied with food preparation and other activities. Possible preventive measures could include legislation on childproof matchboxes and restrictions on very cheap plastic lighters. The UK Department of trade and Industry has conducted research into child-resistant matchboxes and warning labels on match boxes [38]. They concluded such containers were not a viable proposition in the short term, but have developed a new warning label. Work is also in progress to develop a European Standard for child-resistant cigarette lighters based on US Federal Regulations [39].

5.3.4. Other adults

Apart from smoking materials, fatal unintentional dwelling fires with young or middle aged adult victims (particularly those aged 20–39 years) also commonly involved candles or cooking appliances (typically left unattended). The majority of fires claiming victims in this age range occurred during the early hours of the morning. A significant number of the victims belonging to this age group were unemployed. Many of the victims (especially males) were also intoxicated by alcohol at the time of the fire.

To try to reduce the number of such deaths candles could be tested to assure that sufficient design and manufacturing standards are being met and guidance to their safe usage could be placed on the outer packaging or on warning labels attached to the candle. Carefully targeted advertising campaigns highlighting the risk of fires caused by smoking, candles and leaving cooking appliances unattended, particularly whilst the user could be under the influence of alcohol might also be considered, but would be subject to the same difficulties in reaching those most at risk as mentioned previously.

5.3.5. Smoke alarms

The majority of unintentional fatal fires occurred in dwellings that were not fitted with a smoke alarm. It seems likely that at least some of these deaths might have been prevented if a functioning smoke alarm had been present and had detected the fire.

In the UK, campaigns to get smoke alarms fitted have met with a measure of success and it is estimated that around 80% of household own a smoke alarm [40].

However, other research has shown that smoke alarm ownership is substantially lower in disadvantaged inner-city neighbourhoods and among families living in rented accommodation where it is less than 50% [41,42].

The results suggest that ways need to be found of increasing the number of smoke alarms fitted, particularly in the homes of persons belonging to high-risk groups such as smokers, drinkers, the elderly, families with young children and those living in the most socially deprived areas. Some community programmes that have given away smoke alarms free in the UK, in parts of London and the West Midlands, have produced encouraging results, increasing the number of functioning alarms installed in high-risk households and reducing the number of fire-related injuries [43–45].

In common with the findings of other studies a worrying trend that has been identified is the number of smoke alarms not operating due to a battery being either flat or having been removed. To try to combat the problem of flat batteries many fire brigades have tried to encourage people to test batteries every month and change them regularly once a year, (perhaps synchronised with an event such as the clocks going forward). However, this relies on people being either sufficiently motivated or simply remembering to take such action. In some cases it would be better to place responsibility with the local landlord or councils for maintaining an operational smoke alarm. It has also been suggested that insurance companies could offer incentives for having an operational smoke alarm fitted. One innovative solution to the problem that has been developed is a smoke alarm equipped with a rechargeable battery, which can be inserted into a light fitting between the socket and the light bulb [46]. To keep the alarm functioning only requires the light be used for a few minutes each week. Detectors with extended-life batteries (lasting up to 10 years) have also been developed. Ultimately, the installation of mains operated alarms, with a backup battery system would probably be a better option, but would be more expensive and may only be practical for new and recently renovated properties.

In a number of instances, smoke alarm batteries have been removed because of repeated nuisance alarms, typically due to smoke from cooking in the kitchen. To try to prevent this problem from occurring, newer alarm systems have been developed that are fitted with a reset or “hush button” that can be pushed in the event of a nuisance alarm to temporarily disable the sounder. However, Berger and Kuklinski [47] cite research indicating that such hush buttons may be of limited value as the inconvenience of pushing a button leads to many adults simply disconnecting the batteries or removing the detector or pushing the button even in the event of an actual fire. As an alternative, in communities where nuisance alarms are likely to be a frequent problem, they suggest the installation of photoelectric rather than ionisation smoke detectors. Such photoelectric smoke detectors are far less prone to nuisance alarms and are more sensitive to smouldering fires (such as those typically caused by smoking materials being dropped onto bedding or upholstery) but are more costly to buy and are less widely available. They also recommend that when ionisation detectors are installed, that they are situated at least 6 m, and preferably 7.5 m from cooking surfaces and at least 3 m from bathroom doors to reduce the possibility of nuisance alarms.

Even fully functional smoke alarms have their limitations. There were a number of unintentional dwelling fires where the smoke alarm did operate but the victim still failed to escape. In most of these cases the victim was disabled or infirm, intoxicated by alcohol or had an item of clothing on fire. Runyan et al. [14] found some similar results in North Carolina (USA), suggesting that smoke detectors did not reduce the fire death rate for those suffering with cognitive or physical disability. In such instances the onus must fall on trying to prevent such fires from occurring in the first place and using alarms alerting others to the presence of a fire.

5.3.6. Residential sprinklers

Residential sprinklers have great potential for reducing the number of fire deaths in dwellings and a draft British Standard for their installation has recently been developed [48]. However, such sprinkler systems have a significant installation cost and are likely to remain out of reach of those vulnerable groups that would most benefit from their use for the foreseeable future, without government intervention.

6. Conclusion

The results found for the fatal fires investigated in London are broadly consistent with the findings of a number of other international studies. Many of the same risk factors responsible for increasing the risk of death in an unintentional dwelling fire that have been identified in other studies are also apparent in London:

- Smoking,
- Elderly and very young,
- Children playing with fire,
- Living alone,
- Disability, ill health or mental illness,
- Alcohol,
- Not having a working smoke alarm,
- Social deprivation.

Of course many of these factors will have acted in combination to increase the risk of death due to an unintentional dwelling fire. The results would suggest that it is the weakest members of society—the old, the sick and disabled and those suffering from mental illness or an alcohol problem—that are most at risk of unintentional death due to fires in dwellings. The statistics confirm the perceived relationships, but point to the need to re-examine research and social objectives.

The analysis has also highlighted some important lifestyle trends, such as the use of candles as a 'lifestyle' product, the usage of drugs and medicines (particularly sleeping tablets and anti-depressants) and the incidence of alcohol intoxication in young adult male victims, which have played a role in a significant number of fatal unintentional dwelling fires.

Old people would appear to be particularly at risk. Whereas a younger person might be able to survive and recover from the burn or smoke inhalation injuries suffered in a fire it is more likely that an older person would succumb. The data also suggests that many of older fire death victims had limited mobility due to disability (either physical or mental) or infirmity increasing the likelihood that they would be unable to escape in the event of a fire.

To reduce the number of unintentional fire deaths in dwellings, prevention measures will need to be carefully targeted at the vulnerable groups identified. This task represents a considerable challenge since many of the high-risk groups represent those members of the community that are the most difficult to reach ("the hopeless and the helpless"). In order to be effective such measures will also require an inter-agency approach between the local authority services, charities and the fire brigade to help inform and protect those most at risk.

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