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Contribution of Upholstered Furniture to Residential Fire Fatalities in New Zealand

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Abstract

This report examines the features of fatal residential fire incidents involving upholstered furniture in New Zealand over the period of 1996 to 2000.

Included in this report is an analysis of the New Zealand Fire Service (NZFS) Emergency Incident Statistics from 1995 to 1999. Further investigation was also undertaken based on information from the Fire Incident Reporting System (FIRS) data from 1996 to 2000.

It was found that upholstered furniture was involved in 35.4% of all residential fire fatalities in a five-year period between 1996 to 2000. An analysis of common trends found in fatal residential fires involving upholstered furniture has also been included in this report.

It was concluded that fatal residential fire incidents involving upholstered furniture typically resulted in a single fatality even though there was usually more than one person present in the residential structure when ignition occurred. Young children, the elderly and persons intoxicated by drugs or alcohol were particularly susceptible in such fires with most occupants asleep when ignition occurred. The most common cause of death for occupants remote from the room of fire origin was smoke inhalation while for occupants within the room of fire origin, it was from severe burns or exposure to heat and smoke from the fire. Smoke detectors were not present or defective in most of these incidents. Upholstered furniture was usually not the object first ignited, meaning that it was ignited later on in the fire by means of either small flame or large flame ignition sources.

Other factors influencing fire fatalities in residential property were also discussed. Comparisons were made with similar studies done in other countries, namely the U.S., United Kingdom and Australia. Finally, conclusions were drawn from the results obtained. Recommendations and suggestions for future research were also included in this report.

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1 Introduction

1.1 Purpose of Research

Residential fire incidents dominate annual emergency incident statistics in New Zealand and around the world. Typically present in living areas, such as lounges and bedrooms, upholstered furniture is usually the most significant contributor to the fuel load present in a room or space during a fire. Its rapid growth characteristics and flame spread behaviour make upholstered furniture chiefly important when considering the fire hazard risk of residential property.

Some countries have mandatory or voluntary regulations regarding the manufacture and sale of upholstered furniture. Most of these regulations concern the relative ignitability of upholstered furniture and specify a minimum standard required in order to reduce the life-safety risk of such furniture. In New Zealand, there are at present no such regulations or standards. As such, upholstered furniture manufacturers are free to use any composition or combination of upholstery fabric and foam in the making of upholstered furniture.

The purpose of this report is to study the contribution of upholstered furniture to residential fire fatalities in New Zealand based on the information available from the Fire Incident Reporting System (FIRS), New Zealand Fire Service, Coronial Services and other relevant sources. Comparisons to similar overseas research, especially from the U.S. and United Kingdom, will be made to determine the influence of regulatory standards on fatal residential fires involving upholstered furniture. Relevant recommendations will be made based on the conclusions drawn from the outcome of this research.

1.2 General Introduction

Upholstered furniture includes upholstered chairs, sofas and two-seaters (love seats) and also upholstered transportation seating. Some literature place upholstered furniture in the generic category of 'soft furnishings', which also includes mattresses and bedding. It should be noted that mattresses and bedding share certain similar features to upholstered furniture, but are geometrically different and are typically treated separately when considering their burning characteristics (Babrauskas, 1995).

In studying the fire hazard posed by upholstered furniture, efforts were directed towards its contribution to fire fatalities in residential buildings. This would include single-family to two-family dwellings, apartments, boarding houses and other permanent dwellings with lounges and/or sleeping areas. The use of upholstered furniture in transportation seating (e.g. airplanes, cars) was not included in the scope of the research as different standards apply to these types of furniture.

Upholstered furniture is substantially represented in typical New Zealand households, especially in lounges and sleeping areas, and is likely to be the most significant piece/s of furniture in these rooms. Many of these single-family and two-family dwellings are not likely to be equipped with extensive fire safety systems, such as residential sprinklers or smoke detectors, as the installation of these systems is voluntary.

At the time of this study, upholstered furniture manufactured or imported into New Zealand are not subjected to any form of national standard for flammability or ignition resistance. As a result, manufacturers use a wide range of composition and combination of materials whose behaviour in fire is as yet fully known. However, the University of Canterbury conducts ongoing research into assessing the combustion characteristics and severity of New Zealand upholstered furniture materials; Denize (2000), Firestone (1999), and Enright (1999).

1.3 Outline of Report

This report analyses the New Zealand Fire Service Emergency Incident Statistics (NZFS, 1997; NZFS, 1999) for a five-year period starting from 1995 to 1999. Statistics obtained from this source were originally summarised from the Fire Incident Reporting System (FIRS) database. Among the features studied were all types of property involved in fire incidents; the type of residential property involved; rooms or spaces of fire origin in residential structure fire incidents; and the type of property where fatality occurred.

Further analysis was done based on the Fire Incident Reporting System (FIRS) data from 1st July, 1995 to 30th June, 2000. From this information, the following features of fatal residential fire incidents were investigated; the specific type of residential property where fatality occurred; the rooms or spaces of fire origin in fatal residential fire incidents; the object first ignited in such fires; the heat source of the initial ignition; and the supposed cause of the fire.

The degree of involvement of upholstered furniture in fatal residential fires was determined by categorising each fire incident based on the information available from various sources. Among the features of upholstered furniture fires studied were the annual proportion of residential fire fatalities involving upholstered furniture; number of fatalities per incident; number of occupants present at ignition; fatalities by age; involvement of alcohol or drugs; activity at ignition and during the fire; location of fatality at time of ignition; presence of smoke detectors; type of upholstered furniture involved; upholstered furniture - as the first or subsequent object ignited; causes of death; and levels of carboxyhemoglobin (COHb) found in the blood of these fire fatalities.

Other factors influencing fire fatalities in residential property are also discussed in this report. Comparisons were made with similar studies done in other countries, namely the U.S., United Kingdom and Australia. Finally, conclusions were drawn from the results obtained in the analysis of fire fatality statistics in New Zealand.

2 Background

2.1 Introduction

The term 'upholstered furniture' includes a wide variety of styles and models of furniture that share certain similar characteristics. When using the terminology 'upholstered furniture', this refers to full-scale, generic furniture, with a basic 'frame', padded with 'foam' and covered with 'fabric'. In New Zealand, the frame is normally made from timber; the padding foam is typically polyurethane foam while the fabric material is primarily made from synthetic materials (Enright, 2000).

2.2 Fire Scenarios

In reference to the life-safety hazard posed by the fire, there are three basic scenarios to consider:

(1) Smouldering fires, where the occupant may be in the room of fire origin or a remote location.

Smouldering fires have temperatures that rarely exceed 400°C and typically produce high yields of carbon monoxide, carbon dioxide and other combustion products (Purser, 1995). As the build-up of toxic products is slow, detection is unlikely from an occupant. There are usually no obvious cues from a smouldering fire, such as flames and dense smoke. This is even more evident if the occupant is remote from the room of fire origin and/or asleep. Therefore, the primary danger to an occupant is incapacitation due to the influence of combustion products from the fire.

(2) Early flaming fires, where the occupant is in the room of fire origin.

In the early stages of flaming fires, an occupant in the room of fire origin is usually given adequate warning from physical cues to enable safe egress. The time in which tenability limits are reached is dependant on two main factors: the behaviour of the occupant and the growth rate characteristics of the fire (Purser, 1995).

Fatalities often occur when the occupant is incapacitated in some manner that inhibits the ability to evacuate safely (Cropp, 1991). For example, incapacitation due to drugs or alcohol, narcosis due to exposure to toxic gases from the period of smouldering fire, or physical disability or inability (i.e. very young children and bedridden elderly).

In a scenario where the occupant is incapacitated, even the presence of fire safety systems, which typically operate after ignition has occurred, may not be able to adequately warn the occupant in time to facilitate a safe escape (NFPA, 1987). The primary threat to an occupant is exposure to life-threatening levels of narcotic gases, heat from the flaming fire and direct flame contact.

(3) Fully developed or post-flashover fire, where the occupant is in a remote location.

In a fully developed or post-flashover fire, large amounts of toxic gases are produced and distributed throughout the building (Purser, 1995). An occupant is likely to receive knowledge of the fire from any fire safety systems in place or from other physical cues. However, at this stage, the fire has grown to the extent that it may obstruct possible egress routes, thereby making it more difficult to exit the building safely.

If the occupant remains unaware of the fire or attempts to egress through untenable conditions, then the primary threat to the occupant is from exposure to high temperatures

(radiative and convective heat), or incapacitation due to the high concentrations of narcotic gases produced by the fire.

In all scenarios, it is apparent that the characteristics of the available fuel such as ignitability, growth rate, peak heat release rate and toxicity are inherently important in influencing the potential life-safety hazard associated with any fire. Therefore, it becomes vitally important to consider the contribution of the contents in a room to the relative severity of a fire, especially upholstered furniture. The reason for this is that upholstered furniture has become a common feature in most households – durable, comfortable, inexpensive and increasingly popular in relation to other types of furniture, such as wood, metal or leather.

2.3 Chemistry

As mentioned in Section 2.1, the foam used as padding material in most upholstered furniture manufactured in New Zealand is typically polyurethane. Polyurethanes ($CH_aO_bN_c$) do not break down chemically under ambient conditions. Decomposition occurs once temperatures exceed 475K, or 202°C (Tewarson, 1995). During a fire, when the pyrolysis temperature of the material is exceeded, hydrogen cyanide and carbon monoxide are the main products produced as a result of combustion. Other toxic products formed include nitrogen oxides, nitriles, tolylene diisocyanate (TDI) and other isocyantes (Beyler and Hirschler, 1995).

The fabric covering of upholstered furniture is primarily made from synthetic materials as noted previously in Section 2.1. The most popular combination or singular materials for fabrics are polypropylene, polyester and acrylic. Other popular fabrics include leather, vinyl and wool. 'Woollen' fabric, which contains a specified percentage of wool, has some fire retardant qualities.

In bench-scale tests performed, woollen fabric covered foam samples for longer than polypropylene fabric under the same heat exposure. While in furniture calorimeter tests, the fabric on polypropylene-covered armchairs were observed to have melted away quickly with exposure to heat; the fabric on woollen-covered armchairs resisted 'spreading' and prevented the fire from flaring as quickly (Denize, 2000).

2.4 Fire Behaviour

The fire behaviour of any upholstered furniture is influenced by the combination of foam, fabric and frame materials used in its construction. These factors influence the initial ignitability of the fabric, the rate of fire growth once flaming has begun, the peak heat release rate, its fire spread characteristics and as a consequence, its threat to the occupants present (Cleary et al., 1994).

Depending on the initial ignition source and location, the fire may begin as a flaming ignition, or as a smouldering combustion that may or may not develop into a flaming fire. Given the variability of these initial conditions, the time taken to reach the peak heat release rate for an item of upholstered furniture is considered variable.

However, it is known that once flaming takes hold, the fabric burns or melts away, exposing the padding foam. The time taken for this to occur and the fire resistant qualities of the fabric depends on the materials used. When the polyurethane foam is exposed to the flames, it melts to form a flaming pool fire. This expedites the spread of the fire as the flaming pool fire will flow from the burning item to nearby items (Denize, 2000).

Even after the fire in an upholstered furniture item has been extinguished, this does not ensure extinction as smouldering may still be going on inside the item. This characteristic of upholstered furniture fires is particularly dangerous as this smouldering may continue

and progress to a flaming fire, spreading without the knowledge of the occupant (Babrauskas and Krasny, 1991).

2.5 Smoke Inhalation

Smoke inhalation is a generic term used to describe injuries sustained by exposure to narcotic gases produced in a fire. Typically, it covers a multitude of toxic products, depending on the contents and furnishings in the residential structure at the time of the fire. However, most commonly, smoke inhalation is used to describe injuries caused by carbon monoxide poisoning.

Purser (1995) has provided a scientific term for 'smoke inhalation':

Narcosis: Literally 'sleep induction', but used in combustion toxicology to describe central nervous system depression causing reduced awareness, intoxication and reduced escape capability, leading to loss of consciousness and death in extreme cases. The narcotic gases CO, HCN and CO_2 cause narcosis, as does lack of oxygen due to inhalation of an atmosphere low in oxygen, an impairment of gas exchange in the lung. The terms 'narcosis' and 'narcotic gases' are used synonymously with the terms 'asphyxia' and 'asphyxiant gases'.

One of the primary products of combustion, especially in under-ventilated or smouldering conditions, is carbon monoxide (CO). In the bloodstream, carbon monoxide combines with hemoglobin (Hb) in the blood to form carboxyhemoglobin (COHb). Given its higher affinity to bind with hemoglobin in comparison with oxygen, exposure to carbon monoxide reduces the amount of oxygen supplied to the body, especially the brain.

At COHb concentrations of approximately 50 to 70%, death is considered imminent. According to Purser (1995), at about 30 to 40% COHb concentration incapacitation

occurs. However, Christian (1993) stated that the tenability limit of COHb in the bloodstream is highly dependant on the duration of exposure to CO, the presence of other narcotic gases in the atmosphere, level of occupant activity and age of occupant. Furthermore, it was observed that fatalities resulted from COHb levels well below 50% (Hirschler and Christian, 1996).
As the onset of carbon monoxide intoxication is slow and difficult to detect, this poses a real threat in cases of smouldering fires as occupants would be unaware of the danger and not attempt to evacuate. The onset of other more significant effects, such as cerebral depression, decreased respiration and heart rate, is sudden and rapid, causing a severe degree of incapacitation. Once the occupant is incapacitated, this is quickly followed by unconsciousness and coma, and if not rescued, then death (Purser, 1995).

Hydrogen cyanide (HCN) is typically produced when nitrogen-containing materials undergo combustion, such as the polyurethane foam used in the manufacturing of upholstered furniture. It is likely to be present in high concentrations in large, postflashover fires. HCN intoxication is rapid and apparent; effects include hyperventilation, cerebral depression, loss of muscle tone, marked effects on the heart and circulation, followed by unconsciousness and death (Purser, 1995). Blood cyanide levels greater than 3.0μg/ml are generally considered to be lethal (Hartzell, 1997).

Oxygen is used as fuel in combustion processes, thereby reducing the concentration of oxygen (O_2) in a fire environment. Exposure to low concentrations of oxygen causes hypoxia, which is a reduction in the amount of oxygen available for tissue respiration. Effects include degradation of higher mental processes and neuromuscular control, increase in cardiovascular and respiratory activities, then a rapid decline in judgement and comprehension, followed by unconsciousness and death. Severe incapacitation occurs between 11.8 to 9.6% O_2 with critical hypoxia (i.e. unconsciousness and death) occurring at between 9.6 to 7.8% O_2 (Purser, 1995).

Carbon dioxide (CO_2) is one of the main products of combustion. It is not toxic in concentrations up to 5%, but causes hyperventilation (i.e. increased rate of respiration),

which encourages the uptake of other toxic products. At concentrations exceeding 5%, exposure to carbon dioxide causes dizziness, headache and fatigue, followed by unconsciousness (Purser, 1995).

It should be noted that none of these narcotic gases are present singularly in any fire. Interactions between these toxic gases can severely decrease the time taken to incapacitation. Under such conditions, incapacitation can occur at much lower doses and concentrations than if these gases were considered separately.

2.6 Heat Exposure

Incapacitation and death can result from exposure to heat from a fire; either by being in the hot environment and breathing the heated gases produced, or by direct contact with the flames. Exposure to flames and excessive temperatures can result in a variety of injuries, such as heat stroke (hyperthermia), skin burns or thermal damage to the respiratory tract.

In cases of severe burns, the chances of survival are low if more than 35% of the body surface area is burned (Purser, 1995). Initially, the trauma of the fire and the injuries sustained will be accompanied by psychological and physiological shock. Even after a few weeks, death may still occur due to secondary effects on all major organs; the most common of these involves the lungs, typically resulting in respiratory distress that develops into pneumonia.

Heat stroke can result from either a prolonged exposure to a heated environment, or a short exposure to high temperatures (Klote and Milke, 1992). Following this, hyperthermia develops and results in an increase in the body's core temperature. Irreversible damage typically occurs once the body's core temperature has exceeded 5.5°C above its normal temperature (Purser, 1995).

In most fire fatalities, the cause of death is usually a mixture of heat exposure-related injuries, smoke inhalation and activity-related injuries (e.g. sustained while attempting to evacuate).

3 Literature Review

3.1 Introduction

In a monograph of the fire behaviour of upholstered furniture, Babrauskas and Kransy (1985) found that there were four major characteristics of upholstered furniture to be considered; probability of cigarette ignition; probability of small flame ignition; consequences of such ignitions in terms of its heat release rate, flame spread and the development of toxic products; and the contribution of upholstered furniture to the overall fire hazard if it were not the object first ignited in the fire.

The following section provides an overview of previous research and studies done, primarily concentrating on the four characteristics of upholstered furniture mentioned above. Overseas standards and regulations, and the basis for these standards are also discussed.

3.2 Previous Research

3.2.1 Ignition, Growth and Peak Heat Release Rate

The fire performance of individual furnishing items have a crucial effect on the swiftness of a room becoming untenable, thereby preventing further evacuation of occupants within the building, or resulting in fire fatalities (Hirschler, 1997). Upholstered furniture was identified as a potentially significant fire hazard, able to yield a fire severe enough to result in flashover of a compartment.

Ohlemiller (1996) analysed the flammability of real objects in a study done based on the most common objects ignited in residential fire incidents. The flammability of upholstered furniture was dealt with in two ways; by decreasing the likelihood of ignition or decreasing the impact of ignition.

Upholstered chairs have a higher risk of cigarette ignition in comparison to foam mattresses, predominantly due to the form and shape of the chairs; i.e. the juncture of the seat and armrests, and the cervices between the seat and back of the chair. However, mattresses are more likely to be covered by clothing, bedding and other cover fabrics (Babrauskas and Krasny, 1991). Most standards and regulations deal with the cigarette ignitability of upholstered furniture (Section 3.3; CPSC, 2000; BSI, 1988).

In experiments examining the influence of the ignition source on the flaming fire hazard of upholstered furniture, Cleary et. al. (1994) tested typical ignition sources: a radiant heater, a match-like source, a lamp, a cigarette and a burner (i.e. simulating an arson-like source). It was observed in the experiments that only the cigarette ignition produced an initial smouldering fire. Further research suggested that no single ignition source utilised posed the greatest potential hazard for all chair types. In all the scenarios tested, an upholstered furniture fire with a slow fire growth rate and a relatively low peak heat release rate produced the least hazardous outcome.

Limiting the rate of heat release from the fire can decrease the impact of ignition. Typically, this requires the use of modified or flame retardant polyurethane foam, or protecting the foam from direct flame impingement by use of a barrier layer. The addition of flame retardant chemicals in the filling material of upholstered furniture is beneficial in terms of slowing down the rate of growth of a fire in which upholstered furniture was the object first ignited (Hall, 1990). However, some flame retardant materials may increase resistance to cigarette ignition, but reduce resistance to small flaming ignition and/or produce increased amounts of toxic products in a fire, and vice versa (Department of Trade and Industry, 2000).

Several studies have examined the relationship between behaviour exhibited by furniture composites in the cone calorimeter and full-scale mock-ups, such as the California Technical Bulletin 133 and the European CBUF Programme. Other studies have concentrated on different aspects of upholstered furniture fires. For example, Bukowski et. al. (1990) presented a fire risk assessment of upholstered furniture in residential dwellings while Clarke and Steele (1990) developed an upholstered furniture fire hazard model.

3.2.2 Toxicity

In a study of trends and patterns in U.S. fire fatalities, Hall and Harwood (1995) found that the proportion of deaths attributed to smoke inhalation continued to increase despite a fall in the total number of fire fatalities. Furthermore, the analysis found that fires which spread beyond the room of fire origin and resulted in the deaths of victims in rooms remote to the room of origin were largely dominant in smoke inhalation deaths. This trend towards smoke inhalation fatalities was partially credited to changes in design, construction and composition of contents and furnishings in residential dwellings. Addition of materials used in upholstered furniture to increase its resistance to cigarette ignition sometimes resulted in a more severe fire once ignited (Department of Trade and Industry, 2000).

Morikawa and Yanai (1993) studied the toxic gases from house fires involving natural and synthetics polymers (Table 1) under various conditions. A series of fire experiments were carried out in a full-scale, two-story house with natural and a mixture of natural and synthetic polymers burned in the ground floor rooms under different opening conditions. The effects of the toxic gases produced by the fires were evaluated by observing the behaviour of rabbits exposed to this atmosphere on the second floor.

Table 1: List of materials tested.

Series 1 - Natural Polymers	Series 2 - Both synthetic and natural polymers
Wool	Polyacrylonitrile
Leather	Flexible polyurethane foam
Rayon	Rigid polyurethane foam
Cotton	Nylon-6
Plywood	Polyester
Paper	Polyethylene
	Polypropylene
	Wood
	Plywood
	Paper

Note: The listed materials were represented in the experiments by common household items, such as furniture, fabrics and bedding.

From the series of fire experiments performed, it was concluded that:

- The major toxic species generated in the fires were carbon monoxide (CO) and hydrogen cyanide (HCN);
- The gases from the fires involving synthetic polymers were considered more toxic, and this was attributed to higher concentrations of HCN produced;
- The toxicity of the atmosphere in the upper floor room began to increase approximately 1 minute after flashover occurred in the room of fire origin (ground floor), and was generally higher as the size of the opening area of the room of fire origin was reduced;
- Carboxyhemoglobin (COHb) levels in the blood of the rabbits were generally higher when they were exposed to gases from the fires of natural polymers in comparison to gases from the fires involving a mixture of synthetic and natural polymers. This suggested that HCN contributed at least partly to the death or incapacitation of the rabbits exposed to the fires, especially those involving synthetic polymers.

3.3 Standards and Regulations

3.3.1 Introduction

Currently, upholstered furniture manufactured or imported into New Zealand are not subjected to any form of national standard for flammability or ignition resistance. As a result, manufacturers use a wide range of composition and combination of materials whose behaviour under fire conditions is as yet fully known.

However, in the U.S. and United Kingdom, there exist regulations and standards pertaining to the manufacture and sale of upholstered furniture. It is a common trend that these standards involve testing for resistance to cigarette ignition as fire statistics demonstrate that ignition by smoking materials is one of the leading causes of fatal fires in these countries (Miller, 1991; Cropp, 1991).

3.3.2 In the U.S.

In the U.S., there is no mandatory national standard for the flammability of upholstered furniture. However, trade organisations such as the Upholstered Furniture Action Council (UFAC) and the Consumer Protection Safety Commission (CPSC), have adopted voluntary regulations based on NFPA 260 (Babrauskas and Krasny, 1991) and are given as follows:

- NFPA 260A *Standard Methods of Tests and Classification System for Cigarette Ignition Resistance of Components of Upholstered Furniture;*
- NFPA 260B *Standard Method of Test for Determining Resistance of Mock-up Upholstered Furniture Material Assemblies to Ignition by Smouldering Cigarettes.*

On a state-level, California has adopted a mandatory standard for all upholstered furniture offered for sale in the state - the California Standards (Technical Bulletin 116, 117 and 133). These standards contain labelling requirements and performance tests to measure the cigarette and small-flame resistance of all components and finished items of upholstered furniture (CPSC, 2000). Briefly, the standards can be summarised as follows:

- Technical Bulletin 117 is mandatory for all upholstered furniture sold in California;
- Technical Bulletin 116 is a voluntary standard used for compliance screening tests;
- Technical Bulletin 133 is mandatory for all upholstered furniture intended for non-residential public occupancies that are not protected by sprinkler systems.

3.3.3 In the U.K.

In the United Kingdom, there is the Furniture and Furnishings (Fire Safety) Regulations 1988, amended in 1989, intended as a supplementary to the 1980 cigarette ignition regulation (BSI, 1988). In 1992, the regulations were further amended to include second-hand furniture and furniture in holiday homes (Home Office, 1995).

These regulations apply to most upholstered furniture manufactured after 1950 and all new items. It specifies a series of open-flame performance requirements for upholstered furniture, and prohibits the use of all polyurethane foams, except for ignition-resistant 'combustion modified' foams, for use in residential upholstered furniture (Department of Trade and Industry, 2000).

4 Emergency Incident Statistics, 1995 - 1999

4.1 Introduction

This section provides an overview of the fire incident statistics obtained in the New Zealand Emergency Incident Statistics published each year by the Fire Service, which is a general summary of the information found in the Fire Incident Reporting System (FIRS) database.

It should be noted that the statistics cited here are based on the 1995-1999 New Zealand Fire Service Emergency Incident Statistics (NZFS, 1997; NZFS, 1999), which are based on financial years rather than calendar years. This means that incident statistics quoted for the year 1995 actually occurred between 1st July, 1994 and 30th June, 1995.

Unlike subsequent sections, the data quoted here does not include fire incident statistics from the year 1999/2000. The reason for this is that the Fire Service has yet to publish the emergency incident statistics for that year at the time of this report. However, in order to maintain the five-year period coverage, the fire incidents reviewed were obtained from the period 1995 to 1999.

There is also another important issue to consider when reviewing these statistics. In April 1996, firefighters were involved in industrial action that included the non-completion of FIRS reports (NZFS, 1999). As a result, approximately 2,300 fire incidents attended by the Fire Service were not recorded and therefore not reflected in these emergency statistics.

4.2 Fire Incidents

From 1995 to 1999, the New Zealand Fire Service responded to a total of 105,892 recorded fire incidents, averaging out to approximately 21,178 fire incidents per year. From this number of fire incidents, a total of 219 fire fatalities occurred, with an average of 44 deaths every year (Table 2). The statistics cited here are based on the NZFS Emergency Incident Statistics, which in turn have been summarised from the FIRS database.

Table 2: Number of fire incidents and resulting fire fatalities from 1995 to 1999 according to the NZFS Emergency Incident Statistics.

	Year					Total	Average
	1994/95	1995/96	1996/97	1997/98	1998/99		
No. of fire incidents	20542	18242	20951	24664	21493	105892	21178
No. of fire fatalities	46	32	52	47	42	219	44

4.2.1 Summary of Property Involved in Fires

Figure 1 shows the breakdown of fire incidents between 1995 to 1999 according to property type.

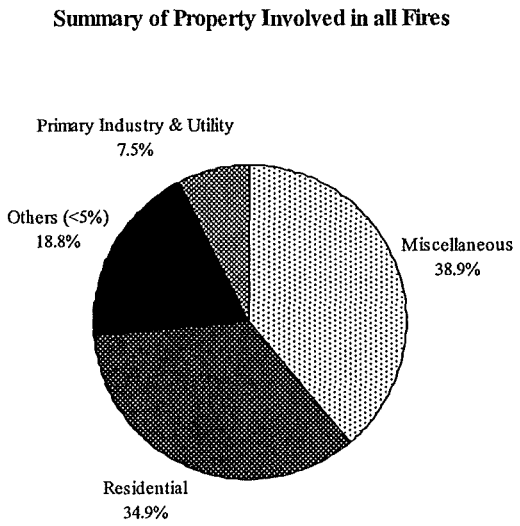

Figure 1: Summary of property involved in all fires from 1995 to 1999. (From: Appendix A, Table 17)

The largest category of property involved in fire incidents were those defined as miscellaneous. Miscellaneous property fires accounted for approximately 38.9% of all fire incidents between the period of 1995 to 1999. This category mainly consisted of fire incidents in a variety of different structures and areas, such as vacant buildings and construction sites; special structures, like fences and public toilets etc; outdoors areas; water areas; railway property; roads and streets; aircraft areas; rubbish tips and transfer stations; and other unclassified miscellaneous property. Most fire incidents classified as miscellaneous occurred in outdoor areas, and on roads and streets (i.e. fires involving vehicles).

Residential property accounted for the second largest type of property involved in fire incidents with approximately 34.9% of all fire incidents over the five-year period considered. Properties defined as residential are single houses; flats, home units and apartments; boarding houses, halfway houses and dormitories; hotels, motels and lodges; and residential outbuildings, garages etc.

The third largest category of property type involved in fire incidents consisted of primary industry and utility structures, accounting for 7.5% of the total number of fire incidents during the five-year period from 1995 to 1999. Significant industries represented in this category includes the farming and agricultural industry, and the forestry industry. Other industries included are those involved in energy production; laboratories; communication and data processing; and mines, quarries and oil wells.

The 'Others' category consists of property types that individually accounted for less than 5% of the total number of fire incidents between the year 1995 to 1999. Included in this category are public assembly property (4.7%); commercial property (4.3%); storage property (3.4%); manufacturing property (3.0%); education property (2.1%); health care and detention property (1.1%); and non-existent address property (0.1%).

4.2.2 Residential Property Involved in Fire

Figure 2 shows the breakdown of fire incidents defined as residential property between 1995 to 1999 according to the major sub-categories specified in the Emergency Incident Statistics.

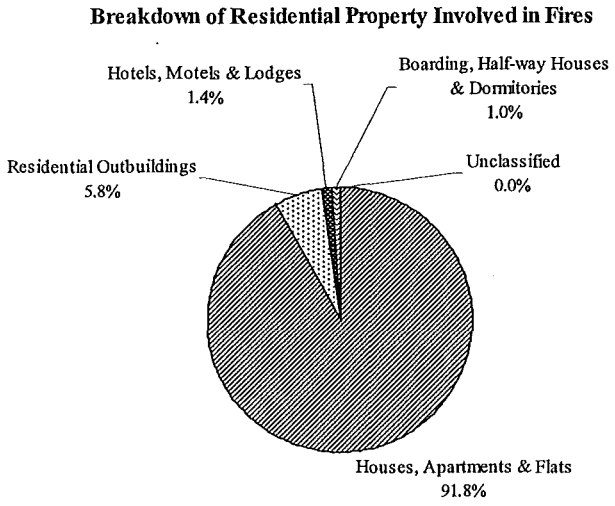

Figure 2: Breakdown of residential property involved in fires from 1995 to 1999. (From: Appendix A, Table 18)

When considering residential fire incident statistics, houses, apartments and flats accounted for the largest proportion of residential property involved in fire incidents, up to 91.8% of all residential fire incidents. This sub-category of residential property includes single-dwelling structures and multi-dwelling structures. Further breakdown of this sub-category showed that single houses accounted for a disproportionate number of residential fire incidents (84.2%).

The second largest sub-category of residential property involved in fire incidents were residential outbuildings, which accounted for 5.8% of all residential fire incidents. This

sub-category includes garages, carports, sheds, children's playhouses, glasshouses, gazebos, pool houses, tents, dog kennels and other unclassified outbuildings.

Hotels, motels and lodges with or without liquor licenses accounted for 1.4% of all residential fire incidents. Meanwhile, the sub-category for boarding, half-way houses and dormitories accounted for 1.0% of the total number of residential fire incidents from between 1995 to 1999, and encompasses boarding houses, half-way houses, university dormitories, nurses' homes, military or police barracks, bunk houses, and workers barracks.

Unclassified residential property accounted for slightly more than 0.01% of the total number of residential fire incident statistics.

4.2.3 Residential Structure Fires - Room or Space of Fire Origin

While the FIRS coding system allows for the classification of upholstered furniture fire incidents, often attending Fire Service personnel do not elaborate further on the type of fuel source involved in the fire beyond the optional first three objects ignited. Taking this into consideration, it is therefore prudent to include the rooms or spaces of fire origin in an analysis of the emergency statistics. For example, it would be reasonable to assume that a fire incident occurring in the lounge or bedroom area would involve upholstered furniture in some way or manner, either as the first object ignited, or ignited later on exacerbating the spread of the fire.

The location of fire origin is the point of origin of the fire or spill within the specific property type, and it is classified according to the use of the room or space within the property at the time of the fire incident. Figure 3 shows the breakdown of residential structure fires between the period of 1996 to 1999, according to the room or space of fire origin.

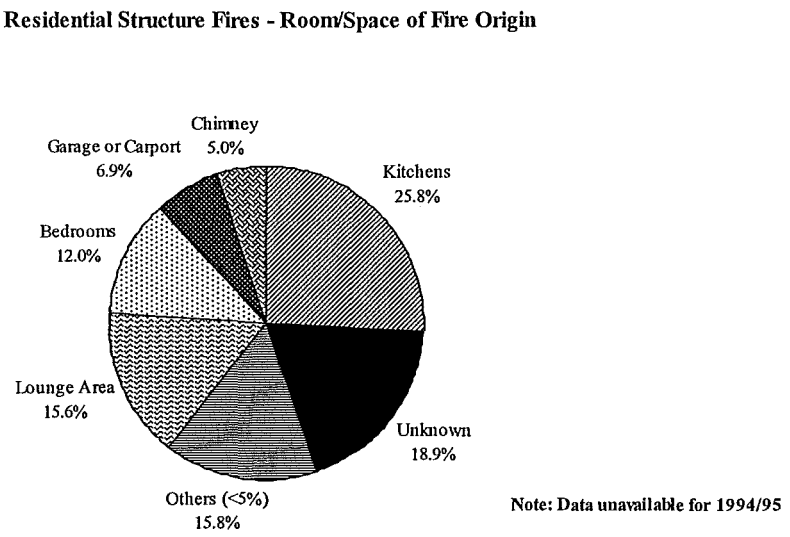

Figure 3: Residential structure fires by room or space of fire origin from 1996 to 1999. (From: Appendix A, Table 19)

Residential fires most often originated in kitchens and other cooking areas, accounting for 25.8% of all residential structure fires in the four-year period considered. The second largest category comprised of fires with an unknown location of origin, which accounted for 18.9% of all residential structure fires between 1996 to 1999.

Lounges and bedrooms accounted for 15.6% and 12.0% of all residential structure fires occurring between 1996 to 1999. According to the FIRS coding system, lounges are classified similarly to common rooms, TV rooms, sitting rooms and music rooms. In order of decreasing frequency, garages or carports (6.9%) were next, followed by fires originating in chimneys (5.0%).

The 'Others' category included all locations of fire origin that individually accounted for less than 5% of all residential structure fires occurring in the five-year period considered. This category includes outside and multiple areas (3.0%); hallways and stairs (2.7%); laundry areas (2.7%); the ceiling and roof assembly (1.9%); storage areas (1.9%); toilets

and bathrooms (1.2%); dining areas (0.9%); service and equipment areas (0.7%); vehicle areas (0.5%); office (0.1%); technical areas (0.1%); and sales and assembly areas (0.05%).

4.2.4 Type of Property Where Fatality Occurred

Figure 4 shows the breakdown of fire fatalities between 1996 to 1999 according to property type.

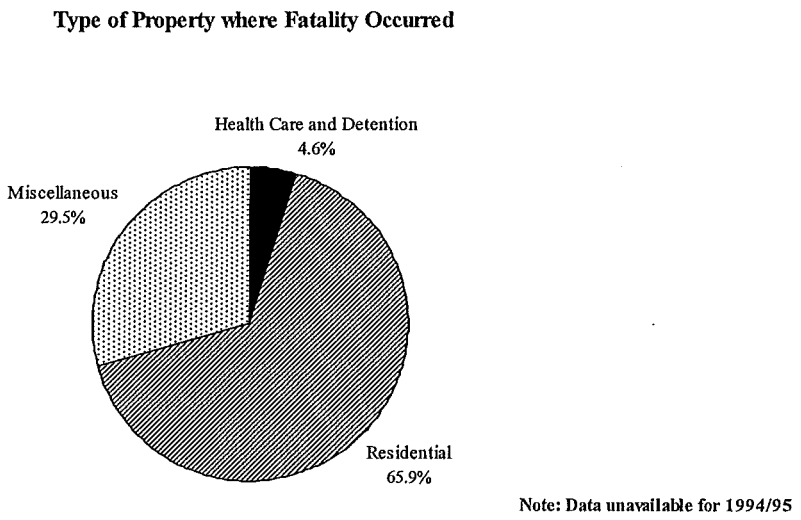

Figure 4: Type of property where fatality occurred from 1996 to 1999. (From: Appendix A, Table 20)

Approximately 65.9% of all fire-related fatalities in the five-year period considered occurred in residential properties. Meanwhile, miscellaneous property types accounted for up to 29.5% of all fire fatalities between 1996 to 1999.

The third largest category of property associated with fire fatalities were health care and detention properties, which accounted for 5% of all fire deaths between the year 1996 to 1999. This category includes rest homes, old peoples homes, care homes for the young, sick and injured, prisons, correctional facilities, and care homes for the physically and mentally disabled.

As such facilities often cater to persons that may be incapacitated, either physically or mentally during the event of a fire, the Acceptable Solutions (BIA, 1992) have different criteria for the fire engineering design of such structures, specifying stricter requirements.

5 Fire Incident Reporting System (FIRS)

5.1 Introduction

The FIRS database was developed to allow for uniform collection of fire incident information, and to provide an effective method of assessing and sharing this information with regional, national and international fire and emergency organisations. Every fire incident responded to by the Fire Service is recorded according to instructions laid out in the *Fire Incident Reporting System Instructions & Coding Manual* (NZFS, 1995).

This section of the report examines residential fire fatalities that occurred between 1996 to 2000 in accordance with the key categories defined in the FIRS database. Statistical data was obtained directly from the New Zealand Fire Service FIRS database and it differed slightly from summarised data published in the New Zealand Emergency Incident Statistics edition for that five-year period. The principal reason for these discrepancies originated from the fact that the statistical data referred to in this section has been filtered to exclude data not covered in the scope of this report, such as:

- Mobile property (defined as structures);

When mobile property, such as caravans, camper vans and mobile homes, are parked for long-term occupancy, the Fire Service routinely refers to fires in such properties as fires relating to structures rather than mobile property fires. The basic differences in coding for these two types of incidents are as follows:

- Fires relating to structures have a *Type of Incident* code of '11??';
- Mobile property fires have a *Type of Incident* code of '12??'.

Note: The question mark represents any single digit number.

When considering the effects of furnishings, it is difficult to classify mobile property fire incidents as these structures typically do not have clearly defined living areas. They are also equipped with certain furnishings not found in residential structures, such as upholstered transportation seating, which could be highly influential on the outcome of any fire. Therefore, mobile property fire incidents were not included in the following statistical analysis.

5.1.1 FIRS Coding Definitions

A residential fire incident refers to an incident involving a fire in a permanent fixed dwelling with the following coding in the FIRS manual:

- Listed as a fire incident;
- A *Type of Incident* coding of '11??';
- A *General Property Use* coding of '3?';
- A *Specific Property Use* coding of '4?'.

This would include all fires in residential structures whether or not damage occurs.

Meanwhile, residential fire fatalities refer to civilian deaths resulting from a residential fire incident as a result of exposure to the fire or its products, and are indicated by a coding in the FIRS manual as:

- Listed as a residential fire incident;
- A *Civilian Casualty* coding of '2?';
- A *Severity of Injury* coding of '4';
- A *Cause of Injury* coding of '1?'.

Note: The question mark represents any single digit number.

This would include fatalities suffered by Fire Service personnel and other emergency service personnel not associated with the Fire Service while attending the fire incident.

5.2 Residential Fire Fatalities, 1996 - 2000

From 1996 to 2000, the New Zealand Fire Service responded to a total of 105 recorded fatal residential fire incidents, averaging out to approximately 21 fire incidents per year. From this number of fire incidents, a total of 127 fire fatalities occurred on residential property, with an average of 25 deaths every year. The statistics cited here are further detailed in Table 3, which shows the breakdown of fatal residential fire incidents each year.

Table 3: Number of fatal residential fire incidents and resulting fatalities each year from 1996 to 2000.

	Year					Total	Average
	1995/96	1996/97	1997/98	1998/99	1999/00		
No. of fire incidents	21	25	24	20	15	105	21
No. of fire fatalities	24	33	28	23	19	127	25

5.2.1 Specific Type of Residential Property Where Fatality Occurred

Figure 5 represents the breakdown of all fatal residential property fires from 1996 to 2000 according to specific property type.

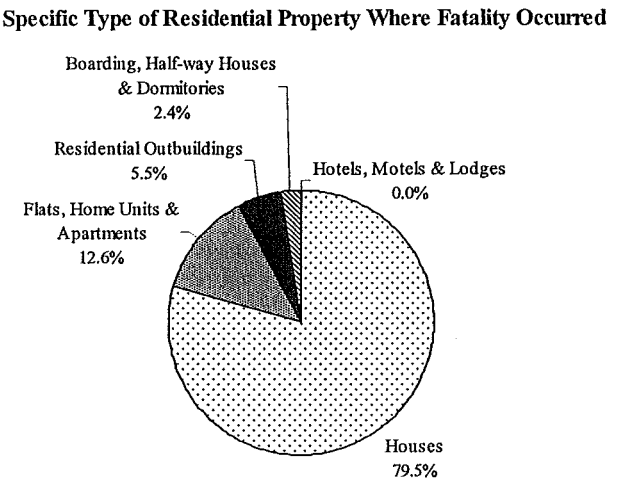

Figure 5: Specific type of residential property where fatality occurred from 1996 to 2000. (From: Appendix B, Table 22)

The largest category of specific property type where fatal residential fires occurred were houses, which accounted for 79.5%, or 101 deaths over the five-year period considered. In many such households, especially those in lower socio-economic areas, even some of the most basic fire precaution safety measures, such as the installation and maintenance of smoke alarms, are occasionally considered financially impractical. As a result, the contents of such single-family dwellings become particularly important in determining the inherent fire hazard.

Flats, home units and apartments were the next largest category at 12.6% of the total number of residential fire fatalities. This was followed by residential outbuildings (5.5%);

and boarding, halfway houses and dormitories (2.4%). From 1996 to 2000, no fatal fires occurred in hotels, motels or lodges.

5.2.2 Residential Fatal Fires - Room or Space of Fire Origin

Figure 6 shows the breakdown of fatal residential fires between the period of 1996 to 2000, according to the room or space of fire origin.

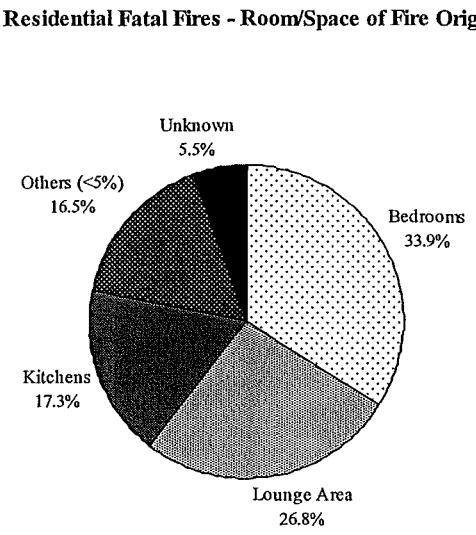

Figure 6: Residential fire fatalities by room or space of fire origin from 1996 to 2000. (From: Appendix B, Table 23)

The largest number of fatalities occurred from fires originating in bedrooms (33.9%); followed by lounge areas (26.8%); kitchens (17.3%); others (16.5%); and fires of unknown origins (5.5%).

Bedrooms and lounge areas were the two most common rooms or spaces of fire origin in fatal residential fires. In marked contrast, most residential structure fire incidents

originated from kitchens, with bedrooms and lounge areas coming in at fourth and fifth. This implies that fire incidents initiating from bedrooms and lounge areas pose a greater life-safety risk to occupants; a trend that Irwin (1997) also observed in a study of the domestic fire hazard in New Zealand.

The 'Others' category included spaces of fire origin that separately accounted for less than 5% of the total number of residential fire fatalities in the five-year period considered. This involves fires beginning in garages and carports (4.7%); hallways and stairs (3.9%); outside and multiple areas (1.6%); dining areas (1.6%); laundry areas (0.8%); ceiling and roof assemblies (0.8%); storage areas (0.8%); toilets and bathrooms (0.8%); service and equipment areas (0.8%); and vehicle areas (0.8%).

5.2.3 Object First Ignited

Figure 7 shows the breakdown of fatal fire incidents that occurred on residential property between 1996 to 2000 according to the object first ignited.

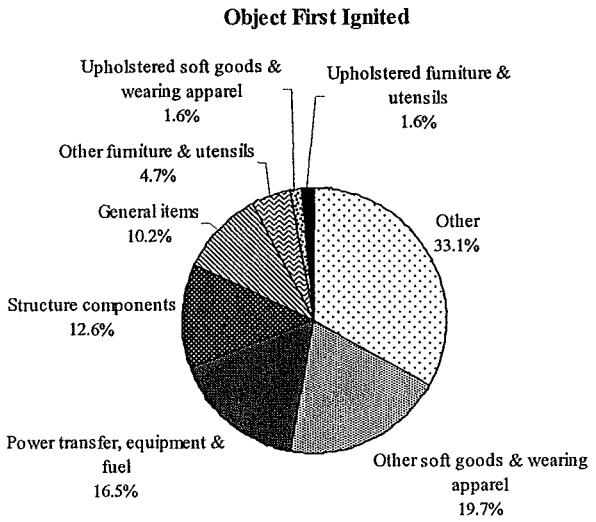

Figure 7: Object first ignited in fatal residential fire incidents from 1996 to 2000. (From: Appendix B, Table 24)

The 'Other' category accounted for the largest proportion of fire fatalities, up to 33.1% over the five-year period considered. This category includes fires in which multiple items were ignited (4.7%) and fires where the object first ignited could not be determined (28.3%).

The second largest category involved non-upholstered soft goods and wearing apparel that accounted for 19.7% of all residential fire fatalities. Items covered in this category includes bedding, blankets and sheets (10.2%); mattresses and pillows (3.1%); clothing and wearing apparel (3.2%); linen, towels and table clothes (1.6%); unknown soft goods (0.8%); and curtains, blinds and drapes (0.8%).

Power transfer equipment and fuel were the objects first ignited in 16.5% of all fatalities on residential property. This category includes fires originating from flammable liquids and gases (14.2%); and electrical wiring and insulation (2.4%).

The next largest category of objects first ignited in fatal residential fires were those involving structure components (12.6%); followed by general items (10.2%); and non-upholstered furniture and utensils (4.7%). Upholstered furniture and utensils accounted for 1.6% of all fatalities in residential property. Included in this category are typical furniture found in living areas, such as chairs, sofas and beds.

While the FIRS database does not have a separate coding for upholstered soft goods and wearing apparel, it was determined from the material of the object first ignited that some items (bedding, blankets and sheets) found in this category contained a combination of polyurethane foam and fabric. These upholstered soft goods accounted for up to 1.6% of all residential fatalities during the five-year period.

According to the data obtained from the FIRS database, upholstered furniture and upholstered soft goods and wearing apparel consisted of a small percentage of the objects first ignited in fatal residential fires. However, one important note to make when considering the FIRS statistics is that the largest category consisted fatal fire incidents where the object first ignited was unknown or consisted of multiple objects. Also, the category of object first ignited does not sufficiently detail the role of furnishings, if any, in the resultant fatalities.

5.2.4 Heat Source

Figure 8 illustrates a breakdown of the heat sources that resulted in fatal residential fire incidents from 1996 to 2000.

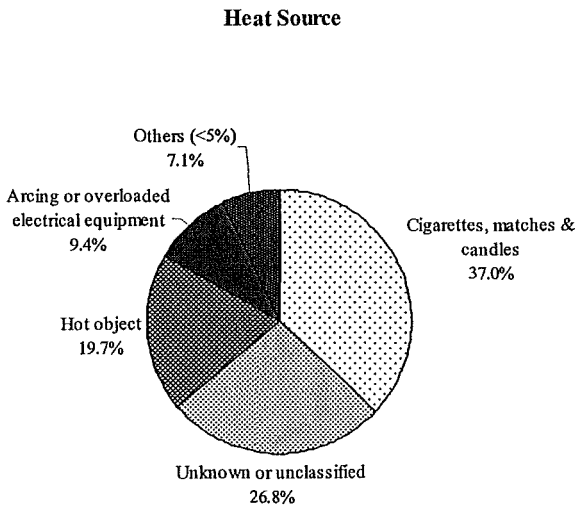

Figure 8: Heat sources involved in fatal residential fire incidents from 1996 to 2000. (From: Appendix B, Table 25)

The largest category of heat sources that resulted in residential fire fatalities were those involving cigarettes, matches and candles (37.0%). This category was further broken down to include lighters (9.4%); cigarettes (7.9%); heating from smoking materials (6.3%); matches (6.3%); candles, candle oil and tapers (3.9%); and unclassified cigarettes, matches and candles (3.1%).

Unknown or unclassified heat sources accounted for up to 26.8% of all residential fire fatalities. The next largest category of heat sources involves hot objects that were responsible for 19.7% of the fatalities considered. Included in this category are heat from

electrical equipment (17.3%); molten material (1.6%); and unclassified hot objects (0.8%).

Arcing and overloaded electrical equipment accounted for 9.4% of all fatalities on residential property. This includes short circuit due to unspecified causes (3.1%); arcing from faulty, loose or broken conductors (2.4%); unclassified arcing and overloaded electrical equipment (1.6%); heat from overloaded equipment (1.6%); and short circuit due to defective or worn insulation (0.8%).

The 'Others' category (7.1%) involved heat sources that individually accounted for less than 5% of the total number of residential fire fatalities. Included in this category are solid-fuel powered equipment (2.4%); gas or liquid fuel powered equipment (2.4%); outside fires, sparks or embers (1.6%); and exposure fires (0.8%).

5.2.5 Supposed Cause

Figure 9 illustrates the varied supposed causes of fatal residential fires from 1996 to 2000.

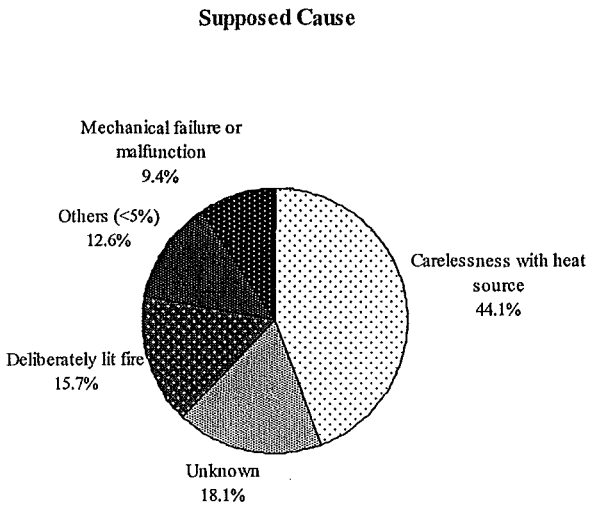

Figure 9: Supposed cause of fatal residential fire incidents from 1996 to 2000. (From: Appendix B, Table 26)

The largest category of supposed causes involved carelessness with heat sources, which accounted for 44.1% of all residential fire fatalities, or 56 deaths over the five-year period considered. Included in this category are falling asleep or kitchen/cooking fires (9.4%); careless disposal of cigarettes, cigars, ashes and embers (8.7%); people playing with heat sources (7.9%); falling asleep other (7.1%); heat sources placed too close to combustibles (6.3%); carelessness with unspecified heat sources (1.6%); people otherwise impaired (1.6%); inadequate control of heat sources (0.8%); and people impaired by drugs or alcohol (0.8%).

Unknown causes accounted for 18.1% of all fatalities that occurred on residential property. The next largest category involved deliberately-lit fires (15.7%); which was further broken down to cover unspecified deliberately-lit fires (3.1%); unlawful fires (4.7%); deliberately-lit fires of unknown legality (0.8%); and suspicious fires (7.1%).

The 'Others' category (12.6%) involved supposed causes that separately accounted for less than 5% of the total number of residential fire fatalities. Included in this general category are reckless fires (4.7%); carelessness with material ignited (3.1%); operation deficiency (3.1%); and design, construction or installation faults (1.6%).

Mechanical failure or malfunction accounted for up to 9.4% of all residential fire fatalities. This category covers mechanical part failure, leaks or breaks (3.9%); other electrical faults (3.9%); and short circuit or earth fault (1.6%).

Cigarettes, matches and candles were the most common heat source in fatal residential fires while carelessness with heat sources was the dominant supposed cause of such fires. Considering this information, it becomes apparent that the ignitability of household objects, such as furniture, soft goods and wearing apparel is exceedingly important in assessing the contribution of these items to residential fire fatalities.

6 Fatalities Involving Upholstered Furniture, 1996 - 2000

6.1 Introduction

This section examines the involvement of upholstered furniture in fatal residential fire incidents. In order to obtain a more complete picture of the fire incident scenario, other sources of information regarding each aspect of the fire (e.g. details of the occupants, residential structure and fire behaviour) were also taken into account in conjunction with the data accessible from the FIRS database, such as:

(a) Coroner's Inquest is undertaken when a fatality occurs in a fire incident or subsequently as a result of injuries sustained in a fire, and typically includes:

- Details of the deceased, such as a general description, the age of the victim and medical history;
- Details of the cause of death as ascertained by the Coroner, including autopsy findings, blood and urine alcohol levels, and concentration of COHb in the bloodstream;
- Description of the condition of the deceased prior to death, which would include any drug-use or pre-existing medical conditions;
- Eye-witness accounts as obtained by the police;
- Any conclusions and recommendations made by the Coroner.

(b) Serious and Unusual Incident Report is filed within three working days by the NZFS when a 'serious or unusual' fire incident has occurred, and typically includes:

- General details of the fire incident, such as date, location of incident and type of incident;

- Comments of fire incidents included in the report vary; from a brief description to a more detailed examination of the fire and the Fire Service response.

(c) NZFS Investigation Report is filed when an investigation of a fire incident is undertaken, and typically includes:

- General details of the fire incident, such as date, location and type of incident, description of structure, and casualties sustained;
- Description of response by the Fire Service and other attending personnel;
- Details of the fire incident, including its discovery, origin, supposed cause and extent of damage;
- Account of fire behaviour and spread, which may include eye-witness interviews, sketches and photographs;
- Any general comments or recommendations made by the Investigating Officer.

6.1.1 Criteria Definitions

In order to further study the features of fatal residential fires involving upholstered furniture, the FIRS database of all residential fatalities had to be filtered into categories describing the involvement of upholstered furniture in each case. Due to the complexity involved in accurately determining the degree of involvement of upholstered furniture in fires, it was decided that these categories should be generic, be able to cover a wide range of possible scenarios and offer a general statement to indicate if upholstered furniture was involved, likely to have been involved, unlikely to have been involved or not involved at all in the fatal residential fire incident.

The following categories define the degree of involvement of upholstered furniture in fatal residential fire incidents under consideration. Inclusion in any one of these categories is indicated by the following criteria:

1) YES

(a) From the FIRS database, fires associated with upholstered furniture are defined under the following inter-related categories, indicated by the following coding in the FIRS manual:

- Listed as a fire incident;
- An *Object Ignited* coding of '211' for upholstered chairs, sofas, beds and vehicle seats, but excludes bedding;
- A *Type of Material Object Made Of* coding of '415' for synthetic foams found in furnishings, upholstering and mattresses (i.e. open cell foam);
- A *Material Generating Most Flame* or *Material Generating Most Smoke* coding of '1605' for foam plastic found in furnishings, upholstering and mattresses (open cell foam).

Note: The question mark represents any single digit number.

(b) Presence of upholstered furniture in the room of fire origin and/or spaces of subsequent fire spread, which have been directly involved with the fire as indicated by the following documentation:

- Testimony from witnesses, obtained from Coroner's Findings, or;
- Observations made by Fire Service personnel, obtained from NZFS fire reports.

2) LIKELY

(a) Upholstered furniture is indicated as part of the fuel load in the room of fire origin and/or areas of subsequent fire spread. However, no mention is made of the

upholstered furniture being directly involved in the fire from fire reports obtained from the NZFS.

(b) Fire originated from and spread to rooms or spaces that would typically be furnished with upholstered furniture (e.g. lounge and bedroom areas). No mention is made of upholstered furniture as part of the fuel load in fire reports filed with the NZFS, but details of the fire and its spread indicates that it would be likely upholstered furniture was present and contributed to the resultant fatality.

3) **UNLIKELY**

(a) Fire originated from and spread to rooms or spaces that would typically be furnished with upholstered furniture (e.g. lounge and bedroom areas). However, no mention is made of upholstered furniture as part of the fuel load in subsequent fire reports filed with the NZFS. Also, details of the fire and its spread do not seem to indicate that upholstered furniture contributed to the resultant fatality.

4) **NO**

(a) Fire originated from and spread to rooms or spaces that do not typically contain upholstered furniture (e.g. kitchen, hallway and garages). No mention is made of upholstered furniture as being part of the fuel load or directly involved in the fire in any of the fire reports filed by NZFS. Details of the fire and its spread do not seem to indicate that upholstered furniture contributed to the resultant fatality.

(b) Deliberately lit fires with the intention to commit suicide are not largely influenced by the type of furnishings in the room of origin. Fatalities that result from such fires are usually inevitable, unless direct intervention occurs when the fire is lit.

(c) In cases of accidental self-ignition, involvement of upholstered furniture is usually minimal, especially in cases where the deceased died of severe burns inflicted by the initial ignition rather than from the effects of the subsequent fire. However, this criteria does not apply to cases where upholstered furniture played a role in the initial ignition.

(d) In cases of arson where there is evidence of use of highly flammable liquids and/or the presence of multiple fires, it is difficult to accurately gauge the influence of furnishings. Therefore, even if upholstered furniture was part of the fuel load, it is unlikely that it would have greatly affected the outcome of the fire incident.

5) UNKNOWN

(a) According to the FIRS coding manual, fires in which the objects ignited are unknown are indicated by the following:

- Listed as a fire incident;
- A *Heat Source* coding of '85' for unknown;
- An *Object Ignited* coding of '912' for unknown;
- A *Type of Material Object Made Of* coding of '913' for unknown;
- A *Supposed Cause* coding of '918' for unknown.

Note: The question mark represents any single digit number.

6.1.2 Case Studies

In order to further illustrate the type of fire incidents covered by each category, the following case studies have been selected as examples.

Table 4: Case study example for fire incidents included in category 'Yes'.

Incident Key	1821 9603064
Date	11/16/96
Address	31A Rawhiti St, Taupo
No. of occupants present	One
Age of deceased	37 years
Classification	Yes
Available fuel	Indicated by FIRS as object first ignited
Other notes	Timber construction with iron corrugated roof Interior - soft board Exterior - timber planks
Location of deceased at ignition/during fire	In room of fire origin
Location of deceased when discovered	Lounge
Cause of death	Smoke inhalation
Presence of alcohol	233mg/100ml (blood) 323mg/100ml (urine)
% COHb	66
Presence of smoke detectors	No
Property type	Single house
Location of fire origin	Lounge, Common room, TV room, Sitting room, Music room
Heat source	Cigarette
Object first ignited	Chair, sofa, bed, vehicle seat
Object first ignited material	Polyurethane foam
Supposed cause	Careless disposal Cigarettes

In this particular fire incident (Table 4), the deceased fell asleep while smoking and accidentally set the lounge chair alight. When he became aware of the fire, he attempted to evacuate through the front door but was prevented from doing so by the fire which was now well-established and rapidly spreading. The deceased then attempted to exit through the back door, but was overcome by the smoke and later perished of smoke inhalation. The level of carboxyhemoglobin in his blood was recorded at 66% (50% is considered fatal). In this case, upholstered furniture played a significant role in the initial ignition, in the resultant flame spread and in the production of toxic combustion products.

Table 5: Case study example for fire incidents included in category 'Likely'.

Incident Key	3263 9801111
Date	6/17/98
Address	10 Wainui St, Brunner
No. of occupants present	One
Age of deceased	62 years
Classification	Likely
Available fuel	In room of fire origin - unknown furnishings, horizontal timber with pinex In room with occupant - chair, bed
Other notes	Weatherboard iron and cement fibre board with corrugated iron roof Interior - pinex and hardboard Flame spread - main damage to kitchen, hallway, ceiling; spread into room with occupant (chair burnt, cat killed)
Location of deceased at ignition/during fire	Remote from room of fire origin (bedroom)
Location of deceased when discovered	Hallway outside kitchen
Cause of death	Smoke inhalation and burns
Presence of alcohol	241mg/100ml(blood) 318mg/100ml(urine)
% COHb	27
Presence of smoke detectors	No
Property type	Single house
Location of fire origin	Kitchen, Cooking area
Heat source	Exposure fire, conducted heat
Object first ignited	Interior wall covering
Object first ignited material	Wood - Sawn, finished timber
Supposed cause	Combustibles too close to heat source

In this case (Table 5), the deceased awakened to discover a fire in his house. He attempted to extinguish the fire by removing what he thought was its source to the outside, but by then the fire had spread from the kitchen to the rest of the house. When he returned into the building, he was struck by a falling piece of architrave and afterwards died from a combination of smoke inhalation and burns. Upholstered furniture was mentioned as part of the fuel load in rooms of subsequent fire spread and is likely to have contributed to the resultant fatality.

Table 6: Case study example for fire incidents included in category 'Unlikely'.

Incident Key	2371 9700978
Date	3/23/97
Address	34 Plymouth St, Wanganui
No. of occupants present	Two
Age of deceased	35 years
Classification	unlikely
Available fuel	In room of fire origin - wooden benchtops, bench, cupboards, stove In other rooms - unknown furnishings
Other notes	Timber construction with corrugated iron roof Interior - match linings with tongue and groove timber ceiling Flame spread - from kitchen to rest of house (flashover occurred). Eyewitness - flames from lounge windows and front doors
Location of deceased at ignition/during fire	Lounge
Location of deceased when discovered	Lounge
Cause of death	Smoke inhalation
Presence of alcohol	140mg/100ml(blood) 193mg/100ml(urine)
% COHb	71
Presence of smoke detectors	No
Property type	Single house
Location of fire origin	Kitchen, Cooking area
Heat source	Heat from electrical equipment improperly operated
Object first ignited	Electrical wire, insulation
Object first ignited material	PVC
Supposed cause	Falling asleep cooking

In this particular fire incident (Table 6), the deceased's partner awakened to discover the house filled with dense smoke. The deceased was alive at this time and was awakened by his partner's yelling, but succumbed to the smoke before he could join his partner and evacuate the building. Upholstered furniture was not mentioned as part of the fuel load in this fire and did not appear to have contributed to the resultant fatality. From eye-witness accounts, it appeared that the deceased was incapacitated by the smoke before flashover occurred and ultimately died from smoke inhalation. The carboxyhemoglobin levels in his blood was recorded at 71%.

Table 7: Case study example for fire incidents included in category 'No'.

Incident Key	1433 99A039215
Date	4/5/99
Address	31C Edward St, Otara
No. of occupants present	One
Age of deceased	60 years
Classification	No
Available fuel	In room of fire origin - pinex softboard ceiling, cupboards, curtains
Other notes	Fatality as a result of injuries sustained in a gas explosion (deceased attempted to repair stove) Kitchen sustained moderate damage
Location of deceased at ignition/during fire	Room of fire origin (kitchen)
Location of deceased when discovered	Died in hospital
Cause of death	severe burns
Presence of alcohol	No
% COHb	Unavailable
Presence of smoke detectors	No
Property type	Single house
Location of fire origin	Kitchen, Cooking area
Heat source	Lighter
Object first ignited	Flammable liquid or gas
Object first ignited material	Natural gas
Supposed cause	Flammable liquid/gas spilled or accidentally released

In this case (Table 7), the deceased died as a result of injuries sustained in a gas explosion. The gas build-up was caused by the deceased attempting to repair a faulty stove. Upholstered furniture was not involved in the initial ignition and the resultant fire.

6.1.3 Involvement of Upholstered Furniture in Fatal Residential Fires

Figure 10 shows the breakdown of all fatal residential fires from 1996 to 2000 according to the degree of involvement of upholstered furniture as specified in the previous section (Section 6.1.1).

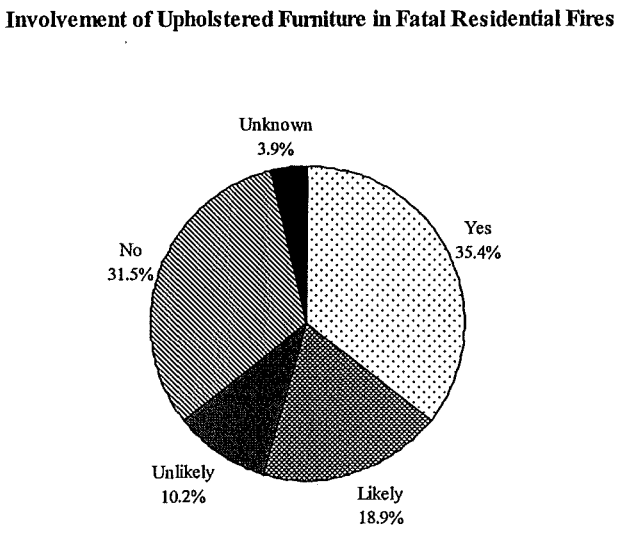

Figure 10: Involvement of upholstered furniture in fatal residential fire incidents from 1996 to 2000. (From: Appendix C, Table 27)

In 35.4% of all residential fire fatalities in the five-year period considered, the involvement of upholstered furniture in these fire incidents was confirmed. This is followed by 18.9% of all fire fatalities where upholstered furniture was likely to have been involved; unlikely to have been involved (10.2%); not involved (31.5%); and 3.9% where the degree of involvement of upholstered furniture, if any, could not be determined.

There are several important points to contemplate when considering the degree of involvement assigned to each residential fire fatality. For example, the general categories

used in the analysis do not indicate the contribution of upholstered furniture to each individual fatality. Indeed, this may be impossible to accurately determine as ignition and fire spread behaviour of individual pieces of furniture is difficult to conclude in the aftermath of a fire, especially if a considerable proportion of the structure has been destroyed in the incident.

Adding to the overall complexity, time of death usually cannot be assessed to such accuracy as to say whether or not the deceased was fatally incapacitated before a particular piece of upholstered furniture was ignited in the fire. Taking these factors into account, it can be said that the degree of involvement categories specified offer only a general statement that upholstered furniture was either involved, likely to have been involved, unlikely to have been involved, or not involved, in the fatal residential fire incident.

In approximately 78% of all fatal residential fire incidents studied, alternative sources of information were available (e.g. Coroner's Inquest, NZFS Investigation Report etc) in addition to the data sourced from the FIRS database. Where these additional sources of information were not available, the degree of involvement was assigned based on the FIRS information.

6.2 Upholstered Furniture in Fires

The following section examines fatal residential fire incidents in which the involvement of upholstered furniture has been confirmed (i.e. 'Yes' category). From 1996 to 2000, the New Zealand Fire Service responded to a total of 105 recorded fatal residential fire incidents, resulting 127 fire fatalities. Of this number, upholstered furniture was identified as being involved with 36 fatal residential fire incidents, resulting in a total of 45 fatalities as shown in Table 8.

Table 8: Number of residential fire incidents and resulting fatalities involving upholstered furniture fires from 1996 to 2000.

	Year					Total
	1995/96	1996/97	1997/98	1998/99	1999/00	
No. of fire fatalities	8	17	8	7	5	45
No. of fire incidents	7	11	7	7	4	36

This section also discusses the common trends apparent in fire incidents involving upholstered furniture, with the intent of providing further insight into the contribution of upholstered furniture to residential fire fatalities. An important point to note is that the values cited here come from a limited pool of upholstered furniture fire incidents from 1996 to 2000.

6.2.1 Proportion of Residential Fire Fatalities Involving Upholstered Furniture

Figure 11 illustrates the proportion of fatalities from upholstered furniture fires in fatal residential fires from 1996 to 2000.

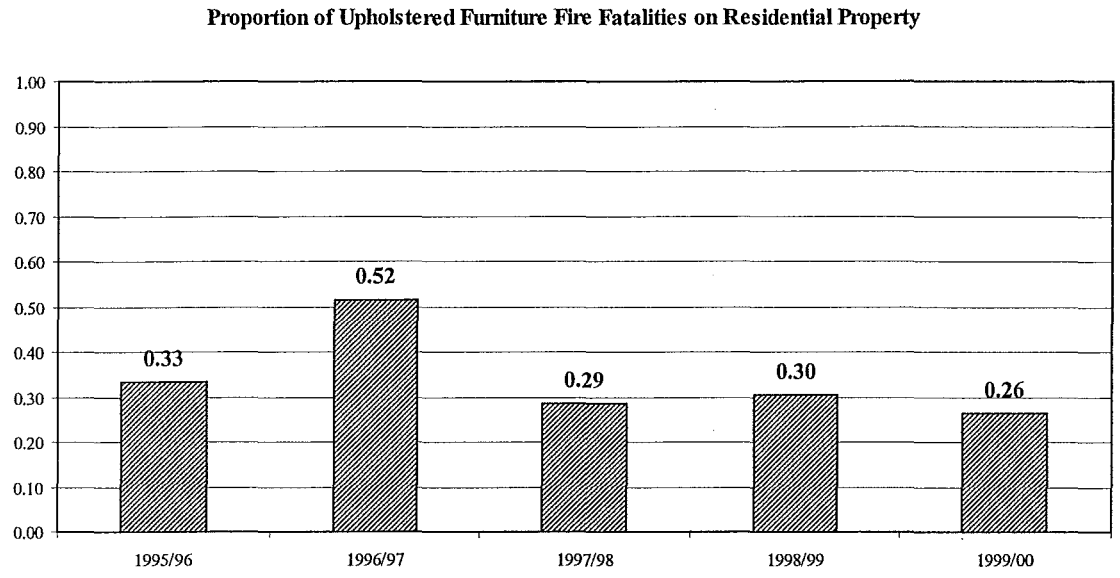

Figure 11: Proportion of upholstered furniture fire fatalities on residential property from 1996 to 2000. (From: Appendix C, Table 28)

Over the five-year period considered, the involvement of upholstered furniture was confirmed in approximately one-third of all residential fatalities each year. However, in 1997, upholstered furniture fires were involved in more than half of all residential fire fatalities. The reason for this sudden increase was the higher than average number of fatalities involving upholstered furniture and the inclusion of several fire incidents that resulted in multiple fatalities as shown in Figure 12.

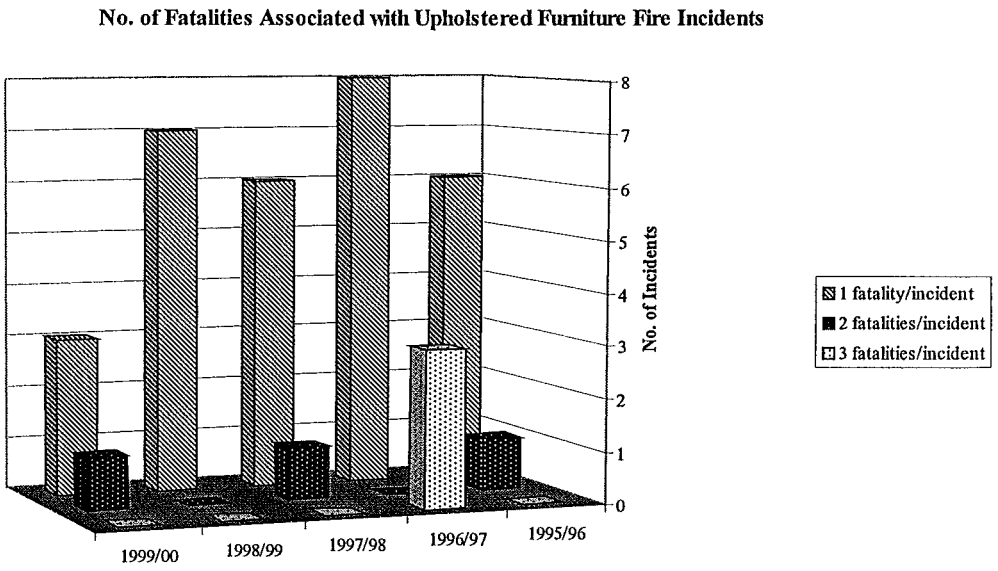

Figure 12: Number of fatalities associated with upholstered furniture fire incidents from 1996 to 2000. (From: Appendix C, Table 29)

6.2.2 Number of Fatalities Per Incident

Figure 13 shows the breakdown of residential fire fatalities involving upholstered furniture from 1996 to 2000 by the number of fatalities sustained in each incident.

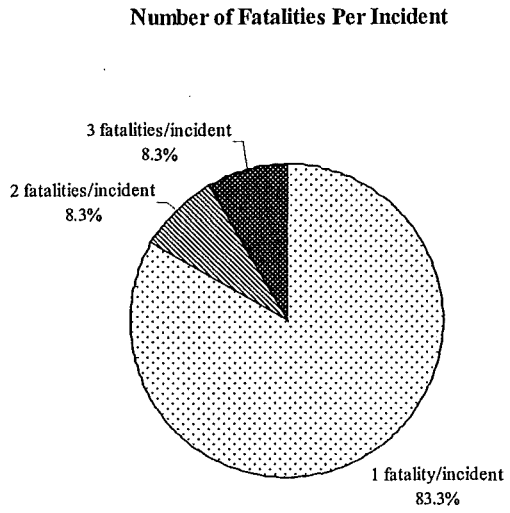

Figure 13: Number of fatalities per incident involving upholstered furniture from 1996 to 2000. (From: Appendix C, Table 29)

Up to 83.3% of fatal residential fire incidents involving upholstered furniture only resulted in one death; with those resulting in two deaths (8.3%), and three deaths (8.3%). Cropp (1991) also noted this tendency towards single-fatality fires in a study of fatal fires in New Zealand, which stated that the large proportion of single-person households contributed to this trend.

6.2.3 Number of Occupants Present at Ignition

Figure 14 shows the breakdown of residential fire fatalities involving upholstered furniture from 1996 to 2000 according to the number of persons present in the residential dwelling at time of ignition of the fire.

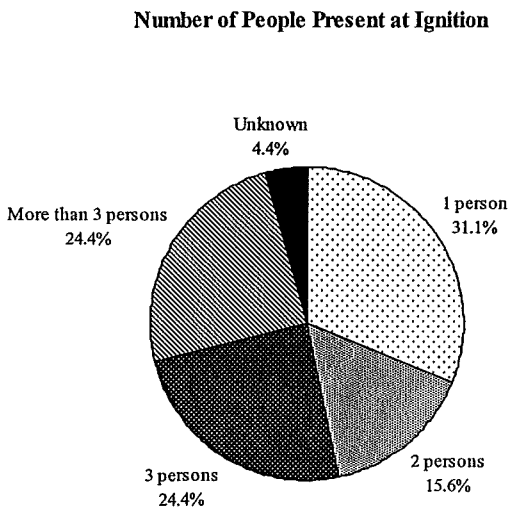

Figure 14: Number of occupants present at time of ignition of fatal residential fire incidents involving upholstered furniture from 1996 to 2000. (From: Appendix C, Table 30)

Further analysis was undertaken to ascertain if Cropp's (1991) observation that the significant proportion of single-person households largely contributed towards the trend of single-fatality fires represented in fire statistics. As observed from Figure 14, only 31.1% of the fire fatalities occurred in residential property where only one person was present at the time of ignition. This was followed by 15.6% where two persons were present; 24.4% where three persons were present; 24.4% where more than three persons were present; and 4.4% where the number of persons present could not be determined.

As shown in Figure 14, most single-fatality fires happened when more than one person was present in the residential property. Anecdotal evidence indicates that the single fatality in such cases is usually a young child (8), a person suffering from limited mobility (2) or intoxicated by drugs or alcohol (4). Meanwhile, the remaining cases of single-fatality fires occurred in single-person households where the single fatality was the only person present in residential property at the time.

6.2.4 Fatalities by Age

Figure 15 shows the breakdown of residential fire fatalities involving upholstered furniture from 1996 to 2000 according to the age of the fatalities.

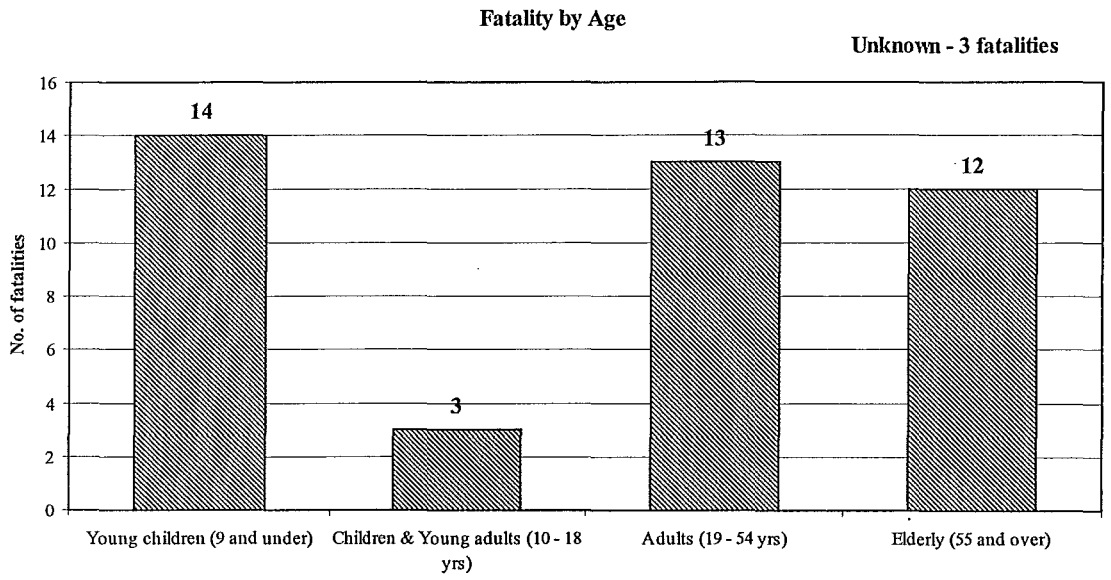

Figure 15: Breakdown of residential fire fatalities involving upholstered furniture by age from 1996 to 2000. (From: Appendix C, Table 31)

Fourteen of the fire fatalities considered were young children below the age of 9 years. Young children have a high rate of fire-related deaths (Cropp, 1991), which is not

unusual. The very young (i.e. babies and infants) are often unable to act independently when confronted with the threat of a fire; while older children are often unaware of correct life-safety behaviour, especially if there is not a family emergency evacuation plan in place. Combined with this inability to evacuate efficiently, young children are also susceptible to lower concentrations of narcotic gases, with the incapacitation of a young child due to smoke inhalation recorded at levels as low as 20% COHb.

Adults between the ages of 19 and 54 years comprised of the second largest age group, with thirteen fatalities between 1996 to 2000. The common trend in fire fatalities involving adults is that the fire occurred while they were asleep (10). Occasionally, alcohol and/or drugs were involved. In such cases, this may have impaired their ability to evacuate, but a considerable majority of adult fatalities were not intoxicated at the time of the fire. This implies that they were either incapacitated by the fire before they awakened, or overcomed while attempting to evacuate.

This common trend in adult fatalities can be clearly illustrated in three common scenarios constructed from the fire incidents investigated. In the first scenario, the occupant awakens to discover the fire and becomes involved in pre-movement activities, such as informing other occupants of the threat, fighting the fire or informing the Fire Service. During this time, the rapid growth rate of the fire results in untenable conditions and the occupant become incapacitated before being able to exit the structure. The type of fuel present in the building, such as the building materials used and the furnishings present would govern the growth rate of the fire.

In the second scenario, the occupant does not awaken and is rapidly overcomed by narcotic gases produced in the fire, especially exposure to carbon monoxide which causes loss of consciousness and coma (Purser, 1995). The absence of smoke detectors and the rapid rate of growth of the fire would be significant factors contributing to fatalities in such cases.

In the third scenario, the occupant inadvertently causes the fire by falling asleep. This is often the case in fire incidents involving ignition of upholstered furniture by smoking materials that were accidentally dropped when the occupant fell asleep either while lying in bed or sitting in a couch. The ignitability of upholstered furniture in such cases played an important role in the resulting fatality.

Elderly persons above the age of 55 years were also considered to be particularly at risk in a fire, with twelve recorded fatalities in the five-year period considered. Often, elderly persons suffer from limited mobility or disabilities that reduce their ability to perceive physical cues from a fire.

Children and young adults between the ages of 10 to 18 years sustained only three fatalities in residential fires involving upholstered furniture. Meanwhile, the ages of three of the fatalities considered could not be determined. In one of these cases, the deceased was described as a young child, but the exact age was not given.

6.2.5 Involvement of Alcohol or Drugs

Figure 16 illustrates the breakdown of residential fire fatalities involving upholstered furniture from 1996 to 2000 according to the involvement of drugs or alcohol.

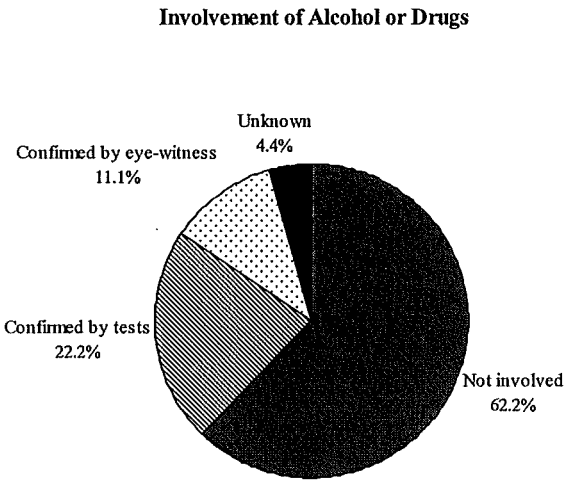

Figure 16: Involvement of alcohol or drugs in fatal residential fire incidents associated with upholstered furniture from 1996 to 2000. (From: Appendix C, Table 32)

In 62.2% of residential fire fatalities considered, alcohol and/or drugs did not play a role in causing the fire or preventing the escape of the resultant fatality. However, alcohol and/or drugs were involved in 22.2% of residential fatalities, and this was further confirmed in tests performed by the Coroner during autopsy. The degree of involvement of alcohol and/or drugs could not confirmed in 11.1% of residential fatalities, but was observed by eye-witness testimony. Meanwhile, the involvement of alcohol and/or drugs could not be confirmed or denied in 4.4% of residential fatalities considered.

6.2.6 Activity at Ignition and During the Fire

Figure 17 illustrates the breakdown of residential fire fatalities involving upholstered furniture between 1996 to 2000 according to activity at ignition and during the fire.

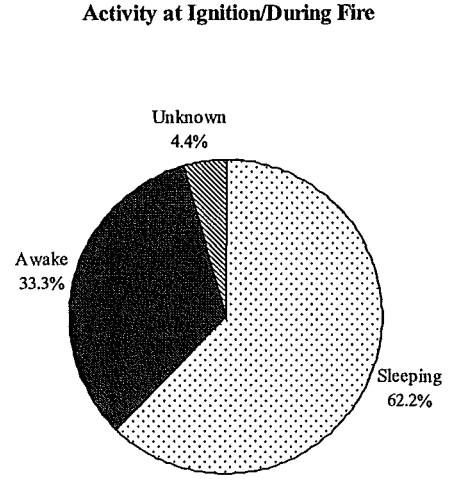

Figure 17: Activity at ignition and during the fire of fatalities associated with upholstered furniture fire incidents from 1996 to 2000. (From: Appendix C, Table 33)

Considering all fatal residential fires involving upholstered furniture, 62.2% of the fatalities were categorised as being asleep. This included sleeping occupants (35.6%); occupants who were asleep at ignition, but then awakened and attempted to evacuate (11.1%); occupants who were intoxicated and asleep during the fire (8.9%); occupants who fell asleep with the heat source (4.4%); and occupants who were asleep at ignition, but then awakened and attempted to fight the fire (2.2%).

Of all the upholstered furniture fire fatalities investigated, 33.3% were awake during the fire. This was further broken down to involve occupants who were awake with the heat source (15.6%); occupants who were awake and engaged in other activities (6.7%);

occupants who were awake and attempted to evacuate (6.7%); and occupants who were awake and attempted to fight the fire (4.4%). Meanwhile, the activities of 4.4% of residential fire fatalities considered were unknown. References made to the heat source in several of these fatal residential fires involved children playing with lighters or matches, or adults smoking cigarettes.

As it can be seen from Figure 17, nearly two-thirds of all fatal residential fires involving upholstered furniture occurred when the occupant was asleep at the time of ignition. Eye-witness reports indicate that many of the survivors who awakened to discover the fire responded to cues from the fire itself; e.g. windows breaking (indicating flashover); the smell of smoke; the sound of the fire; and having perceived unconscious cues that 'something was wrong'.

One-third of all fatal residential fires involving upholstered furniture occurred when occupant was awake and aware of their surroundings. As for survivors who were awake at the time of ignition, anecdotal evidence indicates that many became aware of the fire by direct perception of the fire itself, e.g. seeing smoke and flames; or after being told by someone else who had direct perception of the fire.

6.2.7 Location of Fatality at Time of Ignition

Figure 18 shows the breakdown of residential fatalities involving upholstered furniture from 1996 to 2000 according to the location of the victim at the time of ignition of the fire.

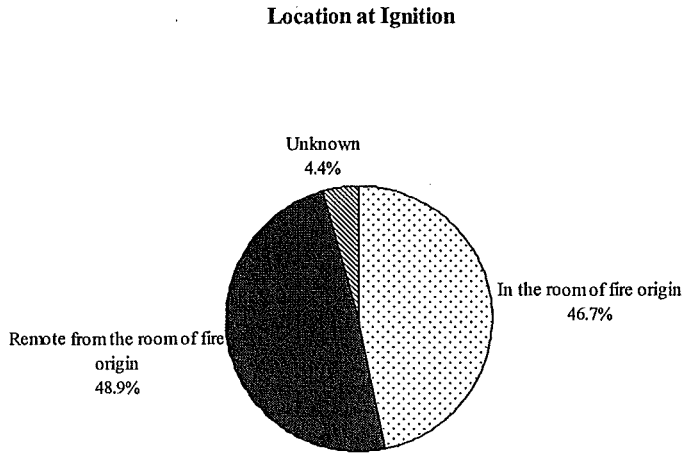

Figure 18: Location of fatality at time of ignition of residential fire incidents involving upholstered furniture from 1996 to 2000. (From: Appendix C, Table 34)

At the time of ignition, 46.7% of the fatalities were present in the room or space of fire origin. In comparison, 48.9% were in a room remote from the room of fire origin. This suggests that the outcome of fires involving upholstered furniture was not significantly affected by the location of the victim at the time of ignition.

In most cases where the victims were remote from the room of fire origin, they were likely to have been asleep and subsequently died from smoke inhalation or injuries sustained from exposure to smoke and heat from the fire. Meanwhile, victims who were present in the room of fire origin at the time of ignition either died from severe burns

sustained in the initial ignition, or were overcome by the effects of the fire before they could evacuate successfully.

6.2.8 Presence of Smoke Detectors

Figure 19 illustrates the breakdown of residential fatalities involving upholstered furniture from 1996 to 2000 according to the presence of smoke detectors in the residential structure at the time of the fire.

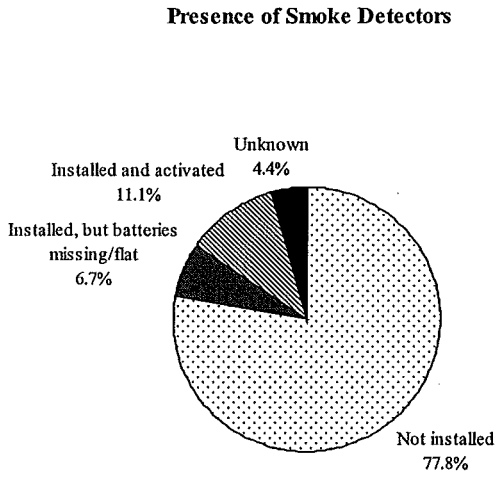

Figure 19: Presence of smoke detectors in fatal residential fire incidents involving upholstered furniture from 1996 to 2000. (From: Appendix C, Table 35)

No smoke detectors were present in fatal residential fires that resulted in 77.8% of all fatalities considered. In 6.7% of residential deaths involving upholstered furniture, smoke detectors had been installed, but the batteries were either missing or flat at the time of the fire incident. The presence of smoke detectors could not be determined in 4.4% of the cases analysed.

Most importantly, smoke detectors were presented and activated during the fire in 11.1% of residential fire fatalities considered. In these cases, the fatalities were the result of other factors. For instance, in two cases, the smoke detector activated but the occupant did not realise the significance of the warning alarm, thus did not proceed to evacuate the building. In three other cases, the occupant died from injuries sustained from the initial ignition of the fire (i.e. was intimate with the fire) and thus, was unaffected by the activation of the smoke detector. However, other occupants who were present in the residential structure at the time responded to the detector alarm and escaped successfully.

6.2.9 Type of Upholstered Furniture Involved in Fatal Fire Incidents

Figure 20 illustrates the breakdown of residential fatalities involving upholstered furniture from 1996 to 2000 according to type of upholstered furniture involved.

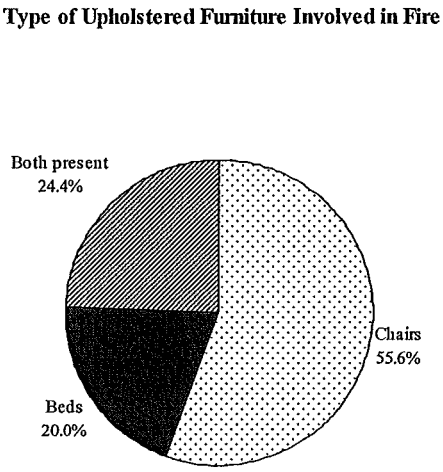

Figure 20: Type of upholstered furniture involved in fatal residential fire incidents from 1996 to 2000. (From: Appendix C, Table 36)

The largest category of upholstered furniture involved in fatal residential fires were chairs and sofas comprising of 55.6% of fatalities considered between 1996 to 2000. This category includes lounge chairs, one-seater and two-seater chairs, 'lazyboy' chairs and settees. Next, the category of beds (upholstered) involved 20.0% of all fatalities. Included in this category are foam mattresses, foam padding and foldout beds with upholstered foam. In up to 24.4% of all residential fatalities involving upholstered furniture, upholstered chairs and beds were both present as part of the fuel load.

6.2.10 Upholstered Furniture - Object n^{th} Ignited

Figure 21 illustrates the breakdown of residential fire fatalities involving upholstered furniture from 1996 to 2000 according to when the upholstered furniture was supposedly ignited.

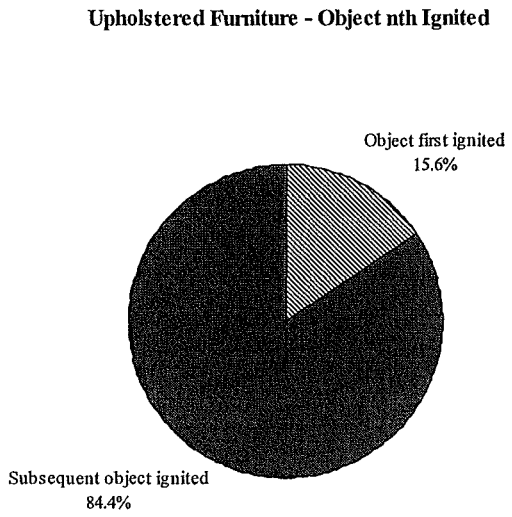

Figure 21: Fatal residential fire incidents involving upholstered furniture as nth object ignited from 1996 to 2000. (From: Appendix C, Table 37)

Upon examining the fire incidents involving upholstered furniture, it was determined that upholstered furniture was not the object first ignited in 84.4% of the fire fatalities considered. Therefore, it is likely flame spread to upholstered furniture in such incidents was via small flame or large flame ignition (i.e. spread from another flaming object).

In 15.6% of residential fatalities considered, upholstered furniture was the first object ignited. In such fires, ignition was commonly the result of carelessness with smoking materials, such as cigarettes, matches and lighters. Usually, ignition occurred when the occupant fell asleep while smoking or failed to adequately extinguish/contain the smoking materials.

6.2.11 Cause of Death

Figure 22 shows the breakdown of residential fire fatalities involving upholstered furniture from 1996 to 2000 according to cause of death as determined from the Coroner's Inquest.

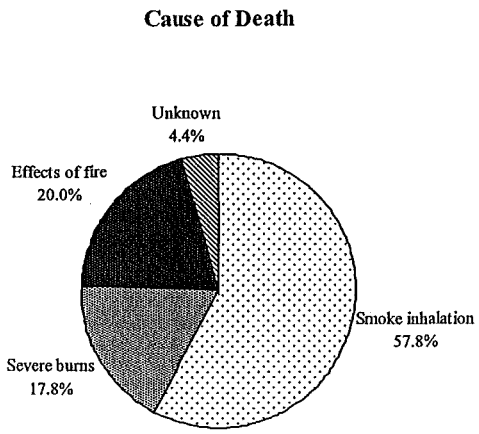

Figure 22: Cause of death of fatalities in residential fire incidents involving upholstered furniture from 1996 to 2000. (From: Appendix C, Table 38)

The largest category of fatalities in the five-year period considered died from smoke inhalation (57.8%), mainly attributed to carbon monoxide poisoning. Blood samples obtained during the autopsy showed that adults who died from smoke inhalation had COHb concentrations between 50% and 85%, while young children were recorded with COHb concentrations as low as 20% up to 50% saturation.

Severe burns were the second most common cause of death for 17.8% of fatalities involving upholstered furniture. In all of these cases, the victims died from severe burns sustained during the fire, or later on from other medical ailments resulting from the initial injuries. In most cases, victims were in the room of fire origin, became intimate with the fire from the initial ignition and upholstered furniture was the first or second object

ignited. The presence of operational smoke detectors in the residential property only contributed to warn other occupants of the fire, but did not affect the outcome of the fatality.

The category 'effects of fire' refers to injuries sustained from exposure to heat and smoke from the fire, involving 20.0% of all fatalities considered. In some of these cases, low levels of COHb concentrations were found in the blood at the time of death.

The cause of death for 4.4% of fatalities involving upholstered furniture could not be determined as information concerning these fatalities was unavailable.

6.2.12 Carboxyhemoglobin Levels

Figure 23 shows the breakdown of fatalities in residential fires involving upholstered furniture from 1996 to 2000 according to levels of carboxyhemoglobin (COHb) found in the blood.

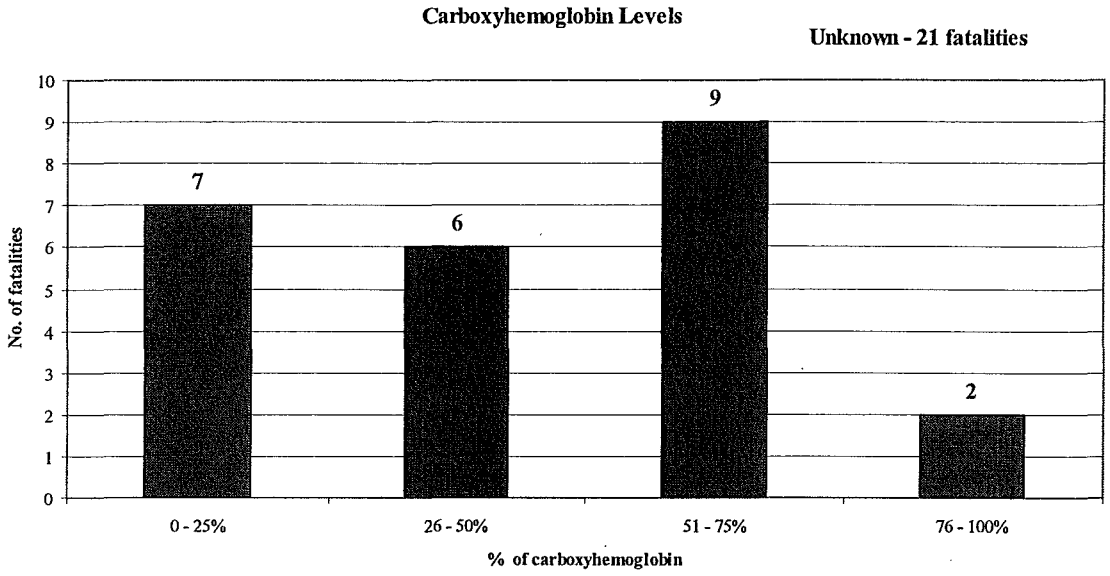

Figure 23: Carboxyhemoglobin levels of fatalities in residential fire incidents involving upholstered furniture from 1996 to 2000. (From: Appendix C, Table 39)

Seven victims were found to have concentrations of COHb in their blood between 0 to 25%. According to Purser (1995), an occupant's behavioural characteristics is affected at low concentrations of COHb between 15 to 20%, but this is typically not enough to result in incapacitation or death. This was apparent in four of the fire incidents where it was determined in the Coroner's Inquest that the victims had died from either severe burns or from exposure to a combination of heat and smoke from the fire, meaning that they died from causes other than carbon monoxide poisoning.

It is also of interest to note that in the remaining three cases, the victims died of smoke inhalation. However, they were all children below the ages of 12 years and were overcome while attempting to evacuate. The low COHb values in these cases may have been attributed to the youthful age of the victims and the high oxygen demand resulting from physical exertion (Hartzell, 1997).

Concentrations of COHb between 26 to 50% were found in six of the residential fatalities considered. Of these, half of the fatalities died from smoke inhalation while the other half were attributed to the effects of the fire (i.e. smoke and heat exposure). Incapacitation from exposure to carbon monoxide can occur at approximately 40% COHb, and even at levels as low as 30% COHb (Purser, 1995).

Hartzell (1997) noted that most fatalities caused by carbon monoxide poisoning occurred at COHb levels of between 50 to 70%. This was observed in the residential fatalities investigated with nine fatalities at COHb concentrations between 51 to 75%, and two fatalities with COHb concentrations at 76% and higher. In twenty-one of the fatalities considered, the concentration of COHb in their blood could not be determined as the information was unavailable.

6.3 Other Factors Influencing Fire Fatalities

While upholstered furniture undeniably plays an important role in fatal residential fires, other factors should also be considered when examining fire fatalities. However, it is usually difficult to apply with any degree of accuracy how substantial these factors are in influencing the patterns and trends of fire fatalities in New Zealand. Some of the main factors that affect the seriousness of residential fires are as follows:

- Installation and maintenance of smoke detectors;

Since the early 1990s, the New Zealand Fire Service has advocated the installation of smoke detectors in residential buildings. Overseas studies (Hall, 2000) show that smoke inhalation fatalities typically occur remote from the room of fire origin while fatalities attributed to burns are likely to occur in or close to the room of fire origin. Smoke detectors allow for earlier warning of a fire and this increases the chances of an occupant being able to evacuate successfully. However, the influence of smoke detectors appears to be restricted to smoke inhalation deaths as smoke detectors would not be able activate in time to warn occupants who are directly in danger from the fire itself (NFPA Fire Analysis Division, 1987).

- Changes in the composition used in furnishings, finishes and other building materials;

Contents of typical New Zealand households have changed considerably with use of more 'modern' materials. This is particularly significant in upholstered furniture, where the trend has been towards synthetic materials that are cheaper and more durable. However, certain materials used in the current production of upholstered furniture may generate more smoke or more toxicants that can lead to greater fatalities in the occurrence of a fire (Denize, 2000).

- Public awareness, and fire safety standards and regulations;

Fire safety campaigns by the New Zealand Fire Service has helped increase awareness of the causes and dangers of residential fires. Some examples of fire awareness campaigns include: encouraging the installation and use of smoke detectors in residential homes, the use of child-safe lighters, and encouraging the discussion and planning of evacuations during a fire. This increased awareness has also led to higher fire safety standards and regulations in production of such items like children's clothing.

Unfortunately, some of these standards and regulations that are intended to reduce a specific hazard of an item, such as the cigarette ignitability of upholstered furniture, may also produce a more severe fire in terms of smoke toxicity (Hall and Harwood, 1995).

- Advances in medical science;

Advances in the treatment of seriously injured victims of fires have helped save people who in the past, would have died from their injuries. These include new techniques for skin grafts and the treatment of burn victims, and improved management of smoke inhalation victims.

- Trends in smoking and alcohol use.

In a study done by Hall (1998) of the patterns of fire casualties in U.S. residential fires by age and sex from 1991 to 1995, it was observed that higher fire death rates were linked to risk-taking behaviour, such as smoking and drinking heavily.

7 Comparison to Other Countries

7.1 Introduction

In the U.S. and United Kingdom, similar research has been done to study the contribution of upholstered furniture to residential fire fatalities. The following section details some of the fire statistics obtained from previous studies and examines the influence of regulatory standards on upholstered furniture-related deaths in those countries.

7.2 U.S. Studies

7.2.1 Miller, 1983 - 1987 (1991)

In a study of U.S. residential fire incidents between 1983 and 1987, Miller (1991) found that upholstered chairs and sofas were the objects first ignited in 22,900 residential fire incidents each year, resulting in 1,044 civilian fatalities, 2,337 civilian injuries and $214.5 million in direct property damage.

Table 9: The ten leading forms of material first ignited in residential fire incidents between 1983 and 1987 (Source: 1983-1987 NFIRS, NFPA Survey).

Forms of Material First Ignited	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage
Rubbish or trash	15.7%	2.5%	3.1%	3.7%
Cooking materials	14.0%	2.7%	16.4%	4.4%
Structural member or framing	7.8%	7.6%	4.4%	18.9%
Mattress and bedding	7.2%	16.1%	15.3%	7.5%
Electric wire or cable insulation	6.8%	3.7%	3.3%	5.4%
Fuel	4.5%	4.4%	6.6%	4.0%
Interior wall covering	4.3%	7.1%	4.0%	8.4%
Upholstered furniture	**3.9%**	**22.9%**	**12.1%**	**6.3%**
Exterior sidewall covering	3.0%	0.6%	0.8%	3.5%
Clothing (not on person)	2.7%	2.3%	3.3%	2.7%

The connection between upholstered furniture and fire fatalities was made based on the forms of material first ignited in fatal residential fires. From Table 9, it can be clearly seen that upholstered furniture was the leading consumer product initially ignited in fatal residential fires in the U.S. between 1983 to 1987.

However, it should be noted that in this study, only 'products' of residential homes were included, thereby excluding such materials like waste or refuse, structural components and exterior coverings. While rubbish, cooking materials and structural members were the top three most common forms of materials initially ignited in residential fires, they were not the leading causes of fire fatalities according to Table 10. Upholstered furniture was the form of material first ignited in 3.9% of all residential fires, but was associated with 22.9% of all residential fatalities.

Table 10:The five leading products associated with residential fire fatalities between 1983 and 1987 (Source: 1983-1987 NFIRS, NFPA Survey).

	Civilian Deaths	
Upholstered furniture	**1044**	**22.9%**
Mattress and bedding	732	16.1%
Interior wall covering	322	7.1%
Clothing (on a person)*	130	2.9%

* Moves up to fourth place if all clothing fires are combined.

Cigarettes were observed to be the leading heat source involved in upholstered furniture fires and related fatalities. This is evident as abandoned or discarded materials, such as cigarettes and matches, was the leading ignition factor in upholstered furniture fires (Table 11).

Table 11: The leading ignition factors associated with upholstered furniture fires in residential property between 1983 and 1987 (Source: 1983-1987 NFIRS, NFPA Survey).

Ignition Factor	Fires	Civilian Deaths	Civilian Injuries	Direct Property Damage
Abandoned or discarded material	43.7%	49.9%	45.3%	41.7%
Incendiary or suspicious	14.6%	4.0%	7.9%	15.2%
Child playing	9.9%	8.2%	13.9%	9.5%
Asleep	8.8%	17.1%	12.5%	6.9%
Combustible too close	4.3%	3.5%	3.4%	4.8%
Short circuit or ground fault	3.5%	2.0%	2.2%	4.9%
Other known*	15.2%	15.3%	14.8%	17.2%

* Consists of individual ignition factors, each of which accounts for less than 3% of these fires.

7.2.2 Consumer Product Safety Commission (CPSC)

In the United States, the Upholstered Furniture Action Council (UFAC) is an industry-based body with voluntary standards governing the manufacture of upholstered furniture. In recent publications on the official Consumer Product Safety Commission website (CPSC, 2000), the UFAC claimed that cigarette ignited upholstered furniture fires had declined by 77% since the 1978 implementation of the UFAC's voluntary standards program concerning the performance criteria of upholstered furniture components and fabrics.

Table 12: Comparison of upholstered furniture fires and related deaths for 1978and 1995 (Source: US Consumer Product Safety Commission, based Federal Government statistics).

	1978		1995		Change	
	Fires	Deaths	Fires	Deaths	Fires	Deaths
Total residential fires	730500	6185	425500	3695	-41.8%	-40.3%
Total upholstered furniture fires	43000	1600	13600	670	-68.4%	-58.1%
Upholstered furniture fires due to smoking materials	28000	1300	64000	500	-77.1%	-61.5%
Upholstered furniture fires due to open flame	7900	200	3500	90	-55.7%	-55.0%
Upholstered furniture fires due to other causes	7100	100	3700	80	-47.9%	-20.0%

While there has been a notable decrease in the fire statistics related to upholstered furniture as can be seen in Table 12, it is difficult to conclude with any certainty that the above comparison of upholstered furniture fires and associated fatalities were significantly influenced by the adoption of the UFAC voluntary national standard for cigarette ignition resistance. In the publication detailing the UFAC's achievements

(CPSC, 2000), the substantial decline of upholstered furniture-related incidents were also attributed to the lower proportion of smokers, increased use and maintenance of smoke detectors, as well as the implementation of communication and consumer education programs.

7.3 U.K. Studies

7.3.1 Home Office: Fire Statistics, 1988 - 1993 (1995)

In 1993, fire personnel in the U.K. attended 108,700 fire incidents in occupied buildings, 1,200 more than in 1992 mainly due to a rise in fires in residential dwellings, private garages and sheds. Of the 65,300 residential dwelling fires that occurred in 1993, upholstered furniture was mainly responsible for the development of the fire in approximately 5.7% of fire incidents, but these fires resulted in over 25% of fire deaths and 14% of non-fatal fire casualties in dwellings.

Table 13: Fire incidents and casualties from all residential dwelling fires attended by local authorities from 1988 to 1993 (Source: Home Office, Statistics Division 3, Research and Statistics Department).

Year	No. of fires (in thousands)	Deaths (per 1000 fires)	Non-fatal casualties (per 1000 fires)
1988	64.2	11.4	159
1989	64.5	10.0	161
1990	63.2	9.9	166
1991	64.1	9.5	175
1992	64.6	9.2	174
1993	65.3	8.2	175

As shown in Table 14, there has been a gradual decrease in the percentage of dwelling fires involving upholstered furniture from 1988 to 1993, despite an overall increase in the number of dwelling fires during this period (Table 13). The proportion of fire deaths per 1000 fires involving upholstered furniture remained higher than those involving dwelling fires over the six-year period considered. While fire reports specifically noted the involvement of foam in over 70% of all upholstered furniture fires, they did not specifically differentiate between combustion modified foam and other foams used in upholstered furniture produced before 1950. As a result, it was difficult to confirm the reasons behind the progressive decrease in fire deaths and non-fatal casualties in upholstered furniture fires.

Table 14: Upholstered furniture-related fire incidents and casualties in the U.K. from 1988 to 1993 (Source: Home Office, Statistics Division 3, Research and Statistics Department).

Year	No. of fires	% of dwelling fires	No. of deaths	Deaths (per 1000 fires)	Non-fatal casualties
1988	4818	7.5	247	51	1896
1989	4482	6.9	201	45	1707
1990	4327	6.9	180	42	1759
1991	4311	6.7	147	34	1803
1992	4048	6.3	166	41	1660
1993	3746	5.7	146	39	1618

7.3.2 Geering and Sutton, 1995 (1996)

From the period July 1994 to June 1995, Geering and Sutton (1996) investigated a total sample of 439 fatal fire incidents, in which 58 incidents occurred outside, in a garage, shed or car and were not included in the final study. Further analysis of the fire incidents

showed that the most common cause of fatal fires was smoking materials igniting upholstery, soft furnishings and bedding material.

Upholstery was the most common material ignited by smoking materials, with 73 fire incidents beginning in this manner. Polyurethane foam was often noted as the material generating the most smoke, and in 15 cases, was the material first ignited in the fire. The living area of the residential dwelling was the dominant room of origin (87%). Many of the fires started smouldering and spread after occupants had left the living area and gone to bed.

In this sample of upholstered furniture fires, 58% of fatalities were male and 47% were over the age of 65 years. Eleven of the fatalities were disabled in some way or were suffering from senile dementia while nine were under the influence of alcohol at the time of the fire. Of this category, 24% had smoke detectors installed in the dwelling, but in only nine cases did the smoke detector activate during the fire. Many of the smoke detectors were not operational because their batteries were either missing or flat.

7.4 Australian Studies

7.4.1 Dowling and Ramsay, 1989 - 1993 (1997)

According to a study done by Dowling and Ramsay (1997) based on data collected by the Australian Fire Incident Reporting System (AFIRS), in buildings with lounge and sleeping areas, fires involving upholstered furniture resulted in more fatalities and relatively more damage. This conclusion was based on statistical data collected from between 1989 to 1993 with an estimated AFIRS coverage of Australian fire incidents between 81 to 85%.

Table 15: Extent of fire damage by form of material ignited first in building structure fires from 1989 to 1993 (Source: AFIRS).

Form of material ignited first	Extent of flame damage				
	Confined to object or room of fire origin	Spread beyond room of fire origin	Other, unknown	All fires*	Spread beyond room of fire origin (%)
Mattress, pillow or bedding	2008	501	34	2543	19.7
Cooking materials	6450	344	391	7185	4.8
Upholstered furniture	**701**	**282**	**11**	**994**	**28.4**
Other forms of materials	21645	5245	983	27873	18.8
Other, unknown	2612	2799	291	5702	49.1
Total	33506	9171	1710	44297	20.7

* Does not include cases where 'Extent of Damage' was not filed.

When comparing forms of material first ignited (Table 15), fires involving upholstered furniture were five times more likely to spread beyond the room of fire origin than fires involving cooking materials, resulting in more damage to the structure and its contents. In addition, once a fire has spread beyond the room of fire origin, it becomes a significant life-safety hazard towards all occupants within the building.

Table 16: Casualties and deaths in building fires by form of material ignited first from 1989 to 1993 (Source: AFIRS).

Form of material ignited first	Injuries		Deaths	
	Occupants	Firefighters	Occupants	Firefighters
Mattress, pillow or bedding	356	44	34	0
Cooking materials	459	28	12	0
Upholstered furniture	**107**	**18**	**17**	**0**
Other forms of materials	1220	361	86	3
Other, unknown	540	298	102	2
Total	2682	749	251	5

While the total number of fire incidents involving upholstered furniture was far less than those involving mattresses and bedding (Table 15 and 16), it was noted in the study that fires associated with upholstered furniture resulted in proportionally more fatalities. Comparatively, fires involving upholstered furniture were also more severe, resulting in a wider extent of flame damage.

7.5 Discussion

When comparing fire statistics from overseas countries, a common trend becomes apparent. In the U.S., United Kingdom and Australia, fire incidents involving upholstered furniture typically pose a higher life-safety hazard and result in a wider extent of flame damage. Various studies showed that fires in which upholstered furniture was the object first ignited resulted in a significant proportion of fire fatalities; 22.9% in the U.S. (Miller, 1991); 35% in the United Kingdom (Department of Trade and Industry, 2000); and 6.7% in Australia (Dowling and Ramsay, 1997). However in New Zealand, fatal residential fire incidents in which upholstered furniture was the object first ignited accounted for only 3.2% of fire fatalities (Section 5.2.3).

Differences between New Zealand fire statistics and overseas statistics can be attributed to several factors. One factor is the incompleteness of the New Zealand FIRS database where approximately 33% of all residential fatalities occurred in fire incidents in which the object first ignited was undetermined. This is a significant percentage of the fire fatality statistics and would certainly influence the proportion of fatal fires involving upholstered furniture.

Upon examining the heat sources associated with upholstered furniture fires, abandoned or discarded materials such as cigarettes and matches were the leading ignition factor in the U.S. and United Kingdom (Miller, 1991; Geering and Sutton, 1996). Characteristics involved with the manufacture and use of such smoking materials would affect the majority of upholstered furniture ignited this way. For example, characteristics such as the type of cigarettes sold, the method of 'rolling' cigarettes from loose tobacco and the tightness of rolled cigarettes would determine if ignition would be possible when in contact with upholstered furniture. The influence of these variable characteristics would affect the probability of ignition of upholstered furniture from smoking materials in other countries and in New Zealand.

While upholstered furniture was the object first ignited in a modest proportion of fatal residential fires in New Zealand, it was shown in Section 6.1.3 that involvement of upholstered furniture was confirmed in fire incidents that accounted for up to 35.4% of all residential fatalities. This is relatively compatible with fire statistics previously quoted for the U.S. and United Kingdom concerning the number of fatalities in upholstered furniture fires. This means that while upholstered furniture in New Zealand is usually not the object first ignited in a fire, it is involved to some degree in a considerable number of fatalities.

8 Conclusions

The main conclusions of this report are as follows:

- Upholstered furniture was involved in 35.4% of residential fatalities or 45 deaths over the period of 1996 to 2000. The FIRS database recorded a total of 127 fatalities resulting from 105 fire incidents on residential property during that five-year period.

- The following are common trends found in residential fire incidents involving upholstered furniture:

➢ Typically resulted in a single fatality;
➢ Usually more than one person was present in the residential structure when ignition occurred;
➢ Young children, the elderly and persons intoxicated by drugs or alcohol were particularly susceptible;
➢ Occupants were usually asleep when ignition occurred;
➢ The most common cause of death for occupants remote from the room of fire origin was smoke inhalation;
➢ The most common cause of death for occupants within the room of fire origin was from severe burns or exposure to heat and smoke from the fire;
➢ Smoke detectors were not present or defective in most incidents;
➢ Upholstered furniture was usually not the object first ignited, meaning it was ignited later on in the fire by means of either small flame or large flame ignition sources.

- Based on the analyses done, upholstered furniture contributed to residential fire fatalities in the following ways:

  - Toxic combustion products; i.e. narcotic gases such as carbon monoxide and hydrogen cyanide;
  - Rapid fire growth rate and flame spread; i.e. tenability limits are reached before occupants are able to evacuate;
  - Cigarette and small flame ignitability; i.e. assists in the start and spread of the fire.

8.1 Recommendations

- The FIRS database should be periodically updated to ensure any new information is included. This will help reduce the uncertainties involved in the data and is especially important as the database is the most convenient source of information concerning the trends and patterns of fire incidents in New Zealand.

- Related sources of information such as Coroner's Inquest reports and subsequent NZFS Fire Investigation reports should be included with FIRS data sheets in the fire incident archives. While most of the newer 1999/2000 fire incident files do include the aforementioned reports, it was difficult to obtain Coroner's Inquest reports related to incomplete fire incident files as the reference numbers for these reports were unavailable except from the Coronial Services offices in Wellington.

8.2 Future Research

- An investigation could be undertaken into the methods and adopted practices in overseas countries, especially in the U.S. and United Kingdom where there exists regulatory standards governing the manufacture and sale of upholstered furniture.

- A cost benefit analysis could be carried out to examine the costs of reducing the potential fire hazard of upholstered furniture in comparison to the benefits gained by reductions in direct property damage and fatalities from fires involving upholstered furniture. This analysis could also cover preventive measures which involve changing the composition, form or materials used in upholstered furniture, and fire safety protection measures which would allow the occupant to escape successfully in the event of a fire (e.g. smoke detectors).

- A similar study of residential fires involving upholstered furniture may be carried in five or so years time in order to examine a larger and more statistically significant pool of upholstered furniture fire fatalities in New Zealand. This study could also further investigate the ignitability of upholstered furniture, the influence of smoke detectors and the effects of alcohol and smoking on the fire fatality rate.

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A. Appendix A: Emergency Incidents Statistics, 1995 - 1999

Table 17: Summary of property involved in all fires from 1995 to 1999.

	1994/95	1995/96	1996/97	1997/98	1998/99	TOTAL
Miscellaneous	7921	6766	8222	9685	8552	41146
Residential	6951	6603	7059	8682	7631	36926
Others (<5%)	3813	3597	4343	4360	3802	19915
Primary Industry & Utility	1857	1276	1327	1937	1508	7905
TOTAL	20542	18242	20951	24664	21493	105892
Public Assembly	999	851	1006	1199	939	4994
Commercial	734	821	1041	1007	952	4555
Storage	789	644	808	765	645	3651
Manufacturing	581	660	721	597	576	3135
Education	461	369	488	506	436	2260
Health Care & Detention	225	202	264	262	246	1199
Non-existent address	24	50	15	24	8	121

Table 18: Breakdown of residential property involved in fires from 1995 to 1999.

	1994/95	1995/96	1996/97	1997/98	1998/99	TOTAL
Houses, Apartments & Flats	6772	5928	6294	7921	6999	33914
Residential Outbuildings	31	505	584	563	468	2151
Hotels, Motels & Lodges	82	101	103	129	86	501
Boarding, Half-way Houses & Dormitories	66	68	78	67	77	356
Unclassified	0	1	0	2	1	4
TOTAL	6951	6603	7059	8682	7631	36926

Table 19: Residential structure fires by room or space of fire origin from 1996 to 1999.

	1994/95	1995/96	1996/97	1997/98	1998/99	TOTAL
Kitchens	*	1059	1186	1342	1224	4811
Unknown	*	862	882	920	853	3517
Others (<5%)	*	691	758	759	738	2946
Lounge Area	*	744	771	759	631	2905
Bedrooms	*	592	615	575	461	2243
Garage or Carport	*	293	350	349	293	1285
Chimney	*	231	277	202	222	932
TOTAL	*	4472	4839	4906	4422	18639
Hallway & Stairs	*	128	129	125	126	508
Outside & Multiple Areas	*	93	133	154	185	565
Laundry area	*	129	140	119	113	501
Ceiling & Roof Assembly	*	77	89	95	86	347
Storage Areas	*	97	98	81	85	361
Dining Areas	*	49	38	46	33	166
Toilet & bathroom	*	49	56	62	58	225
Service & Equipment Areas	*	30	35	42	26	133
Vehicle Areas	*	28	20	23	14	85
Office	*	7	7	3	7	24
Sales & Assembly Areas	*	2	6	0	1	9
Technical Areas	*	2	7	9	4	22

*** Data unavailable.**

Table 20: Type of property where fatality occurred from 1996 to 1999.

	1994/95	1995/96	1996/97	1997/98	1998/99	TOTAL
Health Care and Detention	*	0	6	1	1	8
Residential	*	25	35	29	25	114
Miscellaneous	*	7	11	17	16	51
TOTAL	46	32	52	47	42	219

*** Data unavailable.**

B. Appendix B: FIRS Statistics, 1996 - 2000

Table 21: Incident key, date and address categories of fatal residential fire incidents from 1996 to 2000 according to FIRS database.

Incident Key	Date	Address
1641 9501211	7/4/95	4 Charlemont St, Hamilton
3622 9501714	7/15/95	86 Glasgow St, Dunedin
1432 9508681	7/31/95	227 Bucklands Beach Rd, Pakuranga
1431 9509381	8/19/95	28 Luke St, Otahuhu
2961 9504456	8/22/95	2/22 Miriam St, Masterton
2941 9504786	9/11/95	Cnr High St & Rainey Gr, Taita
2355 9501228	10/15/95	Upper Austin Rd, Normanby
1881 9500986	11/4/95	Ariariterangi St, Rotorua
5A01 9504423	11/10/95	12 Frankleigh St
1821 9500528	11/11/95	79 Hatepe Ave, Taupo
2375 9501079	11/25/95	Rangataua Rd, Ohakune
1891 9600303	2/3/96	Tahuna Rd, Te Teko
1891 9600303	2/3/96	Tahuna Rd, Te Teko
2421 9601326	5/3/96	31 Ngata St, Palmerston Nth
1891 9601169	5/4/96	232 River Rd, Kawerau
1821 9601307	5/19/96	29 Rawhiti St, Taupo
1821 9601307	5/19/96	29 Rawhiti St, Taupo
1887 9601446	5/31/96	Monowai Rd, Atiamuri Vlge
3631 9601350	6/16/96	10 Dryden St, Mosgiel
1421 9607898	6/18/96	303 Tamaki Dr, Kohimarama
2324 9600047	6/22/96	State Highway 40, Waitaanga
2324 9600047	6/22/96	State Highway 40, Waitaanga
2767 9601307	6/22/96	Maunga Rd, Dannevirke
3633 9601468	6/30/96	800 Brighton Rd, Ocean View
1430 9608835	7/9/96	18B Hillcrest Rd, Manurewa
1423 9609002	7/13/96	38 Lexington Dr, Howick
2941 9603755	7/20/96	182 Waddington Dr, Naenae
1431 9609315	7/21/96	26 McIntryre Rd, Mangere
3842 9601305	8/24/96	23 Nightingale St, Wyndham
1641 9602018	9/5/96	111 Fairview St, Hamilton
3821 9601588	10/9/96	187 Erkine Rd, Otatara
3821 9601588	10/9/96	187 Erkine Rd, Otatara
3821 9601588	10/9/96	187 Erkine Rd, Otatara
2947 9605398	10/10/96	19A Feild St, Silverstream
1423 9614306	11/12/96	12 Alana Pl, Mt Wellington
1821 9603064	11/16/96	31A Rawhiti St, Taupo
2944 9606420	11/22/96	179 Wainuiomata Rd, Wainuiomata
2421 9603541	12/8/96	27 Wakefield St, Palmerston Nth
3639 9603131	12/20/96	5 Kelman St, Alexandra
3425 9606410	12/23/96	25 Euston St, Christchurch
2651 9603064	12/29/96	Avenue Rd, Taradale
2681 9603078	12/30/96	35 Royd Rd, Hexton, Gisborne

1891 9700002	1/1/97	14 Weld St, Kawerau
1891 9700002	1/1/97	14 Weld St, Kawerau
1888 9700099	1/11/97	McLean Rd, Mangakino
1888 9700099	1/11/97	McLean Rd, Mangakino
3774 9700167	1/19/97	Tiverton St, Palmerston
1632 9700590	2/23/97	55 Kimihia Rd, Huntly
2371 9700978	3/23/97	34 Plymouth St, Wanganui
1493 9708506	6/20/97	11 Riverside Dr, Point Wells, Ak.
1493 9708506	6/20/97	11 Riverside Dr, Point Wells, Ak.
1493 9708506	6/20/97	11 Riverside Dr, Point Wells, Ak.
2948 9703863	6/20/97	Whitemans Valley Rd, Upper Hutt
1266 9708587	6/21/97	Matauri Bay Rd, Matauri Bay
1266 9708587	6/21/97	Matauri Bay Rd, Matauri Bay
1266 9708587	6/21/97	Matauri Bay Rd, Matauri Bay
2841 9700260	6/22/97	Main Road, Otaki
1633 9701836	7/13/97	153 Park Rd, Horotiu
3424 9704164	8/18/97	10 Kuaka St, Bromley, Chch.
3621 9702094	8/29/97	93D Prince Albert Rd, St Kilda
2931 9705531	9/1/97	4 Lincoln Gr, Cannons Creek,Porirua
2931 9705531	9/1/97	4 Lincoln Gr, Cannons Creek,Porirua
3959 9701371	9/18/97	60 Hastings St, Ohai
2929 9706773	10/19/97	98 Ruskin Rd, Newlands
1641 9702937	11/10/97	83B Pembroke St, Hamilton East
1423 9715772	11/21/97	1 Caen Rd, Panmure, Auckland
1423 9800071	1/2/98	21 Erima Ave, Glen Innes, Auckland
3587 9800287	1/13/98	Esk Valley Rd, St Andrews
1466 9804185	3/5/98	2 Murray Rd, Te Atatu, Auckland
1460 9804458	3/9/98	22 Cutler St, New Lynn, Auck
2944 9802978	4/6/98	20 Karamea Gr, Wainuiomata
1430 9806148	4/10/98	3/17 Green St Papakura
1423 9806229	4/11/98	29 Taratoa St, Pt. England, Auckland
1423 9806229	4/11/98	29 Taratoa St, Pt. England, Auckland
3270 9800751	4/18/98	Golden Sands Rd, Barrytown
1641 9801427	4/24/98	Eliot St, Hamilton
3567 9803010	5/10/98	34 Denby Place, Hamner Springs
1430 9808067	5/21/98	18 Tiranui Station St West, Papakura
3580 9803674	6/14/98	57 McDonald St Timaru
3263 9801111	6/17/98	10 Wainui St, Brunner
1476 9809594	6/22/98	160 Lone Kauri Rd, Karekare
1887 9802531	6/26/98	28 Grace Cr, Tokoroa
1887 9802531	6/26/98	28 Grace Cr, Tokoroa
2651 9802450	6/27/98	75 Hillary Cres, Napier
2651 9802450	6/27/98	75 Hillary Cres, Napier
2481 9802598	7/6/98	21 Broadway, Marton
1871 98A002885	8/20/98	119 Fourteenth Ave, Tauranga
1424 98A003686	8/26/98	2/27 A Shadwell Pl, St Heliers, Auckland
1650 98A011231	10/21/98	Ahurei St, Kawhia
2656 98W010448	11/7/98	703 Park Rd, Sth Hastings
3623 98M013260	11/13/98	115 Mulford St, Dunedin
1438 98A015470	11/18/98	President Ave, Papakura
3623 98M014986	11/29/98	Sidey St, Dunedin

1489 98A020026	12/14/98	144a Parkhurst Rd
3423 99M018816	1/8/99	81 Paparoa St, Papanui, CHCH
3427 99M020507	1/22/99	Shackleton St, New Brighton
3427 99M020507	1/22/99	Shackleton St, New Brighton
1462 99A026456	1/24/99	35 Glass Rd, Waikowhai, Mt Roskill
1460 99A028668	2/6/99	292 Rosebank Rd, Avondale, Auckland
1433 99A036587	3/20/99	28 Israel St, Otara, Auckland
3642 99M027508	3/21/99	Cromwell
3642 99M027508	3/21/99	Cromwell
3642 99M027508	3/21/99	Cromwell
1433 99A039215	4/5/99	31C Edward St, Otara
2681 99W031365	4/24/99	13 Leon St, Gisborne
2944 99W038653	5/30/99	3 Aparoa Grove, Wainuiomata
1267 99A053156	6/22/99	Pungarere Rd, Kerikeri
1867 99A054621	6/29/99	28 Marine Ave, Waihi Beach
1461 99A055070	7/1/99	62 View Road, Mt Eden, Auckland
2838 99W048500	7/25/99	47 Te Moana Road, Waikanae
2941 99W034197	8/5/99	144 Whites Lane, East Lower Hutt
2941 99W034197	8/5/99	144 Whites Lane, East Lower Hutt
1891 99A061633	8/13/99	22 Fenton Mill Road, Kawerau
1891 99A061633	8/13/99	22 Fenton Mill Road, Kawerau
1482 99A067639	9/19/99	114 Ocean View Road, Northcote, Nth Shore City
1272 99A077319	11/14/99	Allen Bell Drive, Kaitaia
2681 99W066290	11/18/99	5 Ngaio St, Gisborne
2655 00W076733	1/2/00	81 Avondale Rd, Napier
2924 00W077244	1/5/00	10 Hepara St, Hataitai, Wgtn
1485 00A090491	1/20/00	16 Glenvar Rd, Torbay, Auckland
1212 00A094237	2/8/00	5 Heretaunga St, Whangarei
1212 00A094237	2/8/00	5 Heretaunga St, Whangarei
2653 00W108879	5/25/00	12 Pufflett Rd, Havelock North
1874 00A122845	5/26/00	44 Maketu Rd, Maketu
1874 00A122845	5/26/00	44 Maketu Rd, Maketu
3494 00M099853	6/10/00	Mayfield, Mayfield
2943 00W113486	6/14/00	359C George St, Stokes Valley, Lower Hutt

Table 22: Specific type of residential property where fatality occurred from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Houses	19	24	23	19	16	101
Flats, Home Units & Apartments	5	4	4	1	2	16
Residential Outbuildings	0	2	1	3	1	7
Boarding, Half-way Houses & Dormitories	0	3	0	0	0	3
Hotels, Motels & Lodges	0	0	0	0	0	0
TOTAL	24	33	28	23	19	127

Table 23: Residential fire fatalities by room or space of fire origin from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Bedrooms	12	9	14	6	2	43
Lounge Area	6	13	3	5	7	34
Kitchens	3	6	7	1	5	22
Others (<5%)	2	2	3	9	5	21
Unknown	1	3	1	2	0	7
TOTAL	24	33	28	23	19	127
Garage or Carport	0	1	0	2	3	6
Hallway & Stairs	0	0	0	5	0	5
Outside & Multiple Areas	0	0	0	1	1	2
Dining Area	2	0	0	0	0	2
Laundry area	0	0	1	0	0	1
Ceiling & Roof Assembly	0	0	0	0	1	1
Storage Areas	0	0	1	0	0	1
Toilet & bathroom	0	0	1	0	0	1
Service & Equipment Areas	0	1	0	0	0	1
Vehicle Areas	0	0	0	1	0	1
Chimney	0	0	0	0	0	0
Office	0	0	0	0	0	0
Sales & Assembly Areas	0	0	0	0	0	0
Technical Areas	0	0	0	0	0	0

Table 24: Object first ignited in fatal residential fire incidents from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Other	7	18	3	9	5	42
Other soft goods & wearing apparel	9	3	5	6	2	25
Power transfer, equipment & fuel	3	5	9	2	2	21
Structure components	1	1	3	6	5	16
General items	3	4	3	0	3	13
Other furniture & utensils	1	0	3	0	2	6
Upholstered soft goods & wearing apparel	0	0	2	0	0	2
Upholstered furniture & utensils	0	2	0	0	0	2
TOTAL	24	33	28	23	19	127
Structure components:						
Structure component (unknown)	0	0	0	2	0	2
Exterior	0	0	1	0	0	1
Floor coverings, carpets & mats/rugs	1	1	1	0	0	3
Interior wall covering	0	0	1	1	3	5
Framing	0	0	0	3	2	5
Other furniture & utensils:						
Chairs, sofas, beds & vehicle seats (other)	0	0	1	0	2	3
Cabinetry, desks, tables & drawers	1	0	2	0	0	3
Other soft goods & wearing apparel:						
Mattress & pillow	2	0	1	1	0	4
Bedding, blankets & sheets	5	2	4	2	0	13
Soft goods (unknown)	0	0	0	1	0	1
Linen, towel & table clothes	0	0	0	0	2	2
Clothing & wearing apparel (not on person)	2	0	0	1	0	3
Clothing & wearing apparel (on person)	0	1	0	0	0	1
Curtains, blinds & drapes	0	0	0	1	0	1
Power transfer, equipment & fuel:						
Electrical wire & insulation	0	1	1	0	1	3
Flammable liquids and gases	3	4	8	2	1	18
General items:						
Rubbish, garbage & waste	1	0	1	0	0	2
Cooking materials & food	2	4	2	0	3	11
Other:						
Multiple items	0	3	1	2	0	6
Unknown	7	15	2	7	5	36
Upholstered soft goods & wearing apparel	0	0	2	0	0	2
Upholstered furniture & utensils	0	2	0	0	0	2

Table 25: Heat sources involved in fatal residential fire incidents from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Cigarettes, matches & candles	12	10	11	7	7	47
Unknown or unclassified	6	11	8	7	2	34
Hot object	4	9	4	3	5	25
Arcing or overloaded electrical equipment	0	3	2	6	1	12
Others (<5%)	2	0	3	0	4	9
TOTAL	24	33	28	23	19	127
Others (<5%)						
Solid fuel powered equipment	0	0	0	0	3	3
Gas or liquid fuel powered equipment	2	0	0	0	1	3
Outside fires, sparks & embers	0	0	2	0	0	2
Exposure fire	0	0	1	0	0	1
Unknown or unclassified:						
Person	0	1	0	2	0	3
Unknown	6	10	8	5	2	31
Outside fires, sparks & embers:						
Open fire for cooking	0	0	2	0	0	2
Gas or liquid fuel powered equipment:						
Heat from gas-fuelled equipment	1	0	0	0	1	2
Heat from liquid-fuelled equipment	1	0	0	0	0	1
Solid fuel powered equipment:						
Spark/ember/flame from wood or paper-fuelled equipment	0	0	0	0	3	3
Arcing or overloaded electrical equipment:						
Arcing or overloaded electrical equipment (unclassified)	0	0	0	2	0	2
Short circuit arc defective or worn installation	0	0	0	1	0	1
Short circuit arc unspecified	0	2	2	0	0	4
Arc from faulty, loose or broken conductor	0	0	0	3	0	3
Heat from overloaded equipment	0	1	0	0	1	2
Hot object:						
Hot objects (unclassified)	0	0	0	1	0	1
Molten material	0	1	0	0	1	2
Heat from electrical equipment properly operating	4	7	4	1	4	20
Heat from electrical equipment improperly operating	0	1	0	1	0	2

Cigarettes, matches & candles:						
Cigarettes, matches & candles (unclassified)	1	0	0	3	0	4
Cigarettes	3	3	2	2	0	10
Heat from smoking material	4	0	0	0	4	8
Matches	3	0	3	0	2	8
Lighter	0	4	6	2	0	12
Candle, candle oil & taper	1	3	0	0	1	5
Exposure fire:						
Conducted heat	0	0	1	0	0	1

Table 26: Supposed cause of fatal residential fire incidents from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Carelessness with heat source	11	16	14	5	10	56
Unknown	6	9	4	2	2	23
Deliberately lit fire	5	3	6	4	2	20
Others (<5%)	2	2	3	6	3	16
Mechanical failure or malfunction	0	3	1	6	2	12
TOTAL	24	33	28	23	19	127
Others (<5%)						
Reckless	0	1	1	4	0	6
Carelessness with material ignited	1	0	1	2	0	4
Operation deficiency	1	1	1	0	1	4
Design, construction or installation fault	0	0	0	0	2	2
Deliberately lit fire:						
Deliberately lit	0	0	2	1	1	4
Unlawful	3	1	1	1	0	6
Legality not known	0	0	0	1	0	1
Suspicious	2	2	3	1	1	9
Reckless:						
Reckless act	0	1	1	4	0	6
Carelessness with heat source:						
Carelessness with heat source	0	0	2	0	0	2
Careless disposal cigarettes, cigars, ashes & embers	2	3	2	2	2	11
Falling asleep or kitchen/cooking fire	0	6	1	1	4	12
Falling asleep other	7	0	2	0	0	9
Inadequate control	0	0	0	0	1	1
Heat source too close to combustibles	1	4	2	0	1	8
People playing with heat sources	0	2	4	2	2	10
People impaired by drugs or alcohol	1	0	0	0	0	1
People otherwise impaired	0	1	1	0	0	2
Carelessness with material ignited:						
Carelessness with material ignited	0	0	0	1	0	1
Flammable liquid/gas spilled or accidentally released	0	0	1	1	0	2
Combustible placed too close to heat source	1	0	0	0	0	1
Mechanical failure or malfunction:						
Part failure, leak or break	0	0	1	4	0	5
Short circuit or Earth fault	0	0	0	2	0	2
Other electrical failure	0	3	0	0	2	5
Design, construction or installation fault:						
Installed too close to combustibles	0	0	0	0	2	2

Operation deficiency:						
Collision, overturn or knockdown	1	0	0	0	0	1
Equipment unattended	0	1	1	0	1	3
Unknown:						
Unknown	6	9	4	2	2	23

C. Appendix C: Upholstered Furniture Fires, 1996 – 2000

Table 27: Involvement of upholstered furniture in fatal residential fire incidents from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Yes	8	17	8	7	5	45
Likely	10	4	5	5	0	24
Unlikely	1	2	3	3	4	13
No	4	9	12	7	8	40
Unknown	1	1	0	1	2	5
TOTAL	24	33	28	23	19	127

Table 28: Proportion of upholstered furniture fire fatalities on residential property from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00
Upholstered furniture	0.33	0.52	0.29	0.30	0.26

Table 29: Number of fatalities per incident involving upholstered furniture from 1996 to 2000.

No. of fatalities/incident	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
1 fatality/incident	6	8	6	7	3	30
2 fatalities/incident	1	0	1	0	1	3
3 fatalities/incident	0	3	0	0	0	3
TOTAL Fatality	8	17	8	7	5	45\36
TOTAL Incident	7	11	7	7	4	

Table 30: Number of occupants present at time of ignition of fatal residential fire incidents involving upholstered furniture from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
1 person	5	3	1	4	1	14
2 persons	3	1	1	1	1	7
3 persons	0	8	1	2	0	11
More than 3 persons	0	5	5	0	1	11
Unknown	0	0	0	0	2	2
TOTAL	8	17	8	7	5	45

Table 31: Breakdown of residential fire fatalities involving upholstered furniture by age from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Young children (9 and under)	2	5	3	3	1	14
Children & Young adults (10 - 18 yrs)	0	2	1	0	0	3
Adults (19 - 54 yrs)	4	5	2	1	1	13
Elderly (55 and over)	2	5	1	3	1	12
Unknown	0	0	1	0	2	3
TOTAL	8	17	8	7	5	45

Table 32: Involvement of alcohol or drugs in fatal residential fire incidents associated with upholstered furniture from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Not involved	4	11	6	5	2	28
Confirmed by tests	2	4	2	1	1	10
Confirmed by eye-witness	2	2	0	1	0	5
Unknown	0	0	0	0	2	2
TOTAL	8	17	8	7	5	45

Table 33: Activity at ignition and during the fire of fatalities associated with upholstered furniture fire incidents from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Sleeping	4	13	4	5	2	28
Awake	4	4	4	2	1	15
Unknown	0	0	0	0	2	2
TOTAL	8	17	8	7	5	45
Sleeping:						
Asleep, then attempted to evacuate	0	5	0	0	0	5
Intoxicated & asleep	3	1	0	0	0	4
Falling asleep with heat source	0	1	1	0	0	2
Asleep, then attempted to fight the fire	0	0	1	0	0	1
Asleep	1	6	2	5	2	16
TOTAL	4	13	4	5	2	28
Awake:						
Awake, with heat source	3	0	3	1	0	7
Awake - other activities	1	1	1	0	0	3
Awake, then attempted to evacuate	0	2	0	1	0	3
Awake, then attempted to fight the fire	0	1	0	0	1	2
TOTAL	4	4	4	2	1	15

Table 34: Location of fatality at time of ignition of residential fire incidents involving upholstered furniture from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
In the room of fire origin	4	5	7	4	1	21
Remote from the room of fire origin	4	12	1	3	2	22
Unknown	0	0	0	0	2	2
TOTAL	8	17	8	7	5	45

Table 35: Presence of smoke detectors in fatal residential fire incidents involving upholstered furniture from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Not installed	8	14	6	4	2	34
Installed, but batteries missing/flat	0	1	0	1	1	3
Installed and activated	0	2	2	2	0	6
Unknown	0	0	0	0	2	2
TOTAL	8	17	8	7	5	45

Table 36: Type of upholstered furniture involved in fatal residential fire incidents from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Chairs	5	10	4	3	3	25
Beds	1	4	3	1	0	9
Both present	2	3	1	3	2	11
TOTAL	8	17	8	7	5	45

Table 37: Fatal residential fire incidents involving upholstered furniture as nth object ignited from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Object 1st Ignited	0	2	1	1	3	7
Subsequent object ignited	8	15	7	6	2	38
TOTAL	8	17	8	7	5	45

Table 38: Cause of death of fatalities in residential fire incidents involving upholstered furniture from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
Smoke inhalation	4	12	3	6	1	26
Severe burns	4	2	1	1	0	8
Effects of fire	0	3	4	0	2	9
Unknown	0	0	0	0	2	2
TOTAL	8	17	8	7	5	45

Table 39: Carboxyhemoglobin levels of fatalities in residential fire incidents involving upholstered furniture from 1996 to 2000.

	1995/96	1996/97	1997/98	1998/99	1999/00	TOTAL
0 - 25%	0	5	1	0	1	7
26 - 50%	1	2	2	2	0	7
51 - 75%	2	3	2	1	0	8
76 - 100%	0	2	0	0	0	2
Unknown	5	5	3	4	4	21
TOTAL	8	17	8	7	5	45

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