Fire Research Report

Human Behaviour Contributing to Unintentional Residential Fire Deaths 1997-2003

Heimdall Consulting Ltd

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This report considers the role of the behaviour of victims (and others) in regard to fire ignition and consequent fatalities in 131 unintentional New Zealand residential fire deaths between 1997–2003. The main study examined inquest files into these deaths to consider a range of fire dynamic, demographic, forensic, and behavioural features in each case. The findings support other research that highlight the potent role of victim behaviours in fire ignition and spread, and in fatal outcomes. Significant factors identified include alcohol consumption, acts of omission, carelessness, dangerous habitual behaviours, and consequences of disabilities. The very young, the elderly, those with disabilities, and lower socioeconomic groups were identified as being at most risk of residential fire deaths.

A simple dichotomy between *intentional* and *unintentional* fires was not established, as several victims fell into a *borderline* group whose role in fire causation was established (although intent to cause harm was not). Accordingly, a new theoretical model relating to intentionality in fire causation is proposed which suggests a need for differential intervention strategies for those "at risk" groups identified by the literature and highlighted in the study. It is concluded effective fire safety and prevention strategies must address behavioural characteristics of victim groups, especially socio-psychological processes, attitudes, and cognitive patterns that contribute to elevated fire risks.

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"...the causes of fires are not sufficiently investigated in places where accidents from fires frequently occur, and that much valuable information would be acquired and generally diffused were the causes of all fires thoroughly investigated. No regular inquiry is now instituted to ascertain the origin of fires unless they are attended with circumstances leading to a suspicion that they have been caused willfully ..."

(From Report of Commission investigating a series of fires in Liverpool cited in Blackstone, 1957).

1998

"Although deaths due to fire are routinely investigated as individual incidents by fire services, the police, and coroners, the diffuse nature of the fatalities has resulted in a lack of attention to the overall nature of the problems and how to prevent then. In the United States, of the estimated 108,000 fire fatalities which occurred between 1971 and 1989, fewer than 1000 cases have been reviewed (Barillo & Goode 1996, p. 85). In addition, fire agencies do not generally maintain databases which document the circumstances surrounding fire-related deaths, and published studies on fire-related fatalities are not extensive."

(from Rhodes & Reinholtd, Residential Fire Fatalities, 1998).

Section 1: Introduction to the Study

1.1. INTRODUCTION

This report investigates behavioural aspects of unintentional fatal residential fires in New Zealand during the period 1997-2003. The study is part of a research series funded by the New Zealand Fire Service[1] Contestable Research Fund in the 2003-2004 year.

The research builds on previous Australasian studies of residential fire deaths. It focuses on *unintentional* residential fire deaths and excludes *intentional* fatalities (eg. suicides and homicides). The purpose for studying on *unintentional* residential fire deaths is twofold –

i. Reports from many jurisdictions show fatal fires mainly occur in residential locations (ie. houses, flats, lodgings etc). In this study **131** unintentional residential fire deaths occurred in New Zealand in 109 separate fire incidents. This averages at 21.6 deaths per year and comprised **56%** of all fire deaths for the period.

ii. In contrast with *intentional* fires, *unintentional* fires occur from a variety of causes which are held to be largely preventable. Accordingly, fire safety and prevention initiatives are logically directed at reducing deaths and injuries from unintentional fires in residential settings as a major public safety strategy.

The study concentrates on human behaviour in fires. It involves analysis of the actions of victims and others in regard to ignition of fires, and on subsequent behaviours that contribute to fatal outcomes. The focus on human behaviour in fires reflects a growing understanding that those confronted with fire do not simply *react* to fire, rather they *interact with* fire through roles in fire ignition (ie. from inadvertent acts, carelessness or omissions), and subsequently in further interactions with fire that often have fatal consequences.

The study examined all coronial files on unintentional residential fire fatalities in 1997-2003. These files contain information from a variety of sources, including - NZFS fire incident reports, specialist technical reports and analyses, witness and survivor reports, findings from post-mortem examinations, forensic and toxicological analyses, and ultimately the coroners verdict following an inquest into each death. This methodology requires an awareness of the sensitive nature of the information and consideration for the dignity of the deceased and feelings of surviving family and friends.

The report places the behavioural analysis into the context of the international literature, comparative fire death statistics from other jurisdictions, and theoretical formulations that account for and predict behaviour in fires. The findings show close similarities with research findings from other jurisdictions and Australia in particular.

The study proposes a new theoretical model relating to intentionality in fire causation, and suggests some targeted strategies that may be differentially applied to "at risk" groups identified by the literature and highlighted by the research.

A sample size of 131 cases provides a useful indication of potential trends and areas of focus. However, it is suggested a larger study be undertaken to expand the database, further examine trends, and critically examine theoretical formulations relating to fire causation and intent to harm. This would assist in better defining the needs of particular groups whose behaviour and life circumstances place them at risk of injury or death from fire.

[1] **Hereafter referred to as NZFS.**

1.2. ACKNOWLEDGEMENTS

The study was funded by the New Zealand Fire Service Commission 2003- 2004 Contestable Research Fund. Due recognition and thanks is accorded to Paula Beever (National Director, Fire Risk Management) and to the valuable assistance and advice of Neil Challands, April Christensen, and James Dance for their support for the project.

Access to the coronial files on fire fatalities was provided by Coronial Services, Tribunals Division, Ministry of Justice. Acknowledgement is made of the assistance of Katherine Baird, Allan Cobham, Clifford Slade, and Nick Dagg who helped access coronial files and provided support for the primary data collection phase of the study.

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The New Zealand Coroners Council has supported the study and recognition is accorded to Richard McElrea (Chairperson) and David Crerar (Secretary) as representatives of the New Zealand Coroners who are the key judicial officers on whose findings the study is based.

Several researchers have provided comment and additional information. Special reference is made to Mavis Duncanson and Patricia Brennan. Their efforts have greatly advanced the analysis of behaviour in residential fires in Australasia over several years. The helpful assistance of Ken Thompson, Forensic Pathologist, and Stuart Dickson, Environment and Scientific Research are also recorded with gratitude.

Consultation included a number overseas agencies and individuals. Gratitude and thanks is extended to Ian Matterson (Magistrate & Coroner, Hobart), Graeme Johnson (State Coroner, Victoria), Damien Killalea (Tasmanian Fire Service), Ian Hunter (Metropolitan Fire Brigade Melbourne), Nicole Harvey (Country Fire Authority, Victoria), Alan Rhodes (Country Fire Authority, Victoria), George Cooney (Victoria Police), Rob Llewellyn (Australasian Fire Authorities Council), Leon Collett (Australasian Fire Authorities Council), Judy Newton (Queensland Fire and Rescue Service), Ken Thompson (New South Wales Fire Brigades), and Anne Lear (New South Wales Fire Brigades).

1.3. EXECUTIVE SUMMARY

Like other countries, most fatal fires in New Zealand occur in residential locations (ie. houses, flats, lodgings, caravans, etc). These are mainly *unintentional* in causation but arise from a variety of causes which are held to be *preventable*. Accordingly, fire safety and prevention initiatives are directed at reducing such deaths and injuries as a major public safety strategy. Part of this strategy is ongoing research into residential fires to identify key features of those groups most vulnerable to fire. The current study was funded by NZFS to examine behavioural aspects of domestic fire fatalities in the period 1997-2003.

In focussing on *unintentional* residential fires 131 cases were identified as forming the basis of the study; all others were classified as *intentional* fires (ie. suicides or homicides). The study examined the behaviour of victims (and others) in regard to fire ignition and consequent fatal outcomes. The primary source of information was coronial files which are a rich source of information from a variety of sources presented at an inquest. This information includes - fire incident reports, specialist and technical reports, witness and survivor accounts, post-mortem examination findings, forensic and toxicological analyses, and coronial verdicts.

The findings broadly support those reported from other jurisdictions. Key points include –

- The New Zealand residential fire fatality rate falls around the middle range when compared with a number of developed countries.

- The four main causes of these fires were - unattended cooking (16.9%), careless smoking (13.1%), unattended burning candles (10.0%), and children playing with fire (9.2%). These causes are also identified in other countries as high risk factors.

- No particular seasonal pattern to these fatal fires was identified.

- As with other studies, the highest time of risk for fatal residential fires was in the weekend period, and at night between 7 pm and 7 am. This correlates with sleep as a common factor that affects timely victim responses to fire cues.

- The main room of origin of fires was bedroom/sleeping areas (33.9%), kitchen/dining areas (29.4%), and lounge areas (19.3%). This suggests a relationship between fire ignition and the behaviour of victims, many of whom were responsible for ignition due to acts of carelessness or omission, or because of various impairments.

- Victims were more likely to be male (62.6% of fatalities), aged between 0-15 years (32.1%) or aged over 60 (25.9%). This pattern reflects that identified in other international studies.

- Nearly 63% of these fatal fires were recorded in properties falling in the Deprivation Index Decile of 7 – 10 reflecting the lower socio-economic status of these victims.

- The primary causes of death were smoke inhalation, carbon monoxide poisoning, hypoxia/asphyxia, and burns/thermal injuries. Analysis of cause of death suggests inhalation of the toxic products in smoke was a significant factor in incapacitating individuals by rapidly impairing their abilities to escape.

- A significant number of victims (38.8%) had pre-existing health conditions that may have impacted on fire ignition and their abilities to escape. These include physical disabilities, sensory impairments, and psychological conditions.

- Analysis of post mortem Blood Alcohol Levels showed high numbers of victims had been drinking prior to the fire. Many exceeded the legal driving limit by a significant margin, and appeared to have caused the fatal fires through carelessness, inattention, incapacity, and acts of omission. Alcohol was also implicated in other actions that placed the deceased at risk through a failure to quickly exit burning residences.

- Nearly two thirds of victims appeared to have insufficient time to escape the fire, or were unable to escape due to their age or disabilities. This reflects the speed at which fires spread and the rapid incapacitation caused by toxic smoke and fumes.

The study confirmed that when confronted with fire most victims did not simply *react to* the fire. There appeared little evidence of panic in a majority of cases. Many victims were involved in *interactions with* fire through their roles in ignition (ie. from inadvertent acts, carelessness, or acts of omission), and in further actions that often had fatal consequences (such as not shutting doors, trying to fight the fire). Significantly, many victims were sleeping when the fires started and this affected their responsiveness to fire cues, especially where alcohol consumption was also involved.

It is apparent a simple dichotomy between *intentional* and *unintentional* fire causation is not always a valid distinction. In 15 cases victims acted in irrational or attention seeking ways such that their intent to cause fires and to cause harm was ambiguous or unclear. It is suggested that these victims are best described as belonging to a *borderline group*. Accordingly, a new theoretical model relating to intentionality in fire causation is proposed which suggests a need for differential intervention strategies to be applied to those "at risk" groups identified by the literature and highlighted by the research.

1.4. RECOMMENDATIONS

Four main recommendations are identified from the study. These are to some extent related. Each supports the others as a basis for reducing the risk of fire deaths and injuries, either from developing more robust theory, or by addressing particular risk factors that contribute to these casualties.

Recommendation 1: The study is based on 131[2] cases of unintentional domestic fire fatalities. The analysis provides an indication of the role of behavioural factors that contribute to fire ignition and subsequent fatal outcomes. However, the findings of would be enhanced by a larger case sample. This should also include analysis of intentional fire deaths in order to evaluate the proposed **Model Intentionality, Harm, & Fire Causation** and to expand on the current study. It is recommended a larger and more retrospective study be undertaken, to include 200-250 fire deaths to provide a more robust analysis in order to develop improved fire intervention strategies.

Recommendation 2: Smoking-related fire deaths are identified as a significant risk in the study. Accordingly, there is a strong a case to require cigarette manufacturers to introduce Reduced Ignition Propensity cigarettes in New Zealand along the lines of recent legislation in New York State and Canada. This might involve collaboration with Australian agencies where such legislative change is being considered.

Recommendation 3: Fire risks associated with alcohol and drug consumption indicate a need for the development of further targeted education initiatives to address these significant contributors to fire fatalities. It is recommended that such initiatives might fruitfully consider aspects of Drink-Drive campaigns that have effected long term behavioural changes in 'at risk' populations through targeted messages.

Recommendation 4: Dangerous habitual behaviours are a significant risk factor in domestic fires. These include leaving cooking unattended, placing heaters too close to flammable surfaces, misuse of heating appliances, and excessive alcohol consumption, amongst other behaviours. Such habitual behaviours are not readily amenable to external scrutiny and individuals may not perceive these as being problematic. Effective fire safety initiatives need to focus on habitual behaviours and underlying cognitive processes that support such risky actions in order to reduce fire deaths and injuries. It is recommended that further studies of the cognitive processes supporting habitual behaviours be undertaken, especially including those in lower socio-economic groups who are disproportionately represented in fire death and injury statistics, to determine more effective strategies to effect enduring behavioural changes in those most at risk.

[2] This includes 130 cases where full information was available and one case where information was incomplete at the time this report was finalised.

1.5. AIMS AND OBJECTIVES

The study has four primary aims and objectives –

a. To evaluate international research on behaviour in unintentional residential fires relating to victim actions that cause, or contribute to, fire ignition, and consequential fatal outcomes. This evaluation includes a review of literature and consideration of theoretical formulations applying to this area of fire safety risk.

b. To obtain statistical and demographic information on unintentional fatal residential fires from other jurisdictions to develop baseline indices against which New Zealand information can be evaluated and compared.

c. To evaluate Australian studies of human behaviour in unintentional fatal residential fires, and to compare these with an analysis of New Zealand cases. This involves application of modified psychological autopsy methodologies to coronial reports and associated information for all cases in the period 1997/98 - 2002/03.

d. To identify behavioural features affecting mortality in unintentional residential fires and relate these to theoretical formulations to develop improved fire safety and public education initiatives.

1.6. LIMITATIONS OF STUDY

All fire deaths in New Zealand are subject to NZFS and Police investigation to determine if they are a result of intentional acts (in which case criminal investigations are warranted). Consequently, it is possible to identify all residential fire deaths for a period and study those determined to be unintentional from an inquest. This permits definition of a complete sample of unintentional residential fire deaths. However, there are some limitations in the study –

- The study examines circumstances and behaviour of those involved in fatal fires. A question may be posed whether those who perish in residential fires exhibit different behaviour patterns and characteristics from those who escape, and if so, in what ways do they differ? While it is reasonable to consider injury fires are no different to fatal fires (apart from obvious fatalities) caution is advised in making global assumptions about human behaviour in fires. There may be little difference between the outcomes in these fires apart from victim behaviours (or even chance factors) that favour escape or lead to fatal consequences. However, this has not been subject to analysis and remains open to further investigation.

- The research is based on investigations into fire fatalities in support of an inquest. A coronial verdict is a legal determination and the investigations are directed to that end. The coroner's verdict may have significant consequences for family and friends of the deceased, including issues of insurance and inheritance. Accordingly, coroners tend to deliberate with caution, and their verdicts are often conservative because the information presented at an inquest may be equivocal or incomplete. The study has worked within this conservative context, and has adopted a cautious approach in the conclusions reached.

- There are differences between a pure research methodology that seeks to control and manipulate variables for study, and applied research which studies variables often not amenable to experimental manipulation. It is not possible to apply pure research methodology to the direct study of fire fatalities for obvious reasons, so an applied methodology has been adopted for the study with the inherent limitations that arise from the nature of fire death investigations.

- The analyses at the core of the study involve witness accounts and reconstructions of events by skilled investigators. Generally these are clear and provide useful levels of information. However, some accounts of fire incidents are sketchy or incomplete. Therefore, inferences or conclusions in cases where information is limited or incomplete are necessarily circumspect.

- The study examined 131 deaths, in which detailed information was available in 130 cases. This is a relatively small sample size and accordingly inferences drawn about particular sub-groupings (eg. ethnicity, occupational status) are largely presented as general findings unless strong evidence supports a particular conclusion.

1.7. ETHICAL CONSIDERATIONS

The study examines detailed information about people who perished in tragic circumstances and who left behind grieving family and friends. These deaths involve psychological and physical trauma for survivors, relatives and friends. Access to coronial findings is normally restricted to close family and to legitimate researchers in order to protect the dignity and privacy of the deceased. Coronial findings sometimes have restrictions placed on reporting aspects of inquests. Balanced against the need to respect privacy are the benefits of research that helps understand and prevent future fire fatalities, which raises ethical considerations that apply to the study -

- Individual victim identities have been protected as far as practicable. However, fire fatalities are commonly reported in the media. In some cases the nature and extent of deaths means such individuals are immediately identifiable. The illustrative case summaries presented in the report provide a minimal description of established details while attempting to convey essential demographic and circumstantial information about each case.

- Coronial verdicts take into consideration the feelings of family and friends of the deceased and usually avoid apportioning of individual blame. Occasionally cases arise in which a coroner makes adverse or critical comment. These usually are deaths resulting from irresponsible or grossly negligent acts involving the most vulnerable members of society - infants, the aged, and the disabled. The study reflects such rare adverse comments *albeit* with circumspection.

- The study has adhered to restrictions imposed by coroners in their verdicts.

Section 2: Literature Review

2.1. 'PANIC' AS A RESPONSE TO FIRE

Fire is a recurring scourge throughout human history. Numerous blazes have inflicted terrible costs on communities all over the globe, and many great cities have been destroyed by fire (often successively), eg., London (1212, 1666), Venice (1106, 1577), Boston (1679), Moscow (1752), Rome (1764), Chicago (1871), Baltimore (1904), San Francisco (1906). A popular image of these cataclysms is of a populace fleeing in high states of panic and disarray. Such popular perceptions of panic has long coloured thinking on fire safety, especially in places of high density populations such as urban buildings and places of public congregation.

Historically, management of fires involving large masses of people placed great emphasis on dealing with 'panic' and the need to ensure orderly crowd control to places of safety. This emphasis gained currency in a number of fires where a high loss of life was attributed to panic, confusion, and lack of orderly behaviour (eg. Iroquois Theatre, 1903; Coconut Grove Night Club, 1942; Beverley Hills Supper Club, 1977). In these examples deaths resulted not only from exposure to fire (ie. inhalation of toxic smoke and from thermal injuries, burns) but also from crushing caused by those trying to escape (Chertkoff & Kushigian, 1999).

While panic is reported as an expected behaviour in fires, there is debate over the true extent of such collective disorganisation, and indeed whether it occurs at all. Some authors argue panic is a 'myth' or of questionable explanatory value (Mawson, 1979; Quarantelli, 1981; Keating, 1982; Sime, 1985; Johnson, 1988; Proulx, 2001). Debate about 'panic' includes the accuracy of descriptions of behaviours when groups apparently act 'in panic' during an emergency, and on understanding of the rationality or otherwise of actions described as being the result of 'panic'. Observations of behaviour in actual fire situations suggest panic is not a normal occurrence -

"*Although the media are very fond of this concept for its drama and sensational connotation which makes good sales, there is little evidence of panic in actual fire situations. It is a widespread misconception to believe that people caught in a fire will panic and try to flee in a stampede, crushing and fighting others. Such crazed behaviours are in fact extremely rare. Panic which supposes irrational behaviour for a situation is rather atypical of human behaviour in fire. On the contrary, people appear to apply rational decision making in relation to their understanding of the situation at the time of the fire. In retrospect, it is easy to point to some decisions that were not optimal and played a negative part on the outcome of the fire; however, at the time of the fire these decisions were rational when all factors are considered.*" (Proulx, 2001).

Research has explored a range of variables that account for individual behaviours in fires. Some studies note that, rather than *panic*, there is a *lack of response* in certain cases (Sime, 1980; Bryan, 2003; Proulx, 1997, 2002, 2003). The point is cogently described by Proulx –

"*Actual human behaviour in fires is somewhat different from the "panic" scenario. What is regularly observed is a lethargic response to the fire alarm, voice communication instruction or even the initial cues of a fire. Except for low-rise buildings, where occupants feel that it is their responsibility to investigate an unusual smell, noise or movement, occupants are usually not very responsive in the initial moments of a fire. People are often cool during fires, ignoring or delaying their response to initial cues of an actual emergency. Once occupants decide that the situation requires moving to an area of safety, the time left could be minimal.*" (Proulx, 2002).

The consensus is that 'panic' is neither an accurate term to describe the behaviour of people confronted with fire, nor do most people act in irrational impulsive ways in such circumstances (eg. Wood, 1972; Sime, 1980; Keating, 1982; Bryan, 2003). Rather, a complex array of behaviours come into play depending on particular features of the fire, individual characteristics, history of fire, and a complex of background factors such as age, health, socio-economic level, and employment status. Generally, it appears those caught in fires act with altruistic, helpful behaviour, and where inappropriate behaviour is observed, it is due to inadequate or ambiguous information concerning the size and location of the fire threat.

2.2. AN HISTORICAL PERSPECTIVE

Shields and Proulx (1999) observe the development of studies on human behaviour in fire is a consequence of the realisation that purely engineering solutions to fire safety were insufficient to achieve effective or acceptable outcomes. These authors note –

"The development of human behaviour in fire into an area of scholarly study of vital importance has been extremely rapid. The advent of performance based fire safety regulations and codes together with the need for robust computer evacuation simulation models gives further impetus and sense of purpose to future endeavours. Hard fire science alone cannot solve the "fire problem". With increasing international emphasis on community fire safety policy initiatives knowledge of occupant behavioural characteristics associated with fire is essential. To develop the human behaviour knowledge bases a coherent collaborative strategic research programme which develops value for money is essential." (Shields and Proulx, 1999).

Bryan (2002) identifies a changing focus in research on human behaviour in fire since the first studies in the early 1900's, resulting in current performance-based safety codes with a strong emphasis on evacuation models. He summarises developments into to three main periods -

Period	Key Developments
Pre-Recognition Years (1900's – 1970's)	• Work on pedestrian velocity and evacuation in USA including development of *Building Exits Code*, evacuation studies of railway terminals, subway stations, theatres, department stores and government buildings (1917-27). • Minimal study of occupant behaviours in significant major fire incidents (eg. Coconut Grove Fire 1942). • UK evacuation studies (1958-75). • Fire engineering emphasis on building safety and fire suppression as primary focus (1950's). • US Fire Research & Safety Act established NCFPC leading to *America Burning* report (1973). • Emerging studies of occupant behaviour in fires (1974).
Productive Years (1970's – 1980's)	• US Federal funding starts to focus on behaviour in fires and educational/safety initiatives. • First seminar on Human Behaviour in Fire, Surrey University 1977 leading to "*Fires & Human Behaviour*" (Canter 1980). • New focus on defining occupant behavioural actions in fires, re-examination of 'panic' as concept, and emphasis on evacuation of high rise buildings. • Research studies on re-entry behaviour occupants in UK and US fires and tendencies to move through smoke (1972, 1977). • First computer modelling studies of behaviour in fires (1982).

Performance Code Incentive Years (1990's – current)	• World-wide movement to performance based codes & greater emphasis on computer modelling of fire evacuation behaviours • Further attention on behavioural research including international studies. • First *International Symposium on Human Behaviour in Fire*, Belfast (1998). • Recognition of time delays affecting evacuation and consideration of behavioural factors that mediate responses to fire threats (1973). • *Second International symposium on Human Behaviour in Fire*, MIT (2001). • Greater linkage of fire engineering and behavioural science approaches to better identify and develop performance-based fire protection codes and building design.

Two main conclusions emerge from Bryan's summary –

- **Focus on High Population Density Settings:** Increases in population densities has seen a focus on safety in high rise buildings, entertainment centres, and transportation systems. This reflects the potentially high magnitude of casualties in these settings demonstrated in a number of serious incidents. Numerous casualties (whether these are deaths or injuries) pose a very high risk of criminal or civil liabilities for the designers and owners of these buildings, along with adverse media and political attention. This has led to improved performance based fire codes. Ironically, the focus on high population density fire risks has seen lesser attention on residential fires which collectively result in a far greater number of deaths and injuries *albeit* as single or small numbers of casualties over time.

- **Engineering/Prescriptive Approaches:** The early focus on prescriptive approaches to fire safety reflected the pre-eminence of engineering at that time as the main source of solutions. Engineering was applied to problems of growing industrialised centres with expanding populations and increased risks from fire. Industrial expansion saw increasing use of multiple occupancy high rise buildings as living accommodation and workplaces. The much later applications of behavioural science to the study of fire arose from wider applications in the 1950's beyond traditional psychological areas of study. Consequently, current performance based fire codes arise from a fusion of engineering and behavioural approaches in which psychological factors are increasingly recognised as having a complementary role in developing effective responses to the threat of fires.

Following the seminal First Seminar on Human Behaviour in Fire at Surrey University in 1977, Canter encapsulated the limits of a predominant focus on engineering solutions to the study of fires with the observation –

"Study of the causes of fire is surprisingly scarce. One dominant aspect of the engineering tradition of dealing with the management of effects rather than the identification of causes seems to have an influence here. But the view that human agency is totally 'accidental' which has, until recently, overshadowed consideration of causes due to human 'error' had led people to focus on prevention as a mechanical engineering consideration rather than as an aspect of management and training." (Canter, 1980).

2.3. OVERVIEW OF BEHAVIOUR IN FIRES

The behaviour of those confronted with fire is complex, with variable factors coming into play with different groups and individuals. Yet traditional considerations have tended to assume a uniformity in responses to fire. At the core of this are assumptions that influence performance based codes of fire safety and supportive behavioural modelling. Brennan & Thomas (2001) argue there is a difficulty with the traditional assumption that occupants confronted with fire will ***react*** to, rather than ***interact with***, fire. They propose a paradigm shift from a reactive to an interactive model of behaviour in fires –

> **'Reactive' Assumption:** Occupants *react* to fire cues (eg. a developing fire, smoke, sounds, safety warnings). This is based on underlying premises that –
>
> - Fire ignition, growth, and cue generation are *independent* of occupants,
> - Fire is an *externally* imposed event,
> - Occupants are *subjected* to fire.
>
> **'Interactive' Assumption:** Occupants *interact* with fires and may be inadvertently involved with fire *ignition*. This involves recognition that –
>
> - occupants in most fires may start the fire by engaging in customary activities,
> - occupants may facilitate or encourage fire growth and spread (through inadvertent actions before or during the fire),
> - there is a 'primitive attachment' between fires and humans which includes attempts to fight fires which may result in fatalities.

This revised model may be illustrated as follows –

A key point supporting this paradigm is the fact the majority of fire fatalities and injuries occur in residential settings, and not in places of occupation, education, or entertainment. In residential fires, occupants are more likely to be intimately involved in interactions with fire both its causation, and in its spread through their direct or indirect behaviour. The complexity of these behaviours with fires is further discussed below.

Studies of human behaviour in fire have identified a range of perceptual, cognitive, emotional and motor processes affecting responses to fire. These interact with other factors such as age, culture, health, socio-economic and employment status. There are also differences between individual and group behaviour. Bryan (2003) summarises these into a series of headings -

Behavioural Process	Key Observations
Awareness of Fire	- Responses to fire vary according to how individuals become alerted to the threat of fire. - Direct perceptual cues (eg, smoke, flames) are more effective in promoting responses to fire than other cues. - Verbal directives are more effective than auditory alarms. - Ambiguous cues of fire are likely to be inhibited by the presence of other people and treated as not urgent. - Social factors may result in diffusion of responsibility to act where cues are ambiguous affecting response behaviours to the threat of fire.
Individual's Decision Processes	An occupants evaluation and understanding of cues of an impending fire threat may include – - **Recognition**. The ambiguity of fire cues, individual's experience and training, and perceptions of personal invulnerability affect responses to fire threat. - **Validation.** Individuals tend to assess the seriousness of threat cues, including validation of the significance of a threat, often by seeking information of others. Social factors may affect/inhibit validation responses. - **Definition.** This involves considering threat cues against other matters such as time and magnitude of fire to interpret the threat. - **Evaluation.** Interpreted threat is evaluated to decide on a response, including - time required to exit, means of exit, and co-operative activities to assist others escape. - **Commitment.** This requires a commitment to effect a response to fire threat such as escape, fighting fire, etc. - **Reassessment.** This applies if attempts to respond to the fire threat are ineffective, or the individual becomes frustrated with efforts to achieve a desired outcome.
Actions of Occupants	Occupants facing fire respond in different ways to the threat, including interacting with the fire rather than a simply responding to it. Behaviours include - notifying others, seeking source of fire, calling fire services, getting dressed, exiting building, collecting family/property etc. - It is noted small numbers fail to act or take protective measures which places them in greater peril. - Gender differences are apparent in responses to fire. - Some individuals will re-enter a fire area to retrieve property and pets, fight the fire, notify others, placing themselves at high risk of injury or death. - Some occupants (typically males) will engage in fire fighting activities to some extent which increases the risk of death or injury. Despite physiological and toxic risks, many occupants will move through smoke, often for some distance, to seek an exit.

Bryan observes -

"The relationship between the physical and social environment in which behaviour occurs is complex. The situation is complicated by the individual's perception of ambiguous fire cues, which is primarily influenced by the person's relevant training and previous fire experience, if any. It must be recognised that fire cues are a product of a rapidly changing dynamic process that is constantly altering the decisions of the building occupant. This dilemma has been summarised: "What is an appropriate action at one stage may be quite inappropriate a minute later"" (Bryan, 2003).

Many researchers have focused on group size as a factor affecting the risk of fire fatalities on the premise that the "greater the affiliation between those involved in fires the higher the chances of deaths" because of inter-group dynamics which may affect successful evacuation (Sime, 1985; Feinberg & Johnson, 2001). This approach reflects a focus on the behaviour of larger groups in fire (typically in places of commerce or entertainment). However, the reality is that most fire fatalities occur in residential settings and account for a greater number of deaths than major fire disasters ever do. As one author comments –

"*Cumulatively, residential fires do represent a major disaster, along the lines of a violent earthquake or large-scale hurricane. Nearly 5,000 Americans die each year in fires, and 80 percent of those deaths result from home fires, according to the U.S. Fire Administration (USFA). Fire kills more Americans each year than all natural disasters combined.*" (Ward, 2004)

Ward describes these deaths as "quiet disasters" that are devastating to the families who loose loved ones and property in residential fires. Increasingly, research has focussed on residential fires because of their cumulative fatal severity and their potential for prevention and reduction strategies. Much of this research has been undertaken in Australasia and provides a basis for the present study.

2.4. RESIDENTIAL FIRE STUDIES

Accounts from a range of developed countries consistently report the majority of fires occur in residential settings. Collectively, residential fires involve significant numbers of deaths and injuries, although these mainly involve single casualties with a few multiple fatality incidents. Unlike major fire events, residential fire deaths and injuries tend to be somewhat overlooked, as Rhodes and Reinholtd (1998) cogently observe "*perhaps because they are a diffuse form of disaster*". For example, the 131 unintentional residential fire fatalities at the basis of the present study would be seen as a major tragedy of the order of the Tangiwai or Mount Erebus disasters if they had happened at once. The apparent lack of immediate reaction to such diffuse casualties is expressed by Rhodes and Reinholtd –

"For example, an event causing 100 deaths in Australia would represent one of the worst disasters in Australia's history and result in an unprecedented level of investigation and action to prevent further occurrences, but the same number of deaths resulting from fires occurring in residential premises elicits quite a different response."(p 5).

Studies of residential fire deaths identify a range of factors relating to victim behaviours and consequent fatal outcomes. These factors appear to have a generality as they are reported in a number of jurisdictions and lead to a consensus that most of these deaths appear to be largely preventable and involve recognised 'at risk' populations as the primary group of casualties.

Barillo and Goode (1996a) conducted a study of fire deaths in New Jersey between 1985-1991 from which they concluded –

"Many fires, and most fire-related injuries, are preventable. Fire requires the interaction of fuel, oxygen and a source of ignition, and the union of these elements is frequently a result of human behaviour. Prevention can be achieved by eliminating or reducing the risk of ignition, by removing the fuel from the site of potential ignition or by altering the human behaviour that brings the fuel and ignition source together. Analysis of human behaviour resulting in fire and fire-related injury is hampered by a paucity of data" (p 85).

The essential conclusion is that most residential fire deaths are preventable and feature a grouping of common factors as identified by studies in a number of countries. Brennan (1998) observes –

"*Certain key demographic and behavioural characteristics of occupants have been shown to have universal relevance to residential fire fatalities and injuries. ""Some factors link primarily to the cause of the fire, some to inhibition of effective response, and some to both. Risk increases with factors such as age (being old or very young), gender (being male), living in poor quality housing, engaging in behaviours which are likely to increase the risk of a fire starting (smoking, overloading power points) or which are likely to inhibit response (sleeping, being under the influence of alcohol or other drugs). Acts of omission (not supervising children who have access to smoker's materials, not having keys for deadlocked doors ready at hand) also contribute to fatalities.*" (p 157).

Brennan cites a number of studies that support this view (eg. Elder *et al*, 1996; FEMA, 1998; Runyan *et al*, 1992; Sezikawa, 1991). Research has continued to identify common risk factors associated with residential fire fatalities, as is shown in **Table 2.4a**

Study	Identified Risk Factors
Barillo & Goode (1996 a)	Smoking behaviours, unsupervised children playing with ignition materials, incapacity with age, use of alcohol or intoxicants, absence of smoke detectors, careless in cooking causing kitchen fires, misuse of heaters.
Marshall, Runyan, Bangdiwala, Linzer, Sacks & Butts. (1998)	Male gender, home alone, alcohol or drug consumption, age (young or old), physical/cognitive disabilities, nil or non-functioning smoke alarms.
Warda, Tenenbein & Moffat. (1999)	Age, male gender, ethnicity, low income, disability, late/night/early morning, type of residence, smoking, alcohol use.
US Fire Administration (2002)	Smoking activities, improperly installed or maintained heating equipment, unattended cooking, non-installed or maintained smoke alarms.
Leistikow, Martin, & Milano (2000)	Cigarettes, smoking materials, lighters, matches, or combinations thereof.

2.5. SPECIFIC RISK FACTORS IN RESIDENTIAL FIRES

The literature consistently identifies certain risk factors that contribute to fire causation and subsequent deaths and injuries. These risk factors appear universal as they are common to most developed countries. Associated with these identified risks are strategies and proposals to target and reduce the extent of their adverse consequences. In all cases there are clear behavioural elements that may be amenable to fire prevention and safety interventions, at least on a wider community level, if not always at level of the individual.

i). Smoking and Related Behaviours

The use of tobacco as a recreational drug reflects its particularly addictive properties that have seen it assume global economic importance over the past four hundred and fifty years. Early methods of consumption largely involved pipe-smoking, chewing, and snuff. The introduction of cigars in the early 1800's and cigarettes in the late 1880s saw a great increase in tobacco use as it became a cheap and commonplace practice. These changes also resulted in an increased fire risk from the consequences of widespread cigarette consumption and inappropriate disposal of smoking materials.

Misuse of tobacco products has led to noteworthy deadly fires, including - 1911 New York Shirtwaist Factory blaze (146 dead), 1987 Kings Cross Station fire (31 dead), 1993 Bangkok Kayder Toy Factory fire (188 dead) and 1999 Mount Blanc Tunnel fire (39 dead). However, the greatest deadly impact of inappropriate use of smoking materials is within residential settings. This impact is reported across a range of jurisdictions, including Australia, Canada, Denmark, Holland, Hungary, Israel, Japan, New Zealand, South Africa, Taiwan, USA, and the United Kingdom (Leistikow et al, 2000). Commentaries on these deaths include, for example –

Canada. "*Fires started by the careless use of smokers' materials are the leading known cause of fire-related death in Canada, on average killing more than 70 people per year. On a per fire basis, fires ignited by smokers' materials result in more fatalities and property damage than fires ignited by other sources. ¨¨ The victims of these fires are often among society's most vulnerable such as children, the elderly and the financially poor."* (Health Canada, Regulatory Proposal Consultation Paper, 2002).

United States. *"The number of fires caused by lighted tobacco products - almost always cigarettes - increased by 19 percent in the most recent year studied, according to research by the National Fire Protection Association (NFPA). The NFPA says that cigarettes are the leading cause of fatal fires in the U.S. Smoking materials led to one out of four fire deaths in 1999, more than any other cause of fire. NFPA's statistical analysis sheds light on how cigarettes lead to fatal fires. Contrary to the popular image, most victims of smoking-material fires did not fall asleep smoking. Many are not even smokers. Rather, these fires typically started when someone abandoned or improperly disposed of smoking materials.*" (Insurance Journal, 2004).

Denmark. "*The death rate for fatal fire accidents in Denmark has doubled since 1951, mostly due to an increase in the number of fire accidents associated with smoking. The most common cause of residential fire deaths in Denmark today is smoking, often combined with alcohol intoxication or handicap*." (Leth, Gregersen & Sabroe, 1998).

United Kingdom. "*Almost half the accidental fire deaths in dwellings were due to fires started by cigarettes, cigars or tobacco (131 fatalities) and they were usually caused through a careless disposal, igniting clothing and textiles or furniture or furnishings. In contrast, relatively few deaths were due to fires started by electrical appliances (8 fatalities)*." (Holborn, 2001).

A compelling case is presented of smoking as a significant cause of fire ignition from careless disposal of burning materials in contact with flammable materials, usually associated with alcohol use or disabilities. Children playing with smoking materials are considered as a separate risk factor, although an association is made between the use of lighters for smoking and the inappropriate access to these by minors.

ii). Alcohol, Drug & Substance Abuse

Alcohol consumption plays a prominent role in many cultures. The effects of alcohol consumption are immediate, dose dependent, and potentially lethal. Effects on physical coordination, cognitive impairment, sleepiness/torpor, impaired sensory perception, depressed neurological functions, disinhibited and antisocial behaviours are recognised consequences of even low levels of alcohol consumption. Addiction is also a risk with chronic use. Other consequences of consumption include increased injury/death risks from motor vehicles crashes, drowning, violence, and involvement in fire.

The role of alcohol in fire fatalities is recognised. This relationship was established from the 1970's through studies of alcoholics at one level and of fire victims at another. Canadian research established the fire mortality risk for alcoholics was 9.7 times higher than the rest of the population (Schmidt & De Lint, 1972). Other studies found a high proportion of fire fatalities "were legally drunk" (Howland & Hingson, 1987); a finding was supported by other studies (Hollis, 1972; Squires & Busuttil, 1997; Marshall *et al,* 1998; FEMA, 1999; Smith, Branas & Miller, 1999; Holborn, 2001).

The role of alcohol in these deaths has not only been attributed to physiological effects, impaired cognition, and increased risk taking behaviours, but also to pharmacological effects that inhibit the choke response and suppress the immune system (Kawanami *et al*, 1990; Kawanami *et al*, 1991; FEMA, 2003). Effects on the immune system are supported by findings that alcohol-affected burn victims are three times more likely to die than those with no alcohol present (Hingson &, Howland 1993). It is noted there is an association between alcohol use and smoking, as these are often linked behaviours which correlate with other fire risk factors as socio-economic status (Ballard, Koepsell & Rivara, 1992). In all, the risk of alcohol consumption as a contributive factor in fire deaths appears to have been underestimated, as FEMA observes -

"*Fire casualties are emerging as an unintentional injury subset highly influenced by problematic drinking behaviours. Because the public's perception of this problem may be low, it may be possible to minimize fire risk by increasing awareness of those who drink and those who are surrounded by regular drinkers. Educational programmes warning the public of the dangers of drunk driving have been successful, and the same can be done to shed light on the subtle dangers of alcohol and fire."* (FEMA, 2003).

While alcohol is implicated in fire deaths, there is also a significant role of other illicit recreational drugs as potential risk factors (Barillo & Goode, 1996b). The widespread use of cannabis, opiates, amphetamines, and other drugs all have a potential to produce physical and cognitive impairments that may cause fire ignition or contribute to fire fatalities. In this regard age may be a significant factor, as the abuse of certain substances is associated with peer group activities. Particular reference is made to solvent or volatile substance abuse (VSA) within adolescent and young adults where there are concurrent risks from the physical/neurological effects of consuming volatile substances and the potential for fires and explosions due to the flammability of these substances (Scerri *et al*, 1992; Flanagan & Ives, 2002).

iii). Unattended Cooking & Careless Heating Activities

Cooking and heating facilities are universal in residential properties. Accordingly, fires caused by careless use or poor supervision of cooking and heating appliances pose fire risks in most countries. In industrialised countries cooking and heating systems have developed from wood or coal fired systems to electric or gas powered ones with improved efficiencies and safety as purported advantages of such new technologies. However electric and gas appliances are vulnerable to misuse, poor maintenance and inadequate supervision leading to fires.

Cooking activities reflect cultural and socioeconomic factors, with differential fire risks according to primary cooking agents and methods. For example, in the United Kingdom chip pan fires arise from a popular method of cooking food in hot fat or oil when these agents ignite on reaching a critical heat. Chip pan fires are reported as the most common source of household fires in 1998, with around 4,500 injuries and 52 deaths attributed to this cause (London Fire Brigade, 2000). While hot oil or fat presents a particular fire risk even boiling food in water is a potential cause of fire if pots are allowed to boil dry. Aluminium pots are a particular risk factor as these are prone to melting when exposed to high heat accelerating the spread of ignited materials rather than containing these as with more solid pots such as stainless steel. Likewise overheated or neglected ovens may also be a source of ignition. While most kitchen facilities are designed to be operated with safety, a key factor appears to be lack of supervision of cooking, poor maintenance of cooking appliances, and spread of fire through inappropriate actions when a fire is discovered. This point is summarised in the Safe as Houses Report -

"*Chip Pan Fires: by far the largest cause of injury in domestic fires was from chip pan fires.…Most of these fires were caused by leaving the pan unattended while cooking and putting too much oil in the chip pan. Most of the casualties result from not knowing how to deal with such a fire once it starts."* (Community Fire Safety Task Force Safe as Houses Report, 1997).

Chip pan and stove top/oven fires are reported in New Zealand. These are associated with particular cultural and socioeconomic features of various vulnerable groups. This matter is further considered in Section 2.6 below.

Types of residential heating also present fire risks. In many countries the use of open or solid fuel fires for residential heating is common, particularly in cold climates. Some of these present fire risks because of the presence of naked flames. The use of open fires for heating is likely to found in older homes as modern building codes discourage such installations on environmental grounds. Consequently, the use of open fires may disproportionately reflect tenancy by poorer socioeconomic groups where older housing presents an affordable residential option. Even where more modern heating appliances are installed there remains a risk from hazardous actions such as placing heater too close to flammable items such as bedding, clothes and furniture (Safe as Houses Report, 1997; Mah, 1998; USFA, 2002a).

A special area of heating related fire fatalities involves misuse and failure of electric blankets. The UK Department of Trade and Industry reports old or damaged electric blankets cause more than 5,000 fires per year with some 20 annual fatalities (DTI, 2004). In USA over the period 1992-2002 more than 35,000 fires were caused by electric blankets resulting in more than 40 deaths (Mah, 1998). The primary cause of these fires is faulty wiring in old or sub-standard electric blankets, along with blankets being left for extended periods on under layers of bedding leading to heat build up. It is noted elderly people are disproportionately at risk of electric blanket fires.

iv). Age Related Risks

A number of studies have identified age related fire risks as a specific area of concern. These risks involve two populations at opposite ends of the developmental spectrum –

- **The young** (infants, children and young adults under 16 years) who are defined by their vulnerability, developmental immaturity, and limited understanding of fire risks in the environment.

- **The aged** who are at risk due to physical infirmity, declining cognitive and sensory capacities, tendencies to live alone, and limited resources.

A range of studies have explored the dimensions of fire risks in these two age groups.

- **Fire Risks and the Young.** Because of their need for protection the young are particularly vulnerable to environmental risks, with a number of international studies recognising fire as a threat to this age group (Roberts, 1995: Whidden, 1996; Squires & Busuttil, 1996; Williams, 1998; Graham, 1998; Loveridge, 1998; Scholer *et al*, 1998; Bruck, 1998; Towner & Ward, 1998; Scholer *et al*, 1999; Warda *et al*, 1999; DiGuiseppi *et al*, 2000; Istre *et al*, 2002; Shai & Lupinacci, 2003; Cunningham, 2004; Bruck *et al*, 2004; Sekizawa, 2004). Fire risks in the young are associated with a range of potential threats and developmental limitations, including –

  - Immobility in the very young, who are often confined to cots and beds because of their extensive sleep needs in the first 3-4 years of life.

  - Limited appreciation of fire hazards particularly when engaged in playing or experimenting with fire, matches, lighters, and incendiary materials.

  - An inability to escape fires, or to form effective escape plans, including children engaging in hiding from fires with fatal consequences.

  - Vulnerability to toxic agents in smoke and fire fumes due to size and higher metabolic levels.

  - Inability to recognise fire threat cues, or to act appropriately when the onset of fires occur, including sleeping through smoke alarm signals.

  - A high dependence on adults to ensure safety, which can be compromised by adult alcohol and drug consumption, smoking, and inadequate child supervision.

  - Development-related physical and intellectual immaturity and incapacity.

- **Fire Risks and the Aged.** The aged present with similar fire risks as children, but also have other age-associated risks. Research has focussed on fire risks in this group because of a particular vulnerability as determined by fires injury and death statistics (Petraglia, 1991; Barillo & Goode, 1996; Elder *et al*, 1996; Kose, 1998; Williams, 1998; Graham, 1998; Bruck, 1998; Loveridge, 1998; Leth *et al*, 1998; Warda *et al*, 1999; DiGuiseppi *et al*, 2000; Istre *et al*, 2001; Istre *et al*, 2002; ODPM Report, 2002; Sekizawa, 2004).

Identified risk factors in the elderly include –

- Age-related mobility problems and dependence on mobility aids (wheel chairs, walking frames) that impede quick egress from fire threats, ability to crawl beneath smoke, and agility to escape through windows and other unconventional exits.

- Declining physical, intellectual, sensory responsiveness and capacities, including age-related dementia in extreme cases, which indicates the need for care and possible institutional support.

- Effects of medications impairing judgements and alertness.

- Inability to escape fires or to form appropriate escape plans, due to a lack of general appreciation of age-related physical limitations.

- Difficulty in recognising fire threat cues and warning signals resulting in delayed responses to fires.

- Engaging in high ignition risk activities, usually involving cooking and heating needs, including placing heaters too close to flammable surfaces, engaging in unsafe fire practices, leaving unattended cooking, and unsafe use of electric blankets.

- Consequences of life time maladaptive patterns of behaviour associated with alcohol consumption, drug abuse, and smoking.

- Consequences of living alone, often with limited resources, including poor safety maintenance and use of unsafe appliances.

v). Socioeconomic Status & Deprivation

A number of studies have identified socioeconomic status and deprivation as being associated with differential risks of fire mortality and injury (Mierley & Baker, 1983; FEMA, 1997; Scholer *et al*, 1998; Byard *et al*, 1998; Warda *et al*, 1999; Istre *et al*, 2001; Rowland *et al*, 2002; DiGuiseppi *et al*, 2002; Lyons *et al*, 2003; Shenassa *et al*, 2004). The contribution of socioeconomic factors to fire fatalities is complex and co-varies with a range of other risk factors including - smoking, alcohol/drug use, gender, education levels, beneficiary/employment status, residential location, and ethnicity.

The complexity of socioeconomic factors is described by Henry as influencing a range of health outcomes –

"The health disparity is not just a function of poverty. It is gradational in nature. A decline in health is observed with each successive class group, as one moves down the scale of advantage. It is intriguing that the gradational effect applies even at the upper end of the social class scale where the upper class is healthier than the upper-middle class just below them. This suggests that health inequality stems from more than just economic factors. A set of characteristics has been found to systematically differ by social class. They broadly fall within the following domains: 1) psychological domain, including norms and habits, abstract-level modes of thought, health knowledge, and behavioral intentions; 2) behavioural constraints, including economic resources and situation effects; 3) physical influence, including physiological stress, genetic dispositions, and environmental conditions." (Henry, 2001).

It is evident socio-economic status is not a *causal* factor in fire fatalities; rather, it is an aggregation of economic, material, and social deprivation measures which provides a *description* of groups who are over-represented represented in fire statistics. However, some reports appear to suggest otherwise. Petraglia (1991) sees higher fire deaths in lower socio-economic groups as reflecting the fact the poor have a reduced ability to respond to fire safety initiatives (eg. having smoke detectors or safe heating systems). While this may be true, it is more likely that differential socio-economic fire risks are a result of much more complex factors such as those described by Henry. The point is well stated in a 1997 National Fire Data Centre report –

"…while the incidence of poverty has been shown to be associated with increased fire risk, poverty in and of itself does not cause fires."

vi). Seasonal & Cultural Factors

The seasonality of fire fatalities is a consideration in a many countries. This primarily reflects *climatic* factors (ie. cold months of winter with increased heating demands and internal living arrangements) and *cultural* factors (from increased fuel loadings and additional fire sources such as candles in homes). The US Fire Administration has determined the December–January Winter Holiday Season (USFA, 2002b) as a high risk period in the United States where the average yearly fire fatality rate almost doubles from 2.4 deaths/1000 fires per day to 3.6 for all winter fires and 4.1 for the Winter Holiday Season. This increase is attributed to activities associated with Christmas celebrations –

"*Fire loads increase throughout the home during the holiday season. Many homes are decorated with seasonal garlands, electric lights, candles, banners or displays. Probably the most popular addition to the home during the holiday season, and a significant fire hazard, is the Christmas tree. Dried-out fir and pine Christmas trees ignite easily and can accelerate fire growth by spreading rapidly to nearby combustible materials in the home*." (USFA, 2002b).

Candle use has been highlighted as a risk associated with other activities including religious purposes, where fires have ignited from unattended burning candles. US reports record 45% of candle fires originate in bedrooms, and 25% of candle fires occur in the holiday season (USFA, 2001). Another example of seasonal/cultural risk factor in the United States is increased residential fire fatalities on Thanksgiving Day. This increased risk is related to unattended cooking activities causing fires (USFA 2002a). One journalist summarises the situation as follows –

"During the holiday season, from Thanksgiving to Jan.1, fires typically injure 2,000 people and cause more than $500 million in property damage in the United States alone. Compare that to last summer's Florida wildfires, which scorched 500,000 acres at a cost of around $400 million. Fire deaths increase in winter because people use more electricity and both traditional and alternative heating sources, according to the United States Fire Administration (USFA). During the holidays, dry Christmas trees and colorful, overheated lights add to the risk." (Kriner, 1999)

British research also reports higher residential fire fatalities in winter months (Holborn, 2001); a pattern is also reported in the Republic of Ireland (National Safety Council, 2003).

vii). Location within Residence

A number of studies note differential fire risks depending on locations in residences. These risks primarily reflect the nature of customary activities that occur in different areas in residences and potential fire sources found in such areas. For example, electric blanket and bedding fires reflect risks associated with sleeping areas, while stove top and oven fires obviously relate to kitchens and cooking areas. Customary activities may involve higher fire risks such as smoking in bed, or placing heaters close to favourite chairs. A consideration is changes in the dynamics of residential areas caused by high levels of occupancy, such as using lounge and living areas as sleeping places in crowded accommodation. Typically kitchens, lounge/dining areas and bedrooms are found to the locations of greatest fire ignition risk (eg. Aust, 2001).

Bounagui *et al* (2004) studied residential fires in Ontario between 1995-2003 and determined that of 6,739 fires (involving 717 fatalities) 28.6% started in kitchens and cooking areas, 12.6% in living areas, and 11.3% in sleeping areas. They noted –

"These three areas listed above are also the most fatal places for fires. The living areas constitute the most deadly places in Ontario homes. They account for 45.1% of fire fatalities; they are followed by sleeping areas (20.0%), and by the kitchen and cooking areas (16.9%)". (Bounagui, Benichou &Victor, 2004).

A related pilot study by Bwalya, Sultan and Benichou (2004) examined fire loadings in Canadian homes and observed –

"*Residential buildings contain a great diversity of combustible household items, ranging from furnishings to electronic audio, visual and computer equipment, all of which are made from an equally diverse range of materials with different burning characteristics. The major combustible building material used in the construction of Canadian homes is wood. It is used in various forms (dimension lumber or engineered types) for the framing, floor joists, panels used for the sub-floors, and the sheathing of the roof and exterior walls. Whereas the fire resistance of wall and floor assemblies can be prescribed and their material composition known with certainty, this is not the case for combustible household contents, for which the quantity, type and arrangement of the combustibles is different for every home. This presents the greatest difficulty in any attempt to predict fire development in a given room with any confidence*".

A observation from this study is that there are marked similarities in Canadian and New Zealand housing construction characteristics. Therefore, it is likely there will be similar differential fire fatality risks according to areas within residences, and with fire loadings associated with various parts of the house and customary activities which occur there. The role of customary activities in these different areas is likely to be a key consideration in analysing the inter-relationship between fire loadings and patterns of fires, with behavioural component providing an important component on fire ignition and spread.

2.6. AUSTRALASIAN STUDIES OF RESIDENTIAL FIRES

A significant number of research studies on residential fire injuries and deaths have been undertaken in New Zealand and Australia. These studies have focussed on identifying vulnerable populations to develop intervention strategies to reduce fire deaths and injuries. Some studies have also encompassed a wider range of injuries and deaths from all fire causes. Particular mixes of behavioural and epidemiological analyses have been adopted in the methodologies applied in these studies.

i). New Zealand Studies.

A number studies have examined aspects of New Zealand residential fire deaths with various epidemiological analyses exploring demographic patterns of such deaths. Studies found residential fires were the primary cause of death by thermal injury in children (Waller & Marshall, 1993) and in adults (Waller, Marshall, & Langley,1998). A related study found fire deaths were more likely to occur in rental accommodation and cheaper houses in the lowest valued areas of town (Cropp, 1991, 1997). This was extended by Irwin (1997) who identified a range of fatal fire characteristics which reflected international findings, including – time, day of week, room of origin, age, gender, equipment involved, form of heat ignition, form of material ignited, ignition factors, condition of victim prior to injury, and lack of escape.

A series of studies by Duncanson and colleagues has examined a range of fire fatality factors including spatial patterns and geographical distribution of incidents, information collection and validation requirements, more detailed analyses of population features, and specific causative agents, including –

- **Information Collection:** Duncanson, Reid, Langley & Woodward (2001) identified the need for improved information collection and inter-agency coordination of fatal fire incident reports to improve the quality of fire prevention initiatives.

- **Spatial, Geographic, and Temporal Distributions:** Duncanson (1999) defined a basis for injury prevention strategies based on geographic distributions of fire fatalities. Duncanson, Woodward and Reid (2000b) further examined the geographic distribution of fire fatalities and concluded those territorial authorities with high fire fatality rates "were also those with high rates of poverty, poor housing, undereducated populations and sole parenting." Duncanson, Woodward, Reid, & Langley (2000) reviewed overall fire fatality data for 1991-98 and concluded mortality rates were highest for adults over 65 and children under 5 years, with Maori having a threefold increase in risk over non-Maori. They also reported fatal incidents were more common in winter and in the early hours of weekend mornings.

- **Cooking Fires:** Duncanson, (2001) examined stove tops or ovens as sources of fatal fires in 1991-97. This included 27 deaths in 22 incidents accounting for 14% of unintentional residential fires. 25 deaths resulted from food left cooking on stove tops or ovens igniting. 2 cases involved misuse of these appliances as heating sources. Male death rates were 2.5 times higher than females while age-standardised rates for Maori were 4 times than Non-Maori. Adult victims included 12 who had consumed alcohol prior to the fires. All 5 child victims had caregivers with a history of recent alcohol consumption. It was noted in 4 incidents the deceased discovered the fire but were unable to contain it or escape, while in 15 other cases the victims appeared to be asleep. Multiple fatalities involved 8 victims in 3 separate incidents. The study found the use of oil or fats occurred in at least half the incidents. There was an absence of installed smoke alarms in 14 of these events.

- **Child Fatalities and Injuries:** Duncanson, Ormsby, Reid, Langley & Woodward (2001a) examined fire deaths in children aged under 15 years for 1991-1997 and identified 39 fire incidents involving 53 deaths of children, with 12 incidents involving multiple fatalities. Male mortality exceeded that of females by a factor of two, and Maori children exceeded all others by 11 times. Children playing with matches/lighters accounted for 36% of these deaths, with misuse of heaters and fireplaces causing a further 26% fatalities. A study of fire injuries and deaths in children age 0-14 in the Auckland region by Kool (2001) found males were more likely to die or be hospitalised. Pacific Island children were most at risk, and low socio-economic status was also an identified risk factor. Playing with matches or lighters was the most common source of ignition. Of these child fatalities 90% died at the scene of the fire, while the remainder in hospital.

- **Fatalities and Injuries in the Elderly:** Studies of fire deaths in the elderly by Duncanson, Ormsby, Reid, Langley & Woodward (2001c) determined mortality rates were consistent with those found in the young adult age groups, but significantly these rates tripled for each decade over the age of 75. Women were at a higher risk, along with Maori. It was found a disproportionate number of victims lived alone and who appeared vulnerable fires originating with heating appliances and bedding as sources of ignition. Duncanson, Reid, Langley & Woodward (2002) noted hospital admissions for fire injuries included adults over age 74 with direct contact or contact of clothing with a heat source as a particular risk factor.

- **General Fire Fatalities and Injuries:** Companion work by Duncanson, Ormsby, Reid, Langley & Woodward (2001b) determined mortality rates in the general adult population and identified high mortality risks for males, particularly Maori. The most common factors in these fires appeared to be materials igniting on stove tops or ovens, smoking materials igniting combustibles, alcohol consumption, and disruption to social routines (eg. social events, returning home late at night, being away from home, having guests). The study confirmed most deaths occurred in permanent private dwellings, although "a significant minority (8 incidents, 10 percent) occurred in temporary accommodation including caravans, tents and garages". The absence of non-functionality of smoke alarms was identified as a feature of note.

- **Socio-economic and Cultural Factors:** A consistent statistic is the high Maori fire mortality/injury risk compared to Non-Maori populations. This has been correlated with social and economic deprivation which extends to other populations groups. Duncanson, Woodward & Reid (2000a) analysed census-based social and economic deprivation indices with fire fatalities between 1988-1998. They found fatalities disproportionately occurred in dwellings located in the most socially and materially deprived census mesh blocks. Significantly, they found fatal fire rates were 4.5 times higher in the most deprived mesh blocks as in the least deprived. In specific response to the disproportionate risk of Maori as fire fatalities and injuries several studies and initiatives have examined initiatives and interventions to reduce this vulnerability, including Sutton (1994), Rayner & Moroney (1999), Duncanson, Woodward & Reid (2000b), and Hoskins, Smith & De Santolo (2001).

In general the findings of New Zealand research confirms the potency of fire risk factors identified in the international literature, with local variations reflecting particular features of national geography, life style, and cultural makeup. The specific vulnerability of Maori and Pacific Island peoples have been identified, along with risks associated with living in rural isolation, living alone, and age related characteristics. The New Zealand picture reflects findings from Australia where there are close socio-cultural similarities.

ii). Australian Studies.

Australian residential fire research has included both an epidemiological emphasis and a focus on behavioural analyses of victims of fire. Studies have examined patterns of fire deaths and injuries across all States and Territories to develop a wider national picture. A study by the National Injury Surveillance Unit found house fires were responsible for 66% of all fire injury deaths in Australia in 1994 (AIHW, 1997).

A major national study by Newton (1998) examined dwelling fire deaths between 1991-1996, whether accidental, deliberate, and undetermined-cause fires. It found 550 deaths occurred in 451 structure fires in the period; however, it noted difficulties in the adequacy of data across all Australian jurisdictions which placed limitations on the findings. The research determined those at greatest risk of fatality were aged 65 and over, children between zero and four years, those not in the workforce, those living in rental properties, and those affected by alcohol. Among key points of note were –

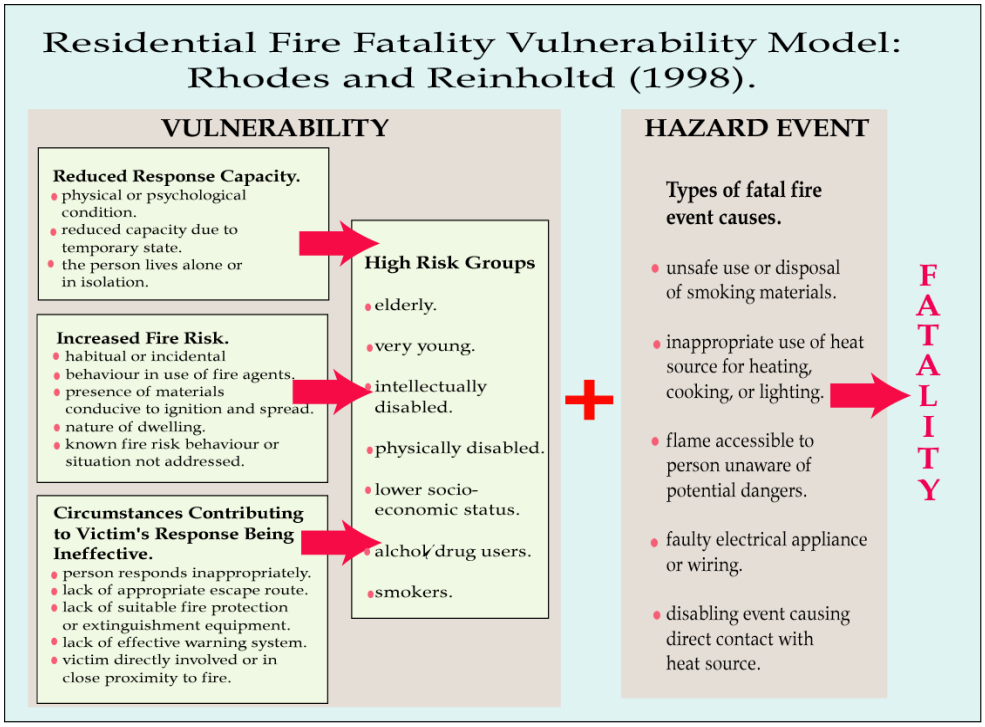
> **Time of Death Analysis:** Of 251 victims whose mortality details were reliably established, some 212 (**80%**) appeared to have been dead prior to, or coinciding with, the fire service alarm notification time.
>
> **Temporal Patterns:** A majority of fire fatalities (**62%**) occurred in the second half of the year, with the most deaths reported in June , July, and August. Winter fires were mostly associated with accidents involving heaters. A higher number of fire fatalities (49%) occurred between midnight and 8am, these deaths being associated with sleeping victims who were exposed to dangerous levels of toxic product of fire thus reducing their chances of escape.
>
> **Property Type:** The study found one or two family dwellings were most likely to be involved in fatal fires. Of those properties where ownership could be determined **57%** were rental properties.
>
> **Cause of Death:** From records established in 323 deaths, 181 (**56%**) died as a result of smoke inhalation, and 42 (**13%**) of a combination of smoke inhalation and burns.
>
> **Smoke Alarms:** Where information on smoke alarms was established, only 7 (**3.5%**) out of 202 properties involved in fatal fires had smoke alarms installed.

Newton (2003) further advanced her 1998 research to examine structural fire fatalities in Queensland between 1991-2000, finding that many of the key features identified in the earlier study were again supported. The greatest at risk groups remained - persons aged 65 and over (particularly those 80 and over), children between zero and four years, adults affected by alcohol, and adults not in the workforce. Higher levels of deaths were found in the colder months, with 96 (**55%**) of 175 deaths between June-September. Alcohol-related fire deaths accounted for 20% of casualties. A major cause of fatal fires was identified as discarded smoking materials, often associated with intoxication or sleeping victims.

Rhodes and Reinholtd (1998) examined residential fire deaths in Victoria between 1 January 1992 and 31 December 1995. The research utilised coronial records as a basis to understand the circumstances surrounding each fire, including a focus on the efficacy of various preventative measures. In all 66 fatalities from 54 fires were examined where fire was established as the primary cause of death. The study used a conceptual framework known as Haddon's Matrix as an analytical tool. This was developed out of injury prevention methodologies by Haddon (1972, 1973) and has been adopted as a tool to identify risks and provide structured preventive responses to such risks (eg. Jensen, 1991; Berger and Mohan, 1996; Runyan,1998; Kobusingye & Sethi, 2002).

The results of the study confirmed a significant involvement of a human agent in each case "who, through their actions, directly or indirectly, contributes to the ignition, and/or spread of the fire." Five fire events were identified as commonly resulting in fatalities. These, included, in order of casualties – unsafe use of disposal of smoking materials (21 fatalities), inappropriate use of heat source for heating, cooking, lighting or other domestic purpose (15 fatalities), flame accessible to people unaware of potential dangers of fire (7 fatalities), electrical appliances or wiring (6 fatalities), disabling event causing direct contact with heat source (5 fatalities), and unknown (12 fatalities).

Using the Haddon Matrix to identify clusters of factors, Rhodes and Reinholtd observe "*that it is the exposure of a vulnerable person to the hazard event which defines the event as a fatal fire*." They propose the following model that relates indicators of vulnerability and hazard events to fatal outcomes in residential fire.



The model argues some fires are more likely to be fatal, and these usually are a result of an interaction between certain human actions and a range of hazard elements. Also some people have increased risk levels than others, and thus consideration of residential fires needs to take into account factors which define certain groups as "high risk" and the hazard or fire event itself. This model relates well to the paradigm proposed by Brennan and Thomas (2001) as presented on page 12. Both are predicated on the notion of human *interaction* with fire, rather than a passive *reaction* to it, as human agency is identified as a powerful element causing fires to ignite in the first instance, and in actions that contribute to resulting fatalities or injuries.

Brennan and colleagues have published a series of papers on human behaviour as a dynamic affecting fire ignition and consequent fatalities and injuries. This research has largely been conducted under the auspices of the Centre for Environmental Safety and Risk Engineering, Melbourne, and includes papers presented at all three International Symposia on Human Behaviour in Fire (1999, 2001, 2004).

The core to Brennan's approach is the inappropriateness of many predictive models of behaviour in fires because these have tended to focus on "time-based fire models and expectations about fire safety features". She observed that these models resulted in increasing attention to understanding timing and initial delays in casualties responses as well as evacuation responses themselves, to which end she noted –

"But how realistic is this conceptualisation? One critical aspect of fires that we are largely ignoring is occupant involvement with ignition. A second is the role of occupants in facilitating or encouraging fire growth and smoke spread, even if inadvertently, by their actions before and during a fire. Together, these behaviours are the major contributors in fire fatalities, as will be shown, but they are overlooked when human behaviour is modelled as purely reactive". (Brennan, 2001. p124).

The strength of this argument is borne out in the type of studies of fatal fire incidents undertaken by Brennan, Rhodes and Reinholtd, and Newton in Australia, and by Duncanson and colleagues in New Zealand. Brennan summarises the matter -

"In developing models to assess the effectiveness of fire safety design, we need to keep in mind that the multiple fatality fires (so prominently reported by the media) are uncommon. They generally represent a small proportion of total fatalities and often result from an improbable series of events. As well, timely occupant response is not the crucial factor in many cases where the victim is involved in ignition. Because it is important in relatively few cases, it may be difficult to predict the effect of response time accurately because it is relevant in relatively few cases. Its importance in individual cases may be harder to assess. Similarly, the effects of sudden changes in conditions, whether brought about by failure of building elements due to the action of the fire, or by intended or unintended actions of occupants, need to be understood and incorporated in fire models.

In order to predict fatalities it may be more useful to discriminate between occupants who initiate an uncontrolled fire and occupants who face a fire not of their own making than to attempt to discriminate different responses and times for a response to a fire. In other words, because the majority of fatalities in residential fires occur within the room or apartment of fire origin, we need to go further back than the pre-evacuation period in looking at human behaviour.

In the case of occupants who start fires (and sometimes die in them) while engaging in customary behaviour, it may be necessary and more cost effective to use specific prevention strategies targeted directly to their needs, rather than to assume that building fire safety design will provide effective solutions.". (Brennan, 2001. p133).

Australian and New Zealand research has developed a particular focus on detailed analysis of individual behaviour in residential fires. It is apparent residential fires in both countries occur in broadly similar circumstances which provide a commonality in research findings. Further, this work collectively supports the thesis that occupants *interact* with fire, and that it is human agency that is a powerful element in causing fires to ignite and in consequent actions that contribute to fatalities or injuries.

Emerging from this work is a new paradigm which raises questions about *intentionality* as a factor in fire causation, especially when behaviours are placed against legal determinations of intent. It is postulated a simple intentional/unintentional dichotomy may not account for complex behavioural dynamics that are at play in fires, but that a range of factors affecting vulnerability of individuals to potential fire hazards is a key determinant. This paradigm is compared against in the results of the study and is discussed in detail in Section 6.

SECTION 3: COMPARATIVE STATISTICS

Fire deaths and injuries are commonly reported in developed countries. Accordingly, it is possible to draw a general comparative view of the extent of fire related deaths across a range of jurisdictions *albeit* with the need for qualifications concerning time base measures and definitional variations. For the purposes of this report New Zealand statistics form a general baseline for comparative analyses.

3.1. NEW ZEALAND FIRE DEATHS 1997-2003

Table 3.1a presents general fire statistics[3] for the period of the study.

	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003
Total Fire Deaths	46	42	28	38	39	41
Unintentional Residential Fire Deaths	25	23	15	16	26	26
All Fire Deaths/ 100,000	1.26	1.11	0.79	1.20	0.98	1.05

From this table the following summary statistics are generated –

Average annual fire deaths	39.0
Average annual residential fire deaths	21.8
Average annual fire deaths/100,000	1.01

3.2. AUSTRALIAN FIRE INCIDENT STATISTICS

Table 3.1b presents Australian fire statistics for the period 1997-2002. These data are drawn from the Australian Government Productivity Commission Report 2004. The data includes the 2001-2002 year as the latest annual period of reporting

	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	Average
Total Fire Deaths	140	138	115	143	97	126.6
All Fire Deaths/ 100,000	0.76	0.74	0.61	0.75	0.50	0.67

No distinction is made between intentional and unintentional deaths. These data do not include Northern Territories. No distinction is made between residential and other fire deaths. The Report observes that the small number of deaths in each period results in difficulties in establishing patterns or in providing detailed analyses. Rate fluctuate from year to year which demonstrated data volatility.

The impact of a single large fire may distort patterns in a period such as with deaths from the Queensland Back Packers Hostel blaze (an intentional fire). Similar provisos should be applied to New Zealand data, given variations around the comparatively small number of fatalities reported each year, and the size of the population base.

[3] Source: NZFS Fire Statistics www.

3.3. REPRESENTATIVE INTERNATIONAL FIRE DEATH STATISTICS

International comparative fire death statistics present some difficulties as they may use differing measurement bases. However, a general comparison is provided by the Geneva Association (2000)[4] which presents the following comparative data for fire deaths/100,000 population for 1997-1999 -

Country	Fire Deaths per 100,000 population	Rate Relative to NZ
Singapore	0.18	-0.92
Switzerland	0.62	-0.48
Spain	0.64 [*1996-98]	-0.46
Netherlands	0.68 [*1994-96]	-0.42
Australia	0.69	-0.41
Austria	0.76	-0.34
Italy	0.77 [*1996-98]	-0.33
Germany	0.82	-0.28
France	0.95	-0.15
New Zealand	1.10	
Czech Republic	1.13	0.03
Slovenia	1.15	0.05
United Kingdom	1.18	0.08
Belgium	1.27 [*1993-95]	0.17
Greece	1.34	0.24
Norway	1.37	0.27
Canada	1.38	0.28
Poland	1.41	0.31
Denmark	1.49	0.39
USA	1.56	0.46
Sweden	1.62	0.52
Japan	1.69	0.59
Finland	1.98	0.88
Ireland	2.02 [*1996-98]	0.92
Hungary	2.14	1.04

These data are provided as indicative measures only because of differences in measurement bases. However, the data suggest the New Zealand gross fire death rate/100,000 population falls around the middle range of rates reported for the countries presented. These data do not delineate between intentional and unintentional deaths, time bases are not fully comparative, and there is no distinction between residential and other fire deaths.

Representative fire statistics from some jurisdictions include -

Ireland: The National Safety Council[5] reports that for 2001 -2004 a total of 187 fire deaths occurred -

Year	2001	2002	2003	2004
Fire Deaths	63	51	37	36

No distinction is made between intentional and unintentional fire causation, or deaths in residential properties.

[4] Reference link www.genevaassociation.org
[5] Reference link www.nsc.ie/FireSafety/Statistics/Name,174,en.html

In a general news report Condon (2001) notes that the National Safety Council reports that "*a person is most likely to be killed in a domestic fire if they are male, over 60, living alone in a rural or semi-rural area and do not have a smoke alarm*".

Canada: The Council of Canadian Fire Marshals (2000) report the following gross fire fatalities for Canada -

Year	Number of Fires	Annual Fire Deaths	Fire Deaths/100,00 Population
1993	65,877	417	1.45
1994	66,719	377	1.30
1995	64,251	400	1.36
1996	60,138	374	1.26
1997	56,292	416	1.39
1998	57,602	337	1.11
1999	55,169	388	1.27
2000	53,720	327	1.06
Average	**59,971**	**379.50**	**1.28**

The Report advises around 74% of fire deaths occurred in residential occupancies. No distinction is made between intentional and unintentional fire causation in this Table.

United Kingdom: The Office of the Deputy Prime Minister reports on United Kingdom fire statistics. The 2002 Fire Statistics Report includes comprehensive data on fires for England & Wales, Scotland, and Northern Ireland. Total fire fatality statistics (with rate 100,000 population in brackets) for 1997-2002 include –

	England & Wales	Scotland	Northern Ireland	United Kingdom
1997	605 (*1.18*)	88 (*1.73*)	30 (*1.80*)	723 (*1.24*)
1998	530 (*1.03*)	96 (*1.89*)	30 (*1.79*)	656 (*1.13*)
1999	487 (*0.94*)	105 (*2.07*)	31 (*1.85*)	623 (*1.07*)
2000	521 (*1.00*)	75 (*1.48*)	17 (*1.01*)	613 (*1.05*)
2001	493 (*0.94*)	96 (*1.90*)	17 (*1.01*)	606 (*1.03*)
2002	465 (*0.89*)	77 (*1.52*)	20 (*1.18*)	562 (*0.95*)
Average	**516.8 (*1.00*)**	**89.5 (*1.77*)**	**24.2 (*1.44*)**	**630.5 (*1.08*)**

No distinction is made between intentional and unintentional fire causation in this Table.

Dwellings are the primary locations for fire fatalities as is shown in the following Table for 1997-2002 –

	Total Fatalities	Dwellings (%)	Other Buildings (%)	Other (%)
1997	723	562 (*77.7%*)	33 (*4.6%*)	128 (*17.7%*)
1998	656	513 (*78.2%*)	28 (*4.3%*)	115 (*17.5%*)
1999	623	463 (*74.3%*)	38 (*6.1%*)	122 (*19.6%*)
2000	613	455 (*74.2%*)	39 (*6.4%*)	119 (*19.4%*)
2001	606	483 (*79.7%*)	42 (*6.9%*)	81 (*13.4%*)
2002	562	430 (*76.5%*)	29 (*5.2%*)	103 (*18.3%*)
Average	**630.5**	**484.3 (*76.8%*)**	**34.8 (*5.5%*)**	**94.7 (17.7%)**

Over three quarters of these fire fatalities occurred in residential dwellings.

Key points from the report include –

- around 80% of all fire-related casualties occur in dwellings (with 430 people dying in their homes in 2002).
- the main cause of accidental dwelling fires is the misuse of equipment/appliances and chip pan fires.
- the main source of fire ignition was cooking appliances.
- about one fifth of all dwelling fires were deliberate in causation (leading to 75 deaths in 2002).
- around 80% of properties have smoke detectors installed and these have lower casualty and damage rates as a consequence.

United States of America: Fire Statistics are recorded by the U.S. Fire Administration as part of the Federal Emergency Management Agency (which came under the aegis of the U.S. Department of Homeland Security in 2003). Considerable attention has been focussed on the consequences of fire in the United States given the high levels of losses caused by fire as a 1997 FEMA report on fire death rates notes -

"*The United States historically has had one of the highest fire loss rates of the industrialised world – both in terms of fire deaths and dollar loss. This unenviable status has perplexed many experts in the fire world. The United States is health and safety conscious in many areas – automobiles, consumer products, food, and medical drugs, to name a few – and has a vast arsenal of technological resources to combat fire. For such a safety conscious and technologically advanced society to be a leader in fire losses is indeed puzzling*" (FEMA, 1997).

The U.S. Fire Administration has published a series of omnibus reports under the titles *Fire in the United States*, the latest including the 13th edition covering 1992-2001. This confirms the dire observations of the 1997 study –

"*The U.S. fire problem, on a per capita basis, is one of the worst in the industrialised world. Thousands of Americans die each year, tens of thousands of people are injured, and property losses reach billions of dollars. There are huge indirect costs of fire as well – temporary lodging, lost business, medical expenses, psychological damage, pets killed, and others. These indirect costs may be as much as 8 to 10 times higher than direct costs of fire. To put this in context, the annual losses from floods, hurricanes, tornadoes, earthquakes, and other natural disasters combined in the United States average just a fraction of those from fire. The public, the media, and local governments are generally unaware of the magnitude and seriousness of the fire problem to individuals and their families, to communities, and to the nation.*" (FEMA, 2004).

The 2004 report observes residential fires are the predominant locations for fire deaths. Injuries, and property loss as shown in the following Table for 2001

Property Type	Deaths/1,000 Fires	Injuries/1,000 Fires	Dollar Loss/Fire $
Residential	7.4	36.4	13,200
Non-Residential	1.0	14.7	20,600
Vehicle	1.7	4.8	3,900
Outside	0.1	1.3	200
Other	0.9	11.1	3,100

The significance of residential fires is aptly summarised -

"*One and two-family dwellings, where 73 percent of the population lives, dominate the residential fire picture in 2001: 73 percent of fires, 78 percent of deaths, 67 percent of injuries, and 76 percent of dollar loss. Cooking is the leading cause of fires and injuries in these structures. Smoking is the leading cause of deaths, followed closely by arson. These causes alone are responsible for 42 percent of deaths. Arson is the leading cause of dollar loss. Heating is the second leading cause of one-and two-family dwelling fires (19 percent) slightly behind cooking (25 percent). Heating plays a much less prominent role in other dwelling fires. Perhaps home-owners are not as attentive as apartment management in maintaining their heating systems.* " (FEMA, 2004).

Other salient findings include –

- kitchens are the area where more fires occur (which is consistent with risks associated with cooking).
- deaths are highest in living room and bedroom fires (which are related to risks associated with smoking).
- fires risks are at the highest between 5 -7 pm (the cooking hours).
- deaths peak in the early morning hours from midnight – 5 am.
- fires and deaths are greatest in the winter months (relating to heating fires and seasonal risks associated with dry Christmas tress and holiday candles).
- 90 percent of households have at least one smoke alarm and those without alarms have a greater incidence of reported fires.
- African Americans and American Indians have a higher fire death rate than the national average, with the former accounting for 25 percent of fire deaths.
- Males are twice as likely to die in fires than females, and those with limited physical and cognitive abilities (the very young and very old) are at higher risk than others.

In general these international fire statistics suggest that fire death and injury rates have decreased over the past two decades as respective national agencies have targeted particular causal factors through education and prevention programmes, and through a wider availability of technological aids such as smoke detectors and sprinkler systems.

The New Zealand fire death and injury rates appear to fall somewhere around the middle of those reported by other developed countries.

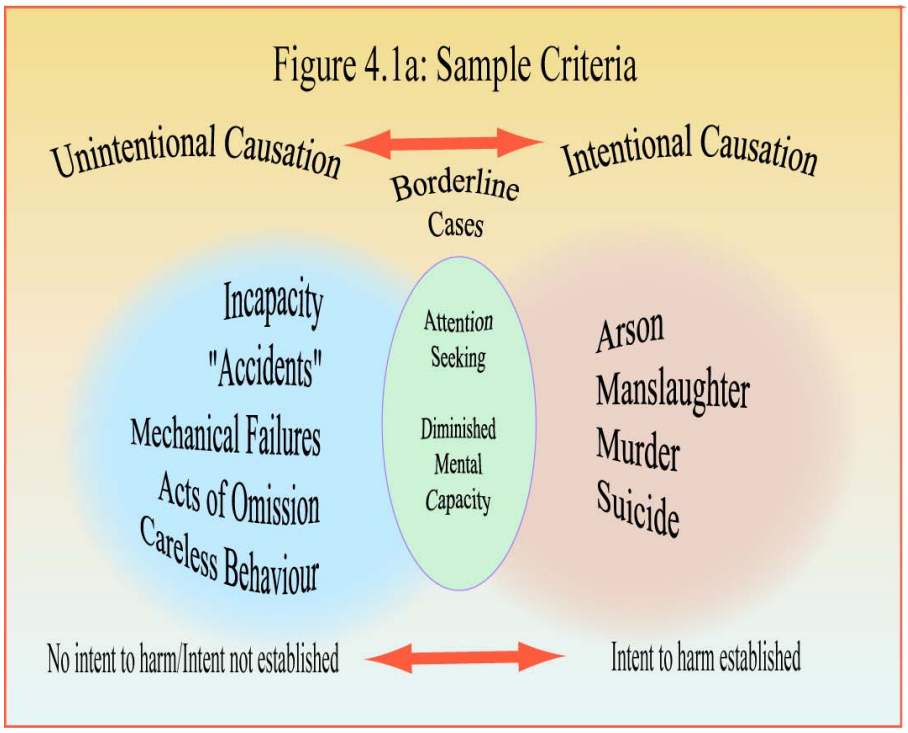
SECTION 4: METHODOLOGY

4.1. SAMPLING CRITERIA

Selection of cases for inclusion in the study was based on two criteria –

(a) the fatalities occurred in *residential* properties,
(b) the fires were *unintentional* in causation.

According to these criteria only deaths in residential settings and fires of unintentional causation were included (ie. fires attributed to arson, suicide or homicide were excluded). The selection model addressing intentionality of causation is presented in **Figure 4.1a.**



In distinguishing between *intentional* and *unintentional* deaths a number of *borderline* cases were identified. The inclusion of these in the study involved a judgement on whether the fire was lit with a clear intent to harm the deceased or others (ie. *intentional*), or whether the fire arose from irrational or attention seeking behaviour, or as a result of diminished mental capacity. The latter cases were deemed to be an *unintentional* result. The decision to include or exclude cases was influenced by coronial findings at inquest as a judicial verdict. In all **15** borderline cases were included on this basis. The question of the validity of a simple dichotomy between *intentional* and *unintentional* fires is discussed in more depth in **Section 6.2**.

4.2. TIME BASE

The study adopted the Corporate Year time base to include all fatal domestic fires for the period 1 July 1997 - 30 June 2003. Accordingly the study encompassed a 6 year period.

4.3. SOURCES OF DATA

a). FIRMS[6]: Initial incident data was obtained from FIRMS. This records all national fire incidents, whether these involved deaths, injuries, property damage, or otherwise. Each incident record contains a comprehensive summary of response and fire incident characteristics. All incidents are defined according to a unique Computer Assigned Dispatch Number which records time and location of each call for assistance and thus establishes an event both in *temporal* and *geographical* terms.

FIRMS has an inherent limitation as a data source as the primary information is collected at the time of an incident or shortly thereafter from NZFS reports. Consequently not all incident information is recorded in FIRMS, and in a small number of cases some data may require later amendment (eg. details of name, age, cause of death, cause of fire, intentionality etc). This is because fire investigation and other forensic activities usually take some time to complete, and then these are presented at an inquest where a formal coronial verdict is reached. The value of FIRMS data lies in defining times and locations of events, and in the collection of a range of response and incident characteristics.

b). Inquest Records: The Coroners Act 1988 grants Coroners wide discretion to enquire into, and investigate, questioned deaths. Inquests are thus a formal public judicial process to examine a range of evidence with the intention of establishing the facts as to who has died, when, where, and how. Key findings include the cause of death and any prevention or safety issues as may be identified from the inquest. Domestic fire deaths fall within a grouping of fatalities that are subject to coronial consideration.

The Coronial Services of the Ministry of Justice maintain records of all cases referred to Coroners, whether these are the subject of a formal inquest or not. Inquest reports are retained by Coronial Services until they are transferred to the National Archives. These reports are a rich source of information on investigations into deaths, determination of causes of death, and behavioural matters associated with such fatalities.

The types of information commonly contained in inquest files of relevance to the study are set out below in **Table 4.3.**

Information Source	Details
Police Reports	All fatal fires must be investigated by police to determine potential criminal intent (ie. if the fire was found to be intentional homicide or suicide is a consideration). Police are required by statute to assist the Coroner in investigating such deaths and to coordinate presentation of evidence at an inquest. Police investigations are usually conducted in parallel with those of NZFS. Police reports typically include background and demographic information on the deceased – ie. age, gender, ethnicity, and occupation.
Fire Investigation Reports	NZFS investigators conduct detailed examinations of fatal fire scenes, including analysis of point of ignition, patterns and contributive factors affecting fire spread, performance of safety mechanisms, and fire causation. The findings are presented in specific Fire Investigation Reports usually attached to the inquest file.

[6] **NZFS Fire Incident Risk Management System.**

Specialist Reports	Specialists are involved if particular types of analysis are required. This includes scientific analysis to detect for various chemicals/substances (eg. accelerants, drugs etc). Other forensic specialists investigate specific environmental risks or equipment failures (eg. electrical system faults or appliance performance that contribute to fire ignition).
Pathologists Reports	Pathologists report on the post mortem examination of the deceased to attempt to establish identity, personal features, and cause of death. Pathologist's reports are supplemented with laboratory analysis of blood/body tissues to ascertain levels of carbon monoxide, alcohol, and drugs, or other medical/environmental factors contributing to death.
Witness Reports	Witnesses may present evidence in person or their reports are included in Police/Fire investigations. Witness accounts relate to features of the fire, behaviour of affected parties, and other relevant information. In some cases these reports include the views of health professionals, agencies familiar with the deceased, and other pertinent information.
Coroners Finding	The Coroners verdict usually includes findings of cause of death and recommendations identified by the inquest. Coroners may link cases to other incidents or make recommendations concerning specific risks or safety matters (eg. installation of smoke alarms, aged care etc).

Note: The nature of information contained in inquest files is sensitive and relates not only to the deceased, but also to surviving family and friends. Accordingly, care has been taken to protect individual identities as far as possible in the study. In general the Privacy Act and the Code of Ethics implicit in the Psychologists Act 1981 apply to this study.

It is important to note that although inquest reports provide a rich source of information, these are primarily judicial findings. Research based on inquest reports requires an appropriate methodology to analyse the information. A combined qualitative/quantitative methodology was adopted in the study.

4.4. SAMPLE VALIDATION

Initial information from FIRMS identified 148 potential cases for the study. Detailed analysis of inquest files determined 131 cases met the research criteria of *unintentional* fatalities, with the remaining 17 cases classified as *intentional* deaths involving suicide or homicide.

Although most inquest files contained comprehensive information in a small number of cases information was at variance with FIRMS data, or was not recorded. Examples included conflicts in name spelling, use of aliases/multiple names, confusion with first and surnames, missing information on birth dates/ethnicity/occupation. A validation exercise was undertaken on questioned information, predicated on a basis that –

- the inquest file was the legal reference point to define data and matters of fact, but where personal information was missing,
- the missing information was sought from NZ Health Information Service records as a secondary reference point for individual information.

4.5. DATABASE FORMAT

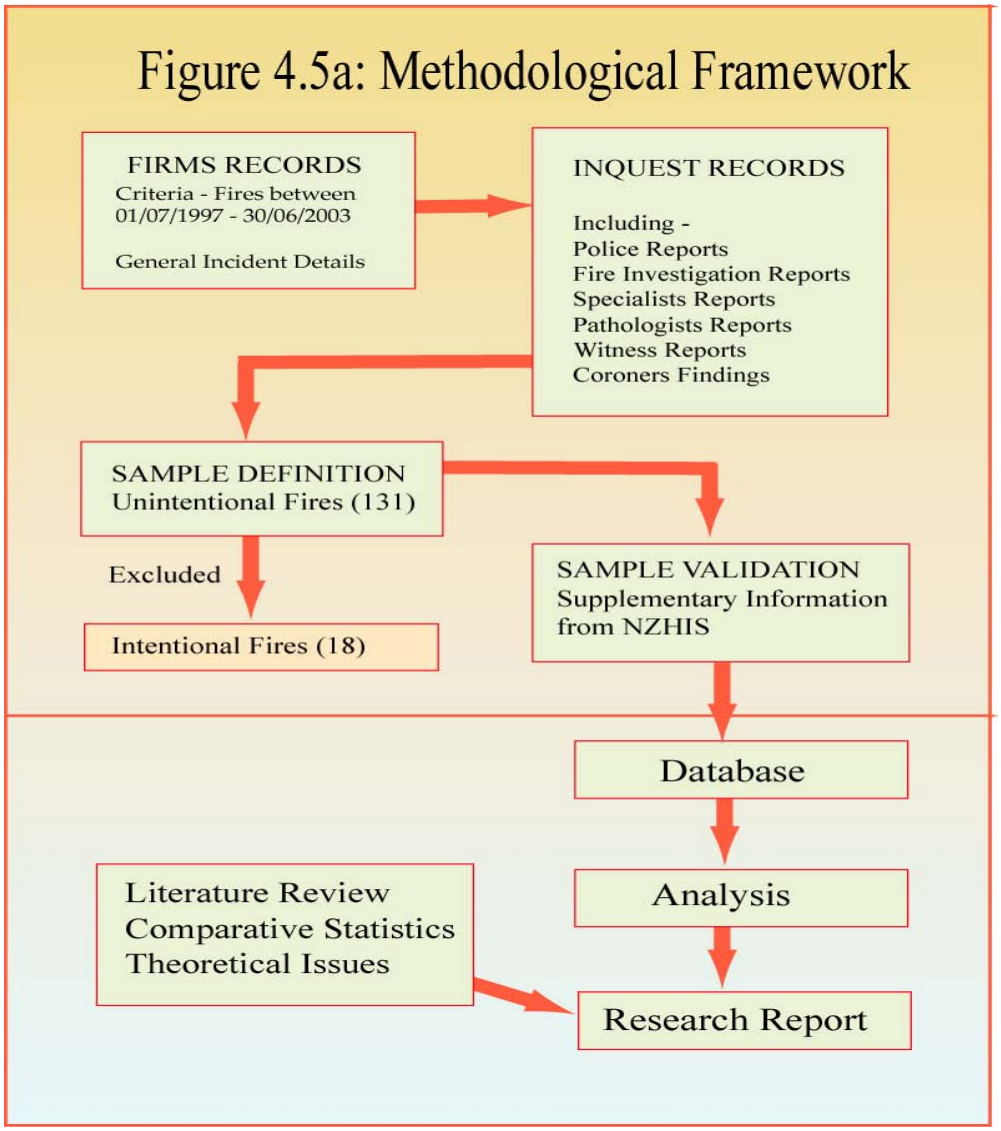
The study data included quantitative and qualitative information –

i. **Quantitative information.** This included victim demography, temporal/geographical features, fire causation, structural/safety features, investigation and pathologist's information.

ii. **Qualitative information.** This included victim behaviour *prior to* and *during* the fire, behaviour of other involved parties, relevant other behavioural matters, victim fire history, victim health factors, and matters of care and supervision.

The data was recorded in MS Excel format. Some fields included grouped categories for ease of analysis. Both numerical and text fields were included in the database.

The methodological framework for the study is set out in **Figure 4.5a.**



SECTION 5: RESEARCH FINDINGS

5.1. DEMOGRAPHIC FEATURES OF FATAL FIRES

i). Annual Fatalities

The study identified 131 deaths in 108 unintentional residential fire incidents, averaging **21.8** deaths per year. These included 14 incidents with multiple fatalities. Annual fatalities are presented in **Table 5.1a**, including multiple fatalities incidents (with total casualties indicated in brackets).

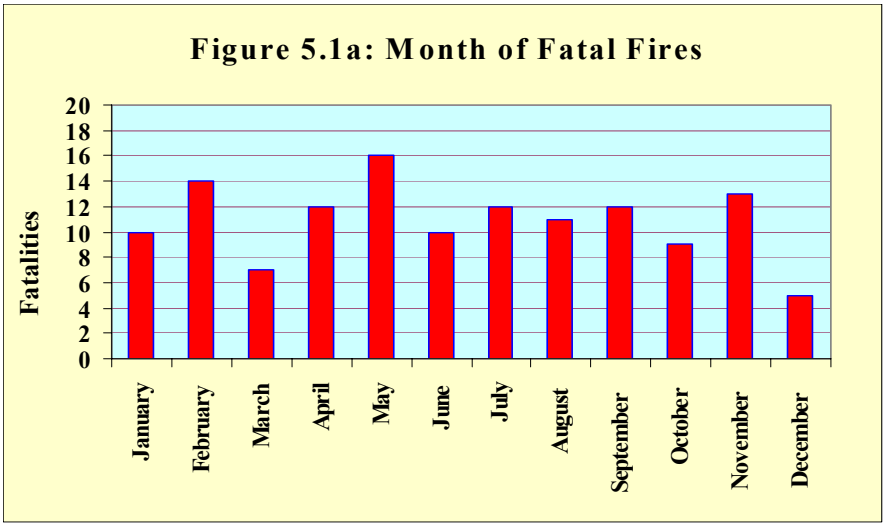
Year	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Individual Fire Incidents	22	18	13	15	21	19
1 Death Incidents	(19)	(16)	(11)	(14)	(18)	(18)
2 Death Incidents	(6)	(4)	(4)		(4)	
3 Death Incidents		(3)		(3)	(3)	(3)
3^{+} Death Incidents						(5)
Total Fatalities	**25**	**23**	**15**	**17**	**25**	**26**

ii). Month of Fires

The month of fatal fires occurred is shown in **Table 5.1b** and **Figure 5.1a**.

Month	Fatalities	Month	Fatalities
January	10	**July**	12
February	14	**August**	11
March	7	**September**	12
April	12	**October**	9
May	16	**November**	13
June	10	**December**	5

Fatalities were highest in May, February, and November, and lowest in December, March, October. No particular monthly pattern is identified from these results.



iii). Season of Fires

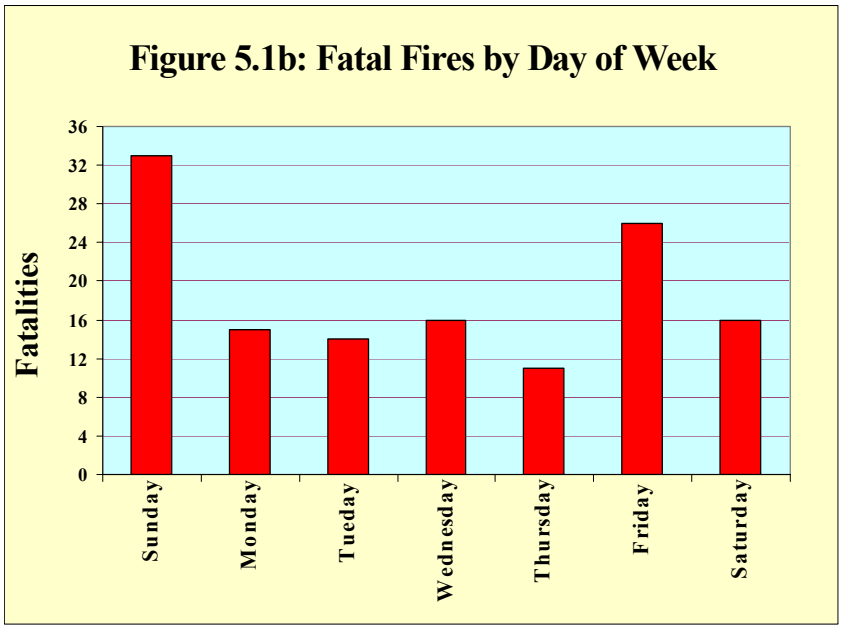
The seasonal patterns of these deaths was investigated, as is presented in **Table 5.1c** No pattern is identified although Summer has lower deaths, possibly reflecting lower demands for residential heating.

Season	Fatalities	% Fatalities
Summer (Dec-Feb)	29	22.2%
Autumn (Mar-May)	35	26.6%
Winter (Jun-Aug)	33	25.3%
Spring (Sep-Nov)	34	25.9%

iv). Day of Fires

The day of week of fatal fires is presented in **Table 5.1d** and **Figure 5.1b**. This identifies the highest number of fatalities occur on Sundays and Fridays.

Day	Fatalities	% Fatalities
Sunday	33	25.2%
Monday	15	11.5%
Tuesday	14	10.7%
Wednesday	16	12.2%
Thursday	11	8.4%
Friday	26	19.8%
Saturday	16	12.2%

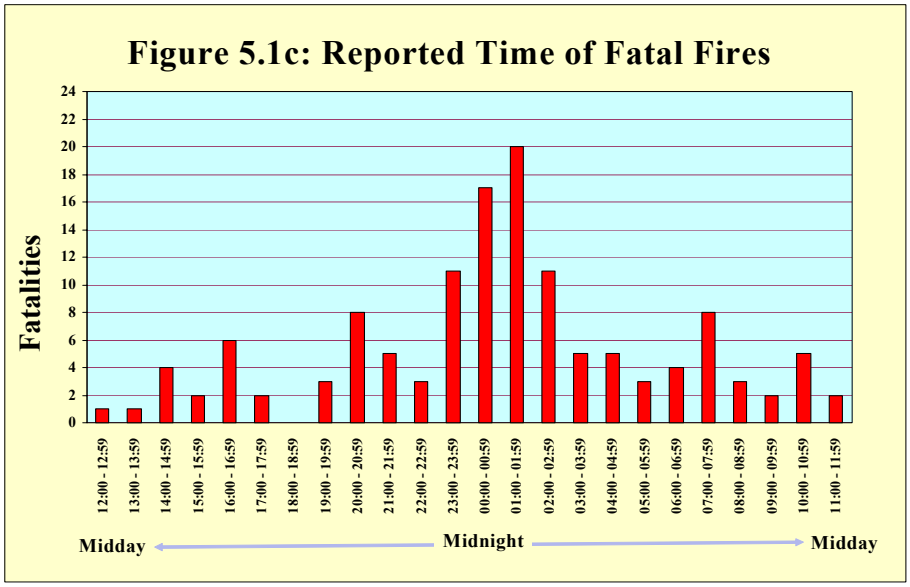


Analysis shows 45% of these fire fatalities occurred in the weekend period between (6 pm Friday – 6 am Monday). This may reflect the consequences of recreational activities and the effects of fatigue, including - impairment associated with alcohol and drug consumption, smoking, involvement in social and cultural events, and habitual activities.

v). Reported Time of Fires

Reported time of fire is based on when NZFS was notified of an incident. In a small number of cases notification was delayed because of the remoteness of fire location and/or lack of reporting the fire. **Table 5.1e** and **Figure 5.1c** presents deaths over 24 hours commencing at midday.

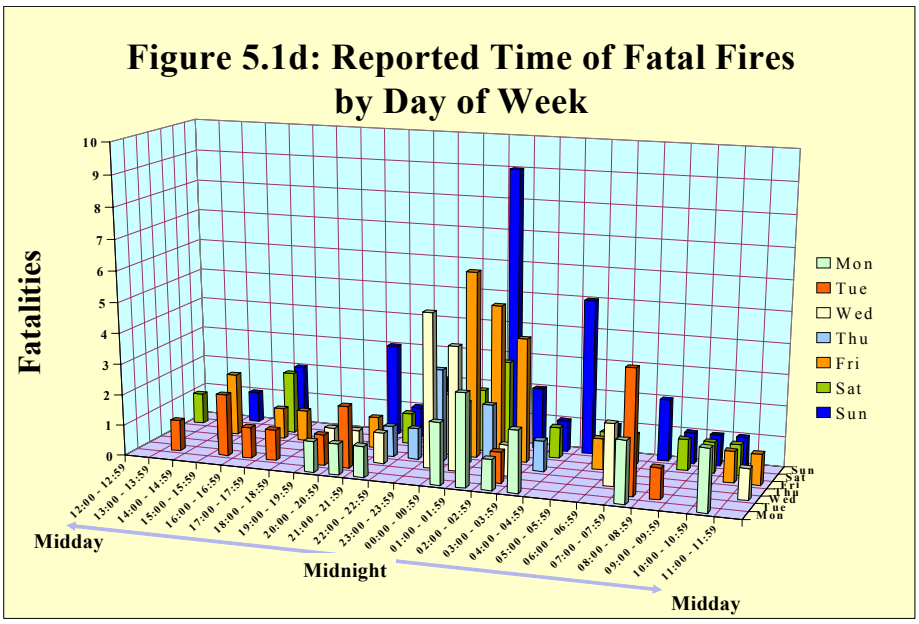
Period	Fatalities	% Fatalities
12:00 - 12:59	1	0.76%
13:00 - 13:59	1	0.76%
14:00 - 14:59	4	3.05%
15:00 - 15:59	2	1.53%
16:00 - 16:59	6	4.58%
17:00 - 17:59	2	1.53%
18:00 - 18:59	0	0.00%
19:00 - 19:59	3	2.29%
20:00 - 20:59	8	6.11%
21:00 - 21:59	5	3.82%
22:00 - 22:59	3	2.29%
23:00 - 23:59	11	8.40%
00:00 - 00:59	17	12.98%
01:00 - 01:59	20	15.27%
02:00 - 02:59	11	8.40%
03:00 - 03:59	5	3.82%
04:00 - 04:59	5	3.82%
05:00 - 05:59	3	2.29%
06:00 - 06:59	4	3.05%
07:00 - 07:59	8	6.11%
08:00 - 08:59	3	2.29%
09:00 - 09:59	2	1.53%
10:00 - 10:59	5	3.82%
11:00 - 11:59	2	1.53%



The salient feature of this figure is the majority of fatal fires are reported during night hours, with, -

- **45%** reported between 11 pm and 3 am,
- **72%** reported between 7 pm and 7 am.

Reported time of fire by day of week is presented in **Figure 5.1d**.



This illustrates an aggregation of fatalities in the night hours, especially in weekends.

vi). Nature of Structures in Residential Fire

The residential structures in which the 108[7] fatal fire incidents occurred are classified by FIRMS as a part of routine incident reporting. The structures in which these fatalities occurred are presented in **Table 5.1f** -

Property Type	Total	Percentage
Single House	80	73.4%
Flats, Apartments (1 - 2 Units)	10	9.2%
Flats, Apartments (3 - 10 Units)	7	6.4%
Caravan, Campervan, Campsite	5	4.6%
Garage	2	1.8%
Garden Shed, Other Shed	2	1.8%
House Bus	1	0.9%
Boarding House	1	0.9%

This shows 73.4% of fatalities occurred in single houses and 15.6% in flats and apartments reflecting the general nature of New Zealand housing arrangements.

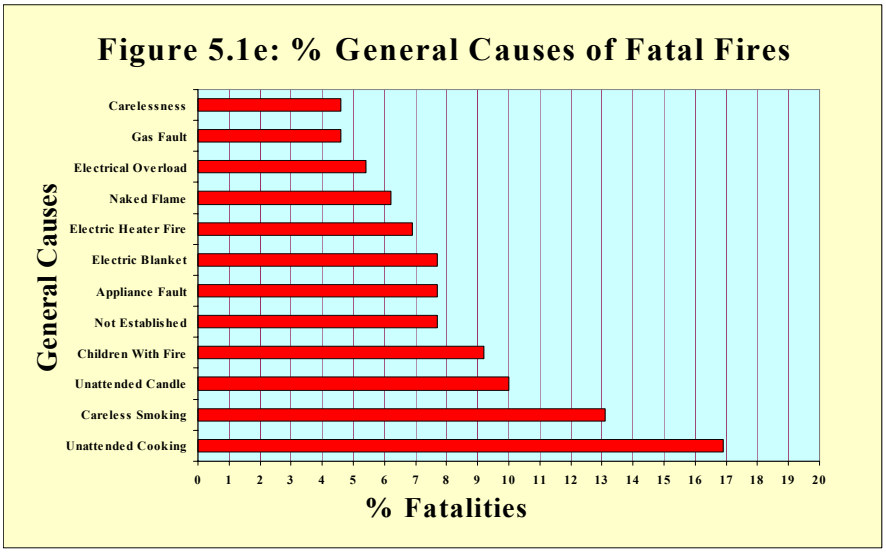
vii). General Causes of Residential Fires

The general causes of fatal residential fires can be summarised into 12 general groups, based on coronial and fire investigation reports. These have been ranked by frequency on an individual casualty basis[8] (and not incident basis) as presented in **Table 5.1g** below-

[7] One case excluded because of incomplete data.
[8] One case excluded because of incomplete data.

Cause Grouping	Deaths	%	Comments
Unattended Cooking	22	16.9%	Stove top/oven fires from ignition of unattended cooking.
Careless Smoking	17	13.1%	Fires resulting from careless disposal or use of cigarettes and smoking materials.
Unattended Candle	13	10.0%	Fires resulting from unattended candles left burning.
Children With Fire	12	9.2%	Children playing with matches lighter and fire causing ignition.
Not Established	10	7.7%	No cause established at inquest due to nature of fire or destruction of evidence.
Appliance Fault	10	7.7%	Failure of electrical or mechanical appliances causing fire.
Electric Blanket	10	7.7%	Fires caused by malfunction and misuse of electric blankets.
Electric Heater Fire	9	6.9%	Fires due to misuse or failure of safety feature in electric heaters.
Naked Flame	8	6.2%	Fire due to ignition by naked flames such as burning coals & embers.
Electrical Overload	7	5.4%	Ignition from electrical systems being overloaded, eg. incorrect fuses.
Gas Fault	6	4.6%	Failure of gas systems causing ignition due to poor or inappropriate maintenance.
Carelessness	6	4.6%	Fire caused by careless acts and omissions, and irresponsible behaviour.

These causes of fire fatalities are presented graphically in **Figure 5.1e.**



This shows a clear picture of the high fire risks from unattended cooking, careless smoking, unattended candles, and children playing with fire. These collectively account for nearly 50% of all fire fatalities in the study.

While the cause of fire was not established in 10 cases, the coronial files suggest smoking and careless use of heaters were most likely causal factors in most of these cases, although there was insufficient evidence to reach a clear determination.

viii). Smoke Alarm Installation

Smoke alarm installation is a significant safety initiative widely promoted as part of a national strategy to reduce fire deaths and injuries. The following information on smoke alarm installation applies to the 108[9] fatal fire incidents, as shown in **Table 5.1h -**

Alarm Installation Status	Total	%
Alarm installed and operative	18	16.5%
Alarm installed but disabled or inoperative	9	8.3%
No alarm installed	66	60.6%
Information not available	16	14.7%

Where information on smoke alarm installation was established by fire investigators (ie. excluding 'Information not available') it was found that **71%** of fatal fire incidents occurred in properties *without* smoke alarms. Where smoke alarms were installed another **9.7%** of fires occurred in properties where these were *inoperative* because of – flat batteries, batteries were removed, or alarms otherwise disabled.

In 3 cases alarms had been installed inappropriately thus limiting their effectiveness.

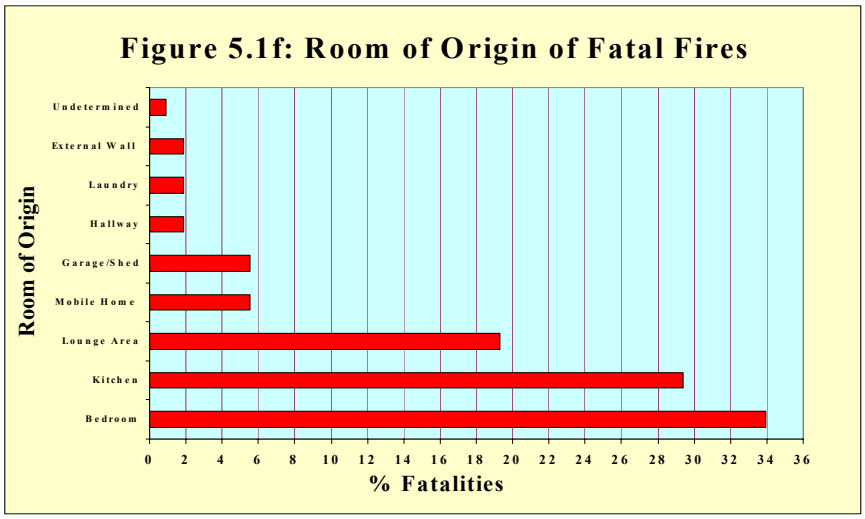
ix). Room of Fire Origin

The room in which fires ignite is an important indicator of spatial risk factors in residential properties. In the 108[10] fire incidents the following information on room of fire origin was determined from the fire investigators reports into each event as presented in **Table 5.1i -**

Room of Fire Origin	Total	%
Bedroom & other areas used for sleeping	37	33.9%
Kitchen, including dining area	32	29.4%
Lounge Area	21	19.3%
Mobile Home (Caravan, Camper Van, House Bus)	6	5.5%
Garage/Shed	6	5.5%
Hallway	2	1.8%
Laundry	2	1.8%
External Wall (eg. meter box, wall cavity)	2	1.8%
Undetermined	1	0.9%

This table shows **82.6%** of residential fires originate in areas of high daily occupancy ie. bedrooms, kitchen, lounge. The data illustrate significant risks associated with kitchen fires and with fires originating in bedrooms and lounge areas which largely involve smoking activities and misuse of heating. The information in **Table 5.1i** is presented in **Figure 5.1f** for additional emphasis.

[9] One case excluded because of incomplete data.
[10] One case excluded because of incomplete data.



x). Geographical Location of Fire Incidents

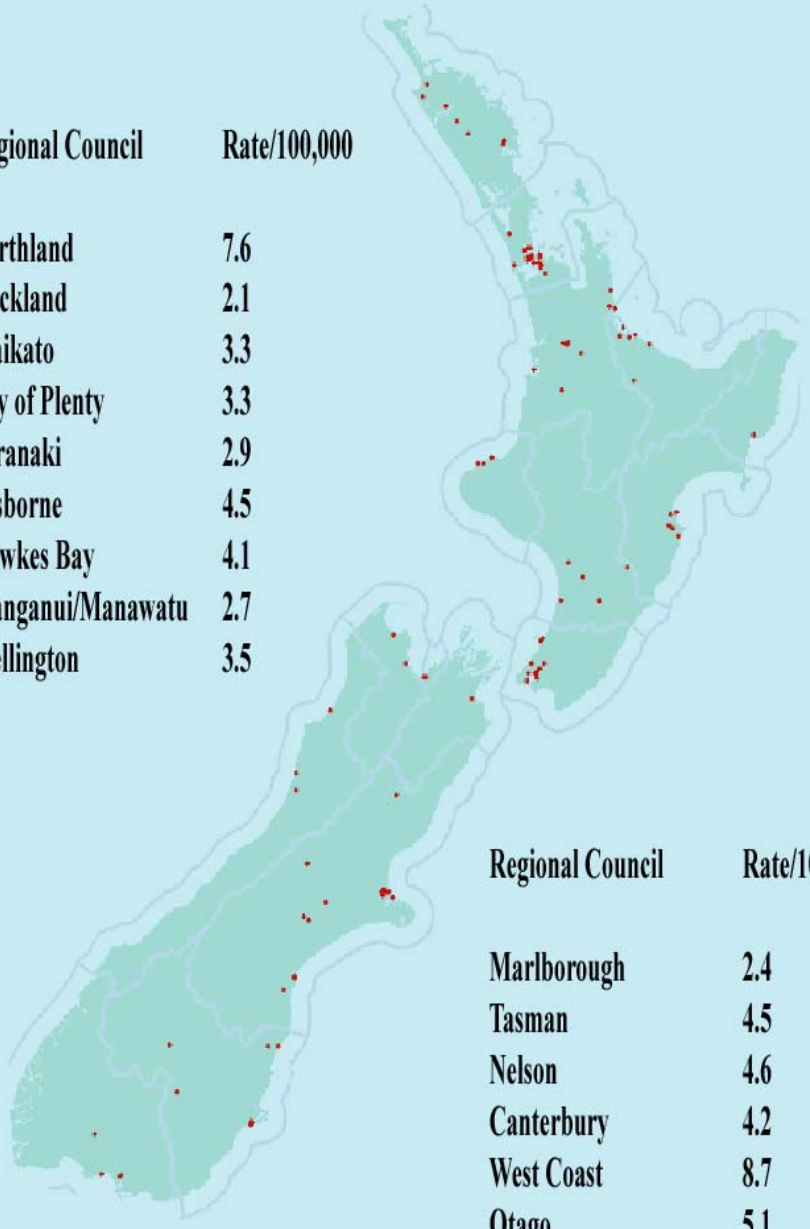
The geographical location of fatal fires is related to local Territorial Land Authority and to wider Regional Council Area through reference to census mesh block (see **Section 5.2. v)** below). The sample size of 131 deaths suggests analysis based on Regional Council Area provides a better comparative measure than Territorial Land Authority. Fatalities according to Regional Council Area are presented in **Table 5.1j** converted to rate per 100,000 population for comparative purposes -

Regional Council Area	Fatalities/100,000
Northland	7.6
Auckland	2.1
Waikato	3.3
Bay of Plenty	3.3
Taranaki	2.9
Gisborne	4.5
Hawkes Bay	4.1
Wanganui/Manawatu	2.7
Wellington	3.5
Marlborough	2.4
Tasman	4.5
Nelson	4.6
Canterbury	4.2
West Coast	8.7
Otago	5.1
Southland	4.2

It is apparent there is a slight increase in fatalities/100,000 with southward movement. The exception is Northland where a cluster of deaths are associated with poor housing. The southward increment in fatality rate may relate to a number of factors including - cooler climate (with increased risk of heating fires), older housing stock compared to Upper North Island (where population drift may have led to more new housing), rural isolation, and disparities in social and support services. However, the sample size does not permit a stronger statistical analysis.

The geographical location of each fire fatality is illustrated in **Figure 5.1g**

Figure 5.1 g: Geographical Location of Fire Fatalities and Rate/100,000 by Regional Council Area



Regional Council	Rate/100,000
Northland	7.6
Auckland	2.1
Waikato	3.3
Bay of Plenty	3.3
Taranaki	2.9
Gisborne	4.5
Hawkes Bay	4.1
Wanganui/Manawatu	2.7
Wellington	3.5

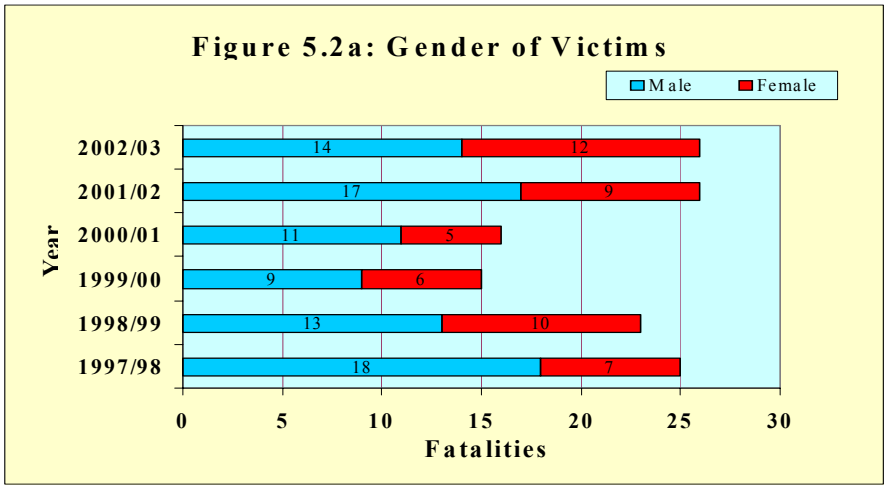
Regional Council	Rate/100,000
Marlborough	2.4
Tasman	4.5
Nelson	4.6
Canterbury	4.2
West Coast	8.7
Otago	5.1
Southland	4.2

5.2. DEMOGRAPHIC FEATURES OF FIRE VICTIMS

i). Gender

The gender of the 131 fatalities included 82 (**62.6%**) males and 49 (**37.4%**) females as shown in **Table 5.2a** and **Figure 5.2a.**

Year	1997/98	1998/99	1999/00	2000/01	2001/02	2002/03
Males	18	13	9	11	17	14
Females	7	10	6	5	9	12

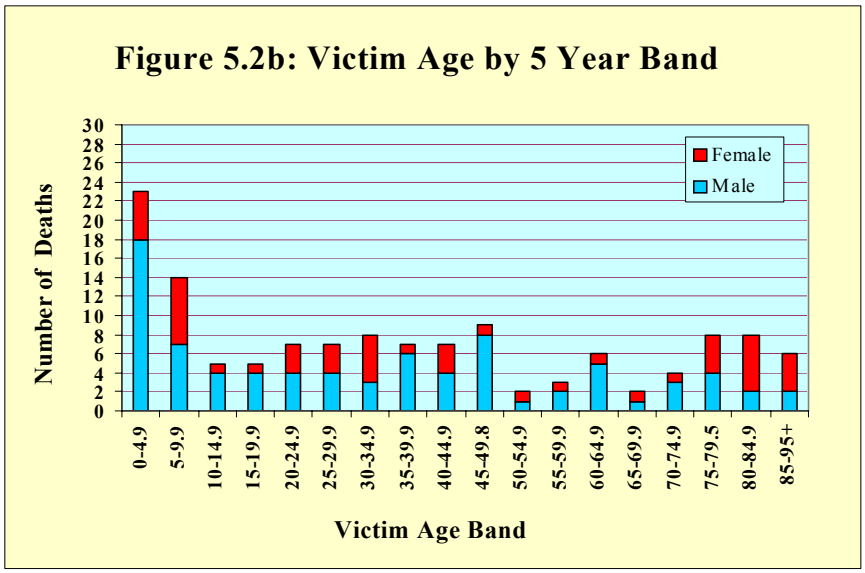


ii). Age

Victim age (in 5 years blocks) by gender and percentage is presented in **Table 5.2b**

Age Band	Male	Female	Total	% Total
0 - 4.9	18	5	23	17.6
5 - 9.9	7	7	14	10.7
10 - 14.9	4	1	5	3.8
15 – 19.9	4	1	5	3.8
20 – 24.9	4	3	7	5.3
25 – 29.9	4	3	7	5.3
30 – 34.9	3	5	8	6.1
35 – 39.9	6	1	7	5.3
40 – 44.9	4	3	7	5.3
45 – 49.9	8	1	9	6.9
50 – 54.9	1	1	2	1.5
55 – 59.9	2	1	3	2.3
60 – 64.9	5	1	6	4.6
65 – 69.5	1	1	2	1.5
70 – 74.9	3	1	4	3.1
75 – 79.0	4	4	8	6.1
80 – 84.9	2	6	8	6.1
85 – 95 $^{+}$	2	4	6	4.6

The high number of fatalities of children/young people aged 0 - 15 is noted (**32%** of all deaths). Those aged 60 or more comprise **25.9%** of deaths as the second largest at risk grouping. These age grouping data are presented in **Figure 5.2b.**



The high number of male children (18) aged 0 - 4.9 are notable. Of these 8 deaths were as a result of children playing with fire (ie. matches/lighters - see 5.3 vii below).

iii). Ethnicity

Victim ethnicity is coded according to the description on the coronial file or from NZHIS records if ethnicity was not recorded in the inquest documents. Because of the small sample size ethnicity is summarised into four basic groups as follows -

Ethnicity	Description
European	European descent whether born in NZ or immigrant.
Maori	NZ Maori descent.
Pacific Islands	Pacific Island descent. eg. Samoan, Cook Islands, Fiji etc.
Other	Indian, Asian, Chinese, or other descent.

From this grouping the ethnicity of victims is presented in **Table 5.2 c** -

Ethnicity	Male	Female	Total	%
European	42	27	69	52.7
NZ Maori	31	21	52	39.7
Pacific Islands	8	1	9	6.9
Other	1		1	0.8

This shows NZ Maori are disproportionately represented in these fire fatalities as is identified in other research (eg. Duncanson *et al*, 2001). The level of Maori fatalities approximately equates to three times the Maori representation in the general population and supports previous findings concerning fatal fire risk factors for this group. The number victims of Pacific Islands descent is comparatively low compared to NZ Maori.

iv). Occupation

Victim occupation is coded according to coronial file description or from NZHIS records if occupation was not recorded in the inquest documents. Because of the small sample size occupation is summarised into four basic groups as follows -

Ethnicity	Description
Child/Young Person	Pre-school, school aged children, and young people yet to enter the work force.
Regular Employment	Persons in regular paid employment.
Not Employed	Persons not in employment or recipients of some form of benefit payment.
Retired	Retired persons in receipt of retirement benefit.

From this grouping the occupation of victims is presented in **Table 5.2 d**[11] -

Occupation	Male	Female	Total	Total %
Child/Young Person	30	14	44	33.6
Regular Employment	20	7	27	20.6
Not Employed	16	11	27	20.6
Retired	16	17	33	25.2

The significant number of children and young persons, and those not in employment (ie. beneficiaries), within this group of fire victims is emphasised by this data.

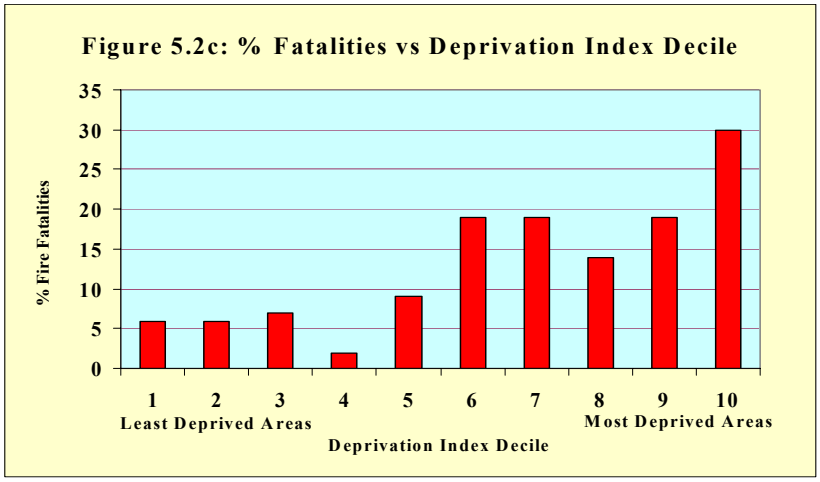
v). Deprivation Index Decile

The Deprivation Index Decile is derived from census mesh block records for all New Zealand addresses. The measure is adjusted with each new censuses to provide an ongoing picture of relative deprivation in all areas. It provides a deprivation score derived from nine variables reflecting eight dimensions of material and social deprivation[12] including measures such as – income, employment, communication, transport, support, qualifications, living space, and home ownership. For a more detailed account of the structure of the Deprivation Index Decile see Salmond & Crampton (2002).

The Deprivation Index Decile measures used in this study are based on an ordinal scale of deprivation ranging from 1 (representing an area with the least deprived scores) to 10 (representing an area with the most deprived scores). The scores are indexed to the 2001 census. These measures provide *indicative* information about properties where fatal fires have occurred rather than *absolute* measures; however, they are included as they offer some objective indication about the socio-economic status of the residences involved in fatal fires. Note: these deprivation scores apply to areas rather than individual people.

The Deprivation Index Decile measures for the sample are presented below in **Figure 5.2c.** It is evident that an overwhelming number of fatalities occur in properties which fall in the decile 7-10 range, accounting for **62.2** % of all deaths.

[11] One case not included because of incomplete data.
[12] Source Ministry of Health website *http//www.moh.govt.nz/moh.nsf*



5.3. VICTIM MORTALITY & HEALTH STATUS[13]

i). Proximity of Death to Fire Event

Most victims died during the fire event (115 deaths) often in the early stages after the fire had become established. Only 15 **(11.5%)** victims initially survived the fires (by their actions or through rescue by others such as the Fire Service) to later die of their injuries. The longest periods of survival post-fire were -31, 26, 22, and 17 days.

ii). Cause of Death

Cause of death is a primary determination established at inquest if possible. This determination greatly relies on findings of post mortem examinations and associated forensic analyses. Post mortem examinations of fire victims will attempt to find certain indicators that help define how long the individual survived before they succumbed to the various lethal elements associated with fires. Measures such as soot or carbon in the airways and bronchial passages provide evidence of inhalation of toxic gases prior to death, while levels of carbon monoxide saturation in the blood are a significant measure of exposure to this lethal by-product of fire. The extent of burning and thermal injury indicates the extent of exposure to flames and heat, and may assist in determining the extent of escape behaviour.

Analysis of pathologist's reports found the primary causes of death relate directly to three general areas of fatal effects –

- consequences of exposure to fire, including (burns, thermal injuries to the airways, and incineration of all or part of the body,
- inhalation of toxic products of combustion, including smoke, carbon monoxide, carbon dioxide, other poisonous gases, hypoxia and asphyxia,
- shock from injuries that precipitate death from pre-existing health conditions such as cardiac failure and respiratory disease.

[13] One case excluded because of incomplete data.

Note: death can be attributed to more than one cause - 79 (**60.8%**) died from a single cause, 47 (**36.2%**) from two causes, and 4 (**3.1%**) from three causes. Specific cause of death is shown in **Table 5.3a**.

Cause of Death	
Smoke Inhalation	72
Carbon Monoxide Poisoning	32
Hypoxia, Asphyxia	14
Cardiac Failure	6
Burns/Thermal Injuries	53
Incineration	3
Multi-organ Failure	3
Respiratory Disease	2

iii). Blood Carbon Monoxide Saturation

Percentage blood carbon monoxide saturation provides a useful quantitative measure of exposure to a lethal by-product of combustion as shown in **Figure 5.3a**[14].

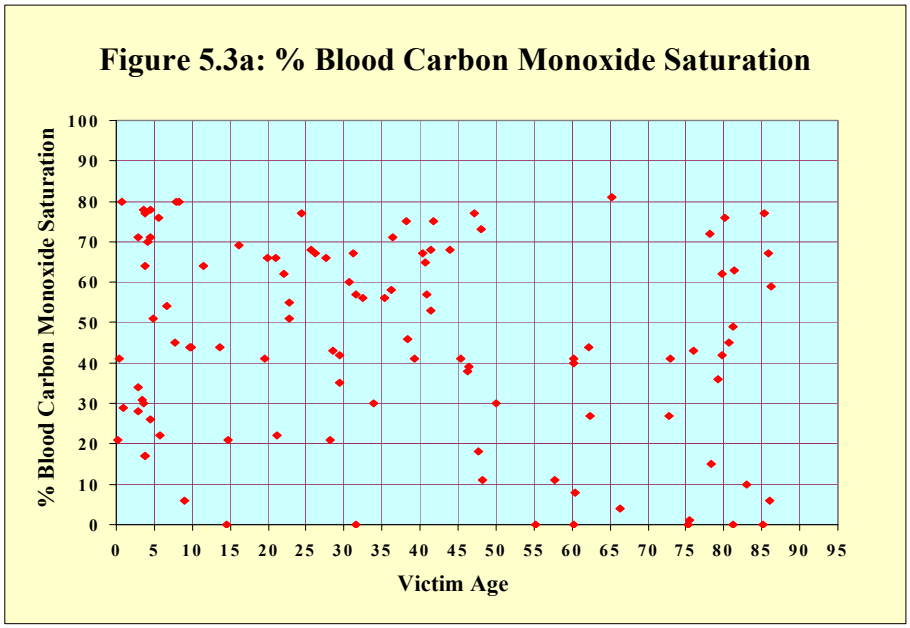


Figure 5.3a shows high levels of percentage carbon monoxide saturation across all age groupings. Levels above 50% are considered to be life-threatening (Baselt, 2004; Ellenhorn & Barceloux, 1988), although some caution is required in extrapolating from purely % blood saturation measures.

[14] Based on 106 cases where carbon monoxide saturation levels were recorded.

Typical symptoms of exposure to carbon monoxide include[15] -

% Blood CO Saturation	Physiological & Subjective Symptoms
10%	No appreciable effects, except shortness of breath on vigorous exertion, possible tightness across forehead, dilation of cutaneous blood vessels.
20%	Shortness of breath on moderate exertion, occasional headache with throbbing in temples.
30%	Decided headache, irritable, easily fatigued, judgement disturbed, possible dizziness, dimness of vision.
40-50%	Headache, confusion, collapse, fainting on exertion.
60-70%	Unconsciousness, intermittent convulsions, respiratory failure, death if exposed too long.
80%	Rapidly fatal.

It is important to note other volatile toxic substances (eg. hydrogen cyanide, sulphur dioxide) may also be ingested from smoke along with carbon monoxide, as combustion may release other substances depending on the chemical constituency of the flammable materials involved. These substances are not routinely measured as part of post-mortem processes. A further risk is posed by high carbon dioxide levels produced as oxygen is depleted from the closed atmosphere by combustion causing physical and mental impairment and contributing to asphyxiation.

The levels of carbon monoxide saturation shown in **Figure 5.3a** suggest that a number of victims were alive and ingesting toxic fumes over some period. Even when the levels of saturation were relatively low, it is probable that there would have been significant impairments to mental and physical functioning that contributed to fatal outcomes. Such actions as walking or trying to move about in smoke filled areas, and arising from a prone position into smoke, would all increase the level exposure to carbon monoxide, especially where exertion was required which would increase respiration rate.

A small number of victims had low levels of carbon monoxide saturation suggesting they may have succumbed to thermal injuries such as burning of airways and bronchial system, and dramatic exposure to excessive heat.

iv). Pre-existing Health Conditions

The coronial records report 50 (**38.8%)** of victims had pre-existing health conditions that may have had some impact on their involvement in fires and consequent fatality. These conditions included physical disabilities, sensory incapacities (eg. vision and hearing losses), cardio-vascular conditions, dementia, and consequences of strokes and neurological conditions that tend to be associated with advancing age. Other victims were affected by diagnosed mental disorders, and drug and alcohol abuse problems, including some younger victims. Several victims had more than one health condition.

A summary of these pre-existing health conditions is presented in **Table 5.3b**.

[15] From Ellenhorn & Barceloux (1988) p821.

Pre-existing Health Condition	Number
Physical disability – limited mobility, frailty	14
Drug/Alcohol dependency	14
Cardiovascular condition – heart disease, hypertension	11
Mental disorder/psychological problems	9
Respiratory disease/problems	8
Stroke/cerebral haemorrhage	6
Sensory disabilities – hearing or vision impairment	4
Diabetic condition	3
Dementia – Alzheimer's disease	3
Epileptic condition	1

In some cases pre-existing health conditions resulted in victims being unable to escape fires, as with those confined to wheelchairs or beds, or those dependent on walking frames. Others appeared to have a limited appreciation of the risks of fire which may have related to existing mental disorders and sensory disabilities that restricted or prevented early and appropriate escape responses.

5.4. SPECIFIC VICTIM RISK FACTORS[16]

i). Careless Smoking

Deaths from careless smoking were the second highest risk factor in the study with 17 fatalities from this risk factor. These included 15 primary victims whose deaths were directly caused by smoking and 2 secondary victims (both children) who died as a result of others' smoking activities. While careless smoking was the specific cause of fire ignition, it is noted 5 victims also recorded high levels of blood alcohol consistent with intoxication (ranging from 291-167 mg/100 ml) and 2 showed evidence of recent cannabis consumption.

Fires from careless smoking were primarily caused by inappropriate disposal of burning cigarettes in waste containers or cigarettes falling on flammable surfaces. The risk of fires was exacerbated by smokers falling asleep while smoking causing ignition of chairs/sofas and beds. Bed fires from cigarettes included two cases where there were previous similar incidents - both victims had disabilities which affected their ability to escape. A small number of victims showed evidence of an inability to adequately look after themselves including some whose homes were extreme fire risks because of the extent of litter and rubbish which increased the fire loading.

[16] Generalised case summaries are presented in the following section as illustrative outlines of the circumstances of fires and victim behaviours during these incidents. Case numbers relate to file numbers assigned by the author. Individual identities are not disclosed in these summaries.

Case 130. The deceased, a retired male aged 76, spent the afternoon drinking and smoking in his lounge. The lounge door was closed. He fell asleep in his armchair where a burning cigarette caused it to ignite. The deceased awoke to the fire but was overcome by smoke and burns. He fell onto the floor after moving forward two meters from the burning armchair. The fire burned out from oxygen starvation, damaging the lounge only. The deceased was not found until two days later when neighbours noticed his mail had not been collected. The cause of death was the effects of smoke inhalation and burns. Operative smoke alarms were installed but the deceased did not respond to their activation.

Case 48. The deceased was an 86 year old woman. She was known to be a very heavy smoker. She fell asleep in the early evening in the lounge. A burning cigarette ignited her clothing which was made of flammable synthetic material. She activated a medic alarm and went to the bathroom where she took off the burning clothes. She then suffered a fatal coronary episode and fell outside the bathroom door. Her blood carbon monoxide level was 6% suggesting the shock of the fire precipitated the coronary episode. The cause of death was attributed to coronary artery disease. An installed smoke alarm was activated.

Case 108. The deceased was a female beneficiary aged 41. She suffered from multiple sclerosis. In the early afternoon a neighbour heard a smoke alarm activate and the deceased call for help. She was extricated from her burning bedroom where she was found tangled in her wheelchair and furniture. The bed was on fire. She was taken to hospital and died the next day from 3rd degree burns to 70% of her body. There was evidence of many previous cigarette burns on her clothing. The cause of death was burns. The smoke alarm successfully attracted attention to the fire.

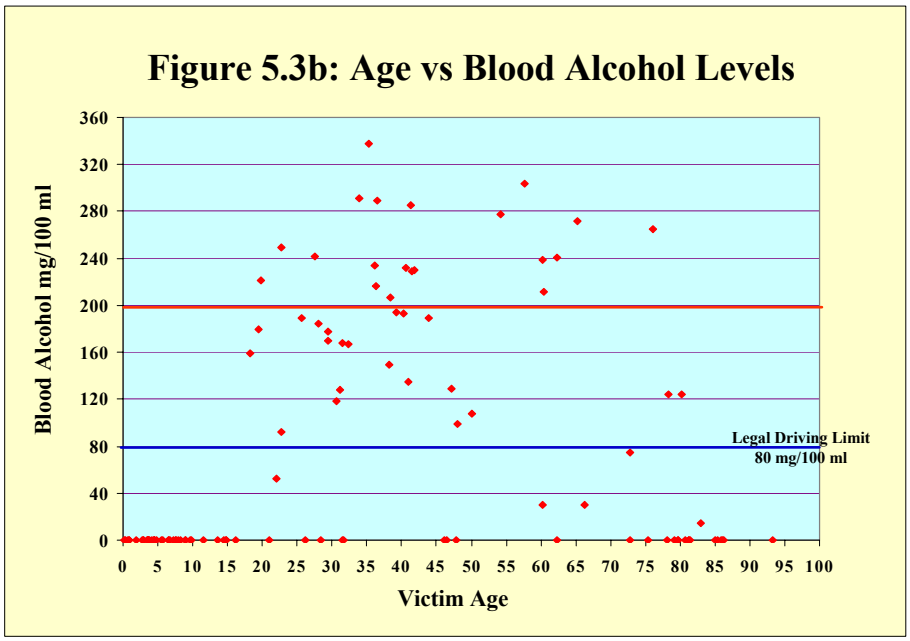
Case 72. The deceased was a 60 year old male who lived alone. He was known to be a heavy smoker. He had recently suffered a stroke and was scheduled for an assessment for elder care. His house was extensively piled with rubbish on the floors and other surfaces. Numerous overflowing ashtrays were found. In the early afternoon a fire started next to the deceased's bed, probably in an overfull ashtray, which set the mattress alight. The deceased tried to remove the burning mattress but was unable to so. He then crawled into a wardrobe where he was found dead. The Fire Service report indicated a fire was almost certain to occur in this case due to the deceased's habits and the fire loading in the property. The cause of death was inhalation of smoke and fumes. The burns sustained by the deceased were deemed survivable. No smoke alarm was installed.

Case 65. The deceased was a 72 year old retired male. A fire was noticed in his house in the early morning hours. The deceased was found dead in a back bedroom where he had been overcome by smoke. He appeared to have fled his bedroom and had made his way down the smoke filled hallway. The fire originated in the lounge and spread from there. The house was littered throughout with extensive piles of cigarette butts and rubbish. There was evidence of earlier fires amongst this litter. The extent of clutter in the house caused the deceased to be missed in a first search by Fire Service personnel. The cause of death was smoke inhalation. An uninstalled smoke alarm was found in a box.

ii). Alcohol Consumption

Routine post mortem procedures include testing for blood alcohol levels from blood and urine samples. In some cases the nature of the fire and consequent injuries may prevent collection of adequate blood or urine samples, eg. fire victims may sometimes be so incinerated samples cannot be obtained. However, most fatalities in the study provided blood alcohol measures. These measures can be evaluated against a Blood Alcohol Level (BAL) of 80 mg/100ml limit legally specified for driving in New Zealand as a benchmark for comparative purposes.

The effects of increasing BAL will vary with age and with an individual's history of alcohol consumption. Young people and those unaccustomed to the effects of alcohol consumption are likely to exhibit indications of intoxication and cognitive/physical impairment at much lower doses than experienced drinkers. Tolerance effects may result in alcoholics being able to function at quite high dose levels which would cause marked impairment in most drinkers. It is noted that 20 victims have BAL's assessed in excess of 200ml/100mg which can be regarded as evidence of a high level of intoxication. A compelling picture is presented when BAL measures are plotted against victim age as is shown in **Figure 5.4b**.



Alcohol consumption at levels in excess of the legal driving BAL limit is recorded in 42 cases. In another 4 cases high levels of intoxication were identified but BAL assessments were not obtained as the victims were hospitalised and died of injuries some time later without BAL measures being taken. The two outstanding features of Figure 5.3.1 are evidence of alcohol consumption as a specific feature in the 20 to 70 age group compared with younger or older victims, and the high BAL's shown in many of cases which are markedly above the legal driving standard.

Case 70. The deceased, a male aged 35, returned from a social function about 12.30 am in a state of extreme intoxication. He commenced cooking a meal but fell asleep in the lounge leaving the food to catch fire. A neighbour heard the fire and woke the deceased's son who escaped. The deceased was roused by the fire and moved through a smoke filled hallway to look for his son who had left. He then went into his own bedroom where he collapsed on the floor next to his bed. His BAL at post mortem was 338 mg/100 ml. Cause of death was carbon monoxide poisoning with a 56% blood saturation level. No smoke alarm was installed.

Case 49. The deceased was a 57 year old alcoholic woman who had been on a drinking binge for several days. While she was in a drunken state a fire broke out in the kitchen from an overloaded power multi box. She was unable to respond to the fire in time and collapsed in a sunroom next to the kitchen while trying to escape. The cause of death was attributed to the effects of fire. Her BAL was found to be 304 mg/100 ml. Smoke alarms were not installed.

Case 123. The deceased, a 41 year old female, spent the afternoon drinking at a local bar. She walked home about 8 pm and at 9.41 the Fire Service was advised of a blaze at her address. The deceased was found on the lounge floor close to the kitchen where the fire originated. Reconstruction suggested the fire spread rapidly causing a build up of smoke and fire products. The deceased was quickly overcome and became disoriented, moving in the wrong direction away from an escape door. Her post mortem BAL was 229 mg/100 ml. The cause of death was carbon monoxide poisoning with a 68% blood saturation level. No smoke alarm was installed.

Case 87. The deceased, a male aged 19, had been drinking from 3 pm until the early hours of the morning. He put a pot with oil on the stove but went to bed. The fire roused a flatmate who tried to waken the deceased but was pushed away. The flatmate left because of heavy smoke. The deceased then left his bedroom for the kitchen where he collapsed next to the stove. It appeared he had tried to put out the fire. A post mortem BAL of 180 mg/100 ml was found. The cause of death was severe hypoxia secondary to carbon monoxide poisoning. No smoke alarm was installed

Case 106. The deceased were two female cousins aged 31 and 41, and the male partner of one, aged 45. They had been drinking all afternoon before returning to their flat. At 11.30 pm a motorist saw smoke coming from the flat and called for help. On entering the flat the Fire Service found the male was unconscious near the front door and the two females dead in the lounge (one near a bed, the other near the kitchen door). The fire originated behind a TV in the lounge where a burning candle was believed to have caused it to ignite a slow smouldering fire that took time to produce lethal levels of smoke and fire products. The male occupant died in hospital 31 days later. The BAL of the females was established at 285 and 128 mg/100 ml respectively. It is believed the deceased were so impaired by alcohol they were not roused by the fire until smoke levels were too lethal for effective escape. Smoke detectors were installed but the batteries were flat.

Secondary Victims: Beyond the immediate impact of alcohol consumption causing impairment (as indicated by BAL) there is a second group of alcohol-related victims. These are secondary victims who lived with, or were in the care of, alcohol affected persons. The deaths of secondary victims are a direct result of impairments, and/or acts and omissions by primary alcohol-affected persons.

Table 5.4a summarises primary and secondary alcohol-involved fire victims based on the legal driving standard of 80mg/100ml as a presumptive indicator of alcohol impairment.

Total alcohol-involved fire incidents	44
Total alcohol-involved fire victims	58
Number of primary alcohol-involved fire victims	44
Number of secondary alcohol-involved fire victims	14

It is noted that 5 of secondary victims were the sole casualties of fires, as other parties managed to escape.

Case 21. The deceased was a 5 month old infant. Her mother had been drinking for most of the day at a friend's house before returning home in the early evening. She was described as being in an advanced state of inebriation. The baby was settled in a cot and went to sleep. The mother then went to a nearby address to borrow a cigarette leaving the baby alone. She was away for over half an hour during which time a major fire developed. The deceased's charred body was found in the remains of the cot. The investigation determined the source of the fire was in a rubbish bag in the kitchen, with the likely cause being discarded smoking materials placed in the bag. The coroner specifically criticised the mother, describing her excessive alcohol consumption as being grossly negligent. No smoke alarm was installed.

Case 35. The deceased were sibling's aged 8 and 6. Their mother had been drinking before retiring to bed. She awoke feeling sluggish and smelling smoke. On getting up she saw small flames in the lounge which had reached the ceiling. She went to the toilet before going to an outside sleep out to call her boarder. On returning she did not go to her children but called to them to get out. She assumed her boarder had the children which was not the case. In a short time the fire developed to a major extent. The bodies of the children were found in their bedroom, one in bed, the other on the floor beside a wardrobe. The fire was attributed to electrical wiring overloading with incorrect fuses installed leaving no overload protection. The post mortem established both children had survived the fire for some time before succumbing to carbon monoxide and smoke. The delay in responding to the fire was a certain factor in their deaths. No smoke alarm was installed.

iii). Methyl Alcohol Abuse

Drinking methyl alcohol (methylated spirits, wood alcohol) is mostly confined to chronic alcoholics who favour it because of cost. Methyl alcohol is a blend of methyl and ethyl alcohol. One fire death involved severe methyl alcohol intoxication.

Case 95. The deceased, a 40 year old unemployed male, had spent most of the day drinking methylated spirits with a flatmate. Both were heavy smokers. The spirits were diluted with water in 2 jugs in their lounge area. Undiluted spirits were left by the deceased chair in an open container. The flatmate was aroused from alcohol induced torpor to find the room alight. He escaped. The deceased had apparently spilled concentrated spirits in the floor which were ignited by smoking materials. He was heavily intoxicated, with a post mortem BAL of 232 mg alcohol/100 ml. He had attempted to crawl from the lounge to the kitchen where he was overcome by flames and badly incinerated. Smoke alarms in the property had been deactivated.

iv). Illicit Recreational Drug Abuse

Illicit drug use is a well recognised social problem in New Zealand. The main drug of abuse is cannabis which is widely abused. Twelve fire victims were found to have consumed cannabis through post mortem blood analysis *albeit in conjunction with concurrent alcohol consumption* in eleven cases. While the consumption of cannabis was unlikely to have been a primary contributor to these fire fatalities it is suggested its use in tandem with alcohol may have contributed to physical and cognitive impairment and thus affected individuals' chance of survival. Secondary victims are also recorded from the consequences of fires ignited as a result of primary drug takers actions (see Case 94 below). A particular risk with cannabis use is the heating of metal objects (such as table knives) to 'spot' cannabis oil or resin which is then inhaled as the cannabis products vaporise.

Case 69. The deceased, a 29 year old male, had been socialising with his partner. She went to bed but was woken by the smell of smoke. She opened the bedroom door to find a significant blaze forcing her to escape through a window. The deceased was found lying in front of his chair in front of the TV. His BAL was established at 170 mg/100 ml. THC at 8.2 mg/100ml confirmed he consumed cannabis in near proximity to the fire starting. The fire was caused by an unattended cooking pot being left on 'high' on the electric stove by the deceased, who had earlier said he was hungry. Cause of death was inhalation of smoke and fumes. An installed smoke alarm was found to have no battery.

Case 96. The deceased was a 50 year old woman who consumed alcohol and cannabis before going to bed. She was caring for two grandchildren. A candle left burning in the bedroom fell over and ignited bedding materials. The deceased was overcome by smoke in the bedroom and was unable to escape. Post mortem blood analysis found BAL was 108mg/100 ml and THC at 4.5 mg/100 ml. Both grandchildren perished in the fire. No smoke alarms were installed. The combined levels of alcohol and cannabis intoxication were likely factors in preventing an effective response by the deceased.

Case 94. The deceased was a 4 year old girl who died in her bedroom after the family home was subject to fire. Her parents managed to extricate three other siblings before the heat of the fire caused them to retreat. The fire was caused by a pot of cooking oil igniting after being left on an electric stove ring set on high. The ring had been used twice earlier in the night by her father to spot cannabis oil, and had not been turned to off. She was found in her bedroom. No smoke alarm was installed in the house.

v). Volatile Substance Abuse.

Within the study cases two occurred where volatile substance abuse was implicated in fatal fires. In both cases petrol was the primary solvent, and both victims had a known history of solvent abuse.

Case 46. The deceased, a 14 year old male, had apparently been inhaling petrol vapour (and possibly aerosol products) in his bedroom while smoking. A friend saw smoke from the bedroom and found the deceased attempting to extinguish the fire. He did not come out of the room when called to do so and was quickly overcome by smoke and fumes. The cause of death was thermal injury, acute pulmonary oedema, and carbon monoxide poisoning. An operative smoke alarm enabled other occupants to escape.

Case 20. The deceased was an 18 year old female who had been inhaling petrol in a sleep out. After the deceased fell asleep the room caught fire, probably from petrol fumes being ignited by a heater. She escaped through the flames and roused her mother. On admission to hospital she gave a lucid account of the incident. She succumbed to her injuries 2 days later, the cause of death being extensive 3rd degree burned to 85% of her body. An operative smoke alarm had a limited effect on waking the deceased in time to escape.

In these two cases the soporific and stupefying effects of solvent inhalation appears to have diminished the victims' ability to act promptly and rationally, and this likely contributed to their deaths.

A further risk is the high volatility of solvents of abuse which greatly increases the risk of serious or fatal injuries because of their risk of explosive flammability. When ignited such vapour may cause severe immediate thermal injury as well as rapid ignition of combustible materials in the vicinity of the fire ball.

vi). Unattended Cooking

Cooking fires accounted for 22 fatalities making this the highest fire risk factor identified in the study. The deaths occurred in 17 separate fire incidents. In terms of multiple casualties, the worst case encountered in the study involved the deaths of 5 family members in one fire when a cooking pot ignited after being left on an electric ring set on high. One other incident involved 2 casualties from an unattended pot. In 16 of these fires involved stove tops being left on causing cooking to ignite. The other case involved an unattended electric fryer.

The consumption of alcohol was established in 12 (54.4%) of these cases. BAL measures ranged from 118–338 mg/100ml, showing significant levels of intoxication. It is apparent there is a strong correlation between drinking and unattended cooking fires which confirms a pattern reported in a number of other studies, especially of intoxicated persons attempting to cook a meal but falling asleep or becoming insensible with fatal consequences.

Case 23. The deceased was a 14 year old female. She was eating in the lounge with her parents when an unattended pot of oil ignited. Although her parents called for her to escape she remained fixed and immobile to be overcome by the developing fire and smoke. She was described as having difficulties with comprehension and being timorous. The cause of death was carbon monoxide intoxication and burning. A smoke alarm was activated.

Case 29. The deceased, a retired female aged 79, put her dinner on to cook and went to have a shower. In her absence the meal caught fire. The deceased emerged from the bathroom and was quickly overcome by smoke. She collapsed at the bathroom door. The cause of death was burning. No smoke alarm was installed.

vii). Children Playing with Flames

Fires caused by children playing with matches, lighters or flames resulted in 12 fatalities in 10 incidents. One victim was a 55 year old adult while all the others were children under the age of 5. Of these incidents, 8 resulted in single deaths and 4 in multiple casualties (2 incidents with 2 deaths). In one case the deceased appeared to put combustibles into a heater, while 7 fires were caused by children playing with lighters, and 1 with matches.

A feature of these incidents is the evident risk from children experimenting with fire usually in private areas in homes. Most fires (6) started in bedrooms. In one incident two children started a fire in the garage but hid in their bedroom where they were overcome by fire. While all these victims were under supervision at the time of the fires, even short periods when supervision was limited (eg. parent putting clothes on line) were sufficient for fatal ignitions to be started. A common feature was the lighting of bedding and bed clothes as part of fire play by children.

Case 18/19. The deceased were twin boys aged 3. They were playing with a lighter in a bedroom they shared with their mother. A young cousin alerted family to the fire but it was not possible to extricate the twins from the room which was filled with smoke. The fire was started on a mattress and had spread extensively when discovered by adults in the house. One child had previously been found playing with a lighter. The cause of death in both cases was determined to be the effects of fire. No smoke alarm was installed.

Case 34. The deceased was aged 10 months. She was asleep in her cot when her 3 year old brother obtained a lighter and apparently caused bedding in the room to catch fire. The 3 year old then called for help and an adult who was hanging clothes on the line discovered the fire. The fire developed too quickly to enable the deceased to be saved. Other lighters accessible to children were found in the house. The cause of death was inhalation of smoke and fumes. A smoke alarm was installed and was activated.

Case 56/57. The deceased were cousins aged 4. They were playing in a garage while their Grandfather mowed a lawn. Alerted by smoke alarms, he saw a fire in the garage but found neither boy was in there. He then searched the smoke filled house. There was no response from the boys as he ran through the house calling for them. The fire was found to have started in foam cushions under a table in the garage. The deceased were found under a bed in the front bedroom where they had apparently hidden. One boy had been playing with a lighter earlier in the day and had been chastised by his Grandfather. It was believed the boys hid as a result of causing the fire in the garage. The cause of death in both cases was asphyxia from smoke inhalation. The removal of a door between the garage and house was a contributing factor in the rapid spread of the fire. Smoke alarms were installed and activated.

viii). Heating Appliance Fires

Fires resulting from the misuse or failure of heating appliances resulted in 9 fatalities in 8 incidents. All but one of these fires involved electrical heaters, the exception being an LPG heater. The one case of multiple fatalities involved two children. All other deaths involved adults, with only one victim being under 60 years. The main risk was from bedding or furniture catching fire when heaters were placed in too close proximity.

Case 22. The deceased was a male aged 78. He retired to bed leaving a heater on in the bedroom. He was reported to be a restless sleeper. During the night bedding fell on the heater causing a fire. The decreased was woken by the fire but was unable to escape. He was found on the floor between the bed and a table. The cause of death was inhalation of smoke and fumes and burns. A smoke alarm was installed and was activated.

Case 86. The deceased was a female, aged 78, described as a reclusive. She was known to have heaters going quite close to her as she reported she was prone to feeling the cold. A fire developed in a wardrobe she used as a bedroom caused by a single bar placed too close to bedding and clothing. The deceased had a previous history of clothing and bedding fires, and witnesses stated the fire was highly likely given her habits and behaviours. The deceased was found on the lounge floor and to have died from inhalation of smoke and fumes. An uninstalled and non-functional smoke alarm was retrieved from the property.

Case 73. The deceased was a male aged 85 who lived alone. He had several health problems and required a walking frame to move about. While attempting to ignite a LPG heater a burst of flame set fire to his clothing. He tried to escape but was unable to do so before succumbing and falling against a chair in his lounge. It was noted the heater had no protective screen facilitating ignition of clothing. The cause of death was extensive burns to the body. A smoke alarm was activated alerting the emergency services of the incident.

Case 114. The deceased was a 31 year old solo mother who shared a flat with another woman. Her two children were away from the address at the time of the fire. Both women had been socialising until the early hours of the morning. The flatmate returned and went to bed leaving a heater on in her bedroom. This ignited bedding and clothes. The flatmate awoke and escaped to call the Fire Service. The deceased was found on the floor of her bedroom. She had been overcome by smoke as she attempted to escape. It appeared she had little warning of the fire. The cause of death was carbon monoxide poisoning from inhalation of smoke and fumes. Inactivated smoke alarms were found installed in the house.

ix). Naked Flame Fires

Fires from naked flames and sparks involved 7 incidents with 8 fatalities. One case was a multiple fatality involving a father and son. Most fires were caused by burning fuel and sparks from stoves and open fires used for heating purposes.

Case 60/61. The deceased were a 25 year old a father and his 8 month old son. The father had been drinking in the day and was intoxicated when he went to bed. In the early hours of the morning burning coals fell from an insecure woodstove door onto the lounge floor. The old timber house quickly caught fire and the deceased were overcome by extensive smoke and fumes. The cause of death was carbon monoxide poisoning from smoke inhalation. Post mortem analysis found the father had a BAL of 189mg/100ml. An smoke alarm was activated but did not wake the father in time to escape the fire.

Case 62. The deceased was an elderly male aged 79. He was described as reclusive and exhibited a degree of dementia. He resisted efforts to place him in care. He lived in the lounge of his house. This was extensively filled with firewood and rubbish. He kept a fire burning and habitually left the fire door propped open with logs. Burning logs fell onto the floor and despite his efforts to extinguish the fire he was overcome by smoke and perished. The cause of death was the effects of fire with inhalation of smoke and fumes. No smoke alarm was installed. It was significant that his previous house was destroyed by fire in almost identical circumstances.

Case 79. The deceased was an elderly woman aged 81. She had a physical disability that markedly reduced her mobility. A burning coal fell from a solid fuel heater in the lounge onto her slipper and caused her clothes to catch fire. A smoke alarm attracted assistance and she was taken to hospital with severe burns. She was lucid at admission and gave an account of the circumstances of the fire. She died 2 days later from acute heart failure associated with 50% burns to her body. The smoke alarm was instrumental in attracting attention to her plight.

x). Unattended Candle Fires

Fires caused by unattended candles were the third most significant risk factor identified in the study. In all 13 deaths occurred in 8 fire incidents, with 8 deaths occurring in 3 multiple fatalities. All victims appeared to have been asleep when the fires started. All victims were Maori, with 8 casualties under the age of 16. In 4 cases the residences were not supplied with electricity. All but 1 residence were recorded as being in the lower socio-economic level of the Deprivation Index Decile.

In every case fire investigations found candles had been left burning and had caused ignition either by coming into contact with nearby materials, or as a consequence of the candle falling over.

Case 74/75/76. The deceased were males aged 6, 8 and 14. The eldest had been babysitting 5 children. All had retired to bed. The investigation found a burning candle had ignited combustibles in the lounge room. It was likely a child had left the candle there to light the way to the toilet. The fire took hold very rapidly due to the age and construction of the building which was sited in a rural location. Other candles were found on the dining table and fireplace as the house was not supplied with electricity. The other children escaped but the three deceased were overcome by smoke resulting in the cause of death being smoke inhalation and carbon monoxide poisoning in each case. No smoke alarms were installed.

Case 53. The deceased was a 9 month old infant. His mother occupied the property with her sister. The deceased was asleep in the lounge. The electricity supply was disconnected because payments were in arrears. A fire broke out in the kitchen which the mother tried to fight. She apparently did not realise the level of danger posed by the fire which rapidly developed and prevented the deceased from being rescued. The investigation determined a burning candle was the cause of the fire. The cause of death was asphyxiation. Three smoke alarms were installed but did not operate.

Case 105. The deceased was a male aged 54. He had been drinking and had retired to bed. He lived alone in a house with no electricity supply. Lighting was by candle. He left a candle burning by his bed which set fire to bedding. The deceased was found dead on top of his bed. He did not appear to have been roused by the fire, probably due to intoxication as determined at post mortem. The cause of death was exposure to fire, partial incineration and inhalation of smoke and gas. A smoke alarm was installed but did operate.

Case 4/5. The deceased were brothers aged 2 and 8. A fire ignited around midnight in an adjacent bedroom occupied by a 14 year old brother. It was apparently caused by a burning candle left on a table next to the bed. The house was supplied with electricity. Items on the table were ignited and the brother awoken and warned his parents of the danger. The father attempted to fight the fire but did not ensure the two boys were safely extricated. The fire rapidly developed and the father was incapacitated by smoke and flames. He was rescued by neighbours. Both boys were awoken and attempted to escape before succumbing to the dense smoke and fumes. The cause of death being smoke inhalation in each case. No smoke alarms were installed.

xi). Electric Blanket Fires

Fires caused by electric blankets resulted in 10 deaths, including 6 elderly people and 4 aged between 20 and 50. Most of the elderly victims were affected by some form of physical disability or medical condition. All fires occurred in bedrooms except in one case where the deceased used an electric blanket to warm himself as he sat in his lounge. All had been asleep and were woken by the fire. Most fires were attributed to misuse of electric blankets either by leaving them set on high for extended periods, or because of faults developed from blanket misuse (such as 'bunching up' causing wires to fray and become hazardous).

Case 131. The deceased was a 93 year old man suffering from secondary dementia. He had recently broken a wrist. His daughter lived next door and cared for him. She attended him at 3 pm and turned off his electric blanket. He later turned it on to full where after the bed caught fire. He was unable to escape and was found partially out of bed. The cause of death was severe burns. An inoperative smoke alarm was installed.

Case 27. The deceased was a male aged 81. He had significant mobility problems. He habitually wrapped an electric blanket around his legs as he watched TV in the lounge. The deceased went to bed leaving the blanket 'on' and crumpled on the floor. It caught fire during the night. The deceased was awoken by the fire but was unable to escape in time. His body was found on the hallway floor near his bedroom door. The cause of death was smoke inhalation. No smoke alarm was installed.

Case 77. The deceased was a woman aged 80. She had number of physical disabilities and limited mobility. She apparently discovered her electric blanket was too hot, took it off the bed, disconnected it from the power supply, rolled it up and placed it under her bed. It continued to smoulder and set the bed afire. She fell out of bed but was unable to escape. The cause of death was smoke inhalation. No smoke alarm was installed.

Case 32. The deceased was an 80 year old woman. She lived alone. After drinking alcohol she went to bed. During the evening she discovered her electric blanket was on fire. She turned it off at the wall socket and went to sleep in the spare bedroom. The blanket later ignited. The deceased was found in bed in the spare bedroom - apparently overcome by smoke in her sleep. It was suspected she was impaired by alcohol with a BAL of 124mg/100mls being found. The cause of death was carbon monoxide toxicity from smoke inhalation. No smoke alarm was installed. Her actions were not considered rational.

Case 64. The deceased was a 46 year old father. He returned home in the afternoon to discover his wife had taken a sick child to the Doctor. He opened the door to the child's bedroom and was engulfed in a fireball. This was caused by an electric blanket left on which set the bed afire. Additional oxygen provided by the open door caused the flash over. The deceased was overcome and fell onto the hallway floor. The investigation determined the blanket electrical lead had been damaged by a bed leg causing arcing and fire. The cause of death was asphyxiation from smoke inhalation. Smoke alarms were installed and operated.

xii). Faulty Electrical Appliances

Fires caused by faulty electric appliances caused in 10 deaths in 8 fire incidents. The sources of appliance faults included – meter box (2 fires), faulty TV (1 fire), damage to light flex (2 fires), electric heater control (1 fire), toaster cut-off mechanism (1 fire) and unspecified (1 fire). Most victims were asleep when the fires started.

Case 81. The deceased was an 86 year old woman who lived alone. A flex attached to a standard light had been damaged by an armchair castor running over it for some time. During the night the flex shorted out and caught fire. The deceased was woken by the fire but on opening her bedroom door was thrown back by the heat and flames. She was overcome and fell face down on the bedroom floor. The cause of death was carbon monoxide poisoning from inhalation of gases. A smoke alarm was installed and appeared to activate.

Case 64. The deceased was a 40 year old man. During the night a relative discovered a fire in the house and alerted the deceased, his partner and their two children.. All other parties evacuated the house but the deceased decided to go to the lounge to remove a burning TV set which had developed a fault causing the fire. He was driven back by the smoke and was found slumped over the hand basin in the bathroom. The cause of death was inhalation of smoke and fumes. No smoke alarms were installed.

xiii). Other Causes of Fires

Overloaded electrical circuits caused 7 deaths in 4 fires. In two cases fires were caused by incorrect fuses being installed resulting in no overload protection at all. Two other cases arose from overloading an electrical multi-box causing failure.

Faulty Gas appliances caused 6 deaths in 5 fires. These fires were largely due to ignition of leaking LPG cylinders.

The cause of fire was not established in 8 fires involving 10 casualties.

xiv). Careless Behaviour

A small and problematic group were those individuals who acted with extraordinary carelessness resulting in fire ignition. These included 6 instances where the deceased engaged in irrational or extremely careless behaviours that directly led to their death, although the coroner's found these deaths were unintentional.

Case 68. The deceased was a female beneficiary aged 26. She had a psychiatric history. She had been sitting on her bed in the mid-morning flicking lighted matches about the room. Most burned out but one caused materials to ignite. She was unable to escape the ensuing smoke and collapsed unconscious on her bed. The coroner question discounted the death as a suicide. The cause of death was carbon monoxide poisoning and smoke inhalation. It is not known if a smoke alarm was installed.

Case 9. The deceased was a 16 year old autistic boy regarded as having a low mental age. His father left the home for around 45 minutes during which time the deceased appears to have gone to a downstairs bedroom and set fire to clothes he had placed in the middle of the room. He then went upstairs to his bedroom where he was trapped by smoke and fire. He sought refuge in his wardrobe with fatal consequences. The coroner accepted the deceased lit the fire but did not attribute this to any intent to kill himself. The cause of death was carbon monoxide poisoning from inhalation of gases. No smoke alarms were installed.

Case 117. The deceased was a male aged 19 years. He had a psychiatric history and was prone to alcohol abuse. He had expressed suicidal ideation in the past. In the early hours of the morning he roused a neighbour saying he had discovered a fire in his flat but had put it out. He was quite intoxicated. Soon afterwards a fire broke out. The Fire Service found the deceased on the lounge floor. It was evident he had previously lit a fire under a heater which he extinguished. He then set fire to a chair which he unsuccessfully attempted to put out. He had left letters with three neighbours saying he did not want to lose their friendship. The coroner concluded the motives for the fire lighting were attention seeking but the deceased did not intend to take his life. The cause of death was carbon monoxide poisoning. His BAL was 221mg/100ml. An installed smoke alarm had its battery removed.

Case 120. The deceased was a female aged 21. She had a dispute with her partner and attempted to leave their property. He tried to get her to stay. She doused the bonnet of a car with petrol and rubbed herself on it. She then lit the petrol on the bonnet and was engulfed in flames. She screamed for her partner to put out the fire. She was badly burned and died 17 days later. The cause of death was bilateral pneumonia and burns. The coroner accepted she lit the petrol but did not intend to kill herself as she did not anticipate she would be engulfed in the flames. In incident occurred by a garage. No smoke detector was installed and would not have affected responses to the fire.

5.5. SPECIFIC VICTIM BEHAVIOURS

i). Fire Ignition

The role of victims in fire ignition is a significant element identified by Brennan and Thomas in their paradigm. Analysis of victim behaviours contributing to fire ignition can be classified according to the following general categories –

General Ignition Category	Description
Careless Acts	Ignition caused by careless actions reasonably expected to cause fires. ie. disposal of burning cigarettes, leaving candles burning, placing heaters close to furniture.
Acts of Omission	Fires caused by acts of omission. eg. leaving children unattended; not preventing access to matches, lighters, or fireworks; leaving cooking pots unattended.
Disability	Ignition caused by physical/psychological disabilities. eg. falling on heater, inability to control heating, irrational acts not intended to cause fires to start.
Environmental Failure	Fire caused by failures in the living environment. ie. failures in electrical systems, sparks from building activities, appliance failures.
Secondary Victim	Ignition caused by *some other* person resulting in the death of the individual as a secondary victim. eg. children in care, fatality to flatmates or other residential occupants.
Not Known	Behaviour not established or known in any detail.

These general categories only provide a summary of behaviours contributing to fire ignition. Application of a category is *specific* to *the individual responsible for fire ignition and not to secondary victims* of that person's actions, or to environmental failures where assignment of responsibility is not possible. **Table 5.5a** summarises victim involvement in 130 cases -

General Category	Number	Percentage
Careless Acts	48	36.9%
Acts of Omission	13	10.0%
Disability	6	4.6%
Environmental Failure	12	9.2%
Secondary Victim	41	31.5%
Not Known	10	7.7%

Assignment of victim contribution to fire ignition is possible in 67 fire deaths. The remaining 63 cases are considered to be a result of *environmental failure*, *secondary victim classification*, or *not known*. It is apparent that *careless acts* and *acts of omission* are involved in nearly half the fire ignitions, either directly or indirectly, which lends support to Brennan and Thomas's proposition.

ii). Behaviours Contributing to Fatality

Beyond roles in causing fire ignition, victim's behaviour may also contribute to the fatal outcome as individuals become involved in interacting with fire in various ways as proposed by Brennan and Thomas.

Interactive behaviours with fire include such actions as attempting to fight the blaze and entering/re-entering burning properties. Further, the extent of victim movements from when they first became aware of the fire to where they ultimately were found or were overcome by fire provides an indication of behavioural interactions with fire. A two phased analysis of interactive behaviours is suggested –

a). Victim Actions in Relation to Fire Ignition
b). Victim Actions in Relation to Fatal Consequences

a). Victim Actions in Relation to Fire Ignition

Of the 130 cases where information is available, it appears that the seat of the fire (ie. the place of ignition) in relation to the location of the victim was as follows –

Victim in Same Room as Seat of Fire	58	44.6%
Victim in Another Room from Seat of Fire	70	53.8%
Victim External to Property	2	1.5%

Where the fire originated in the same room as the victim was initially located it is noted that *carelessness* was the primary behavioural cause in 33 cases. This includes such actions as smoking in the presence of petrol or other volatile liquids, allowing burning cigarettes to fall on bedding or furnishings, and such irrational actions as placing a smouldering electric blanket beneath a bed. Alcohol consumption was evident in a large number of these cases. Victims with *disabilities* that precipitated fire ignition included 5 deaths including such actions as falling over heaters and being too close to flames causing clothing to catch fire. Acts of *omission* such as leaving heaters on next to bedding and pots cooking on stoves accounted for 14 deaths in this group. 4 deaths were as a result of *environmental failures*. Of these 58 fires that ignited in the same room as the victim was initially located, 28 deaths were associated with bedrooms or sleeping places, and 16 were in lounge/living areas.

Of the 70 fires which originated in another room as the victim was initially located, 34 started in kitchen areas, 15 in bedrooms or sleeping areas, and 9 in lounge/living areas. In 53 cases the victims were initially located in bedrooms, with a further 35 in lounge/living areas. In this group fire ignition was attributed to *carelessness* in 17 cases, action of *omission* in 18, and 9 to *environmental* failures. A majority of this group of victims were asleep when the fires ignited as can be discerned from the numbers who were initially in bedrooms and sleeping areas.

b). Victim Actions in Relation to Fatal Consequences

The actions of victims which contributed to fatal consequences are complex but can be summarised into general groupings which relate to their responses when they discovered the fire had developed. In a great number of cases these response were minimal, as the deceased only became aware of the fire a very short time before they were overcome by flames, heat, smoke and fumes rendering any escape impossible. Where others attempted to escape they frequently were overcome by smoke and fumes so their ability to move away from danger was rapidly compromised. In the case of infants and those with disabilities escape was impossible due to their circumstances. In a small number of incidents victims attempted to fight the fire and were then overcome by it. Some victims escaped or were extricated by rescuers only to later die of their injuries.

For summary purposes the following categories of victim behaviours relating to fatal consequences are proposed -

Victim Not Aware in Time	Victim unaware of fire or only becomes aware shortly before they are overcome.
Victim Unable to Escape	Victim is unable to escape because of age or disabilities.
Victim Attempts Escape	Victim attempts to escape fire but is overcome.
Victim Extricated/Escapes	Victim escapes fire or is extricated by rescuers to later die from injuries.
Victim Attempts To Fight Fire	Victim attempts to fight fire in some manner.
Victim Goes To Fire	Victim goes to fire and is then in mortal danger
Victim Impaired by Disability	Victim has a disability affecting their ability to escape fire

For the 130 cases where information is available the following Table indicates general behaviours which may have contributed to victim fatalities.

Behavioural Grouping	Number	Percent
Victim Not Aware in Time	51	39.2%
Victim Unable to Escape	26	20.0%
Victim Attempts Escape	23	17.7%
Victim Extricated/Escapes	14	10.8%
Victim Attempts To Fight Fire	7	5.4%
Victim Goes To Fire	5	3.8%
Victim Impaired by Disability	4	3.1%

This summary shows that nearly two thirds of victims either had insufficient time to attempt an escape, or simply were unable to escape because of their age or as a result of disabilities. The mortal risk of residential fires is evidenced by the fact only around 11% of victims escaped from the fire or were extricated by rescuers. This emphasises the lethality of smoke inhalation and fire injuries as rapid agents of incapacitation. A result is that behavioural interactions with fire may only be brief before the victim is overcome and dies in a short period.

These observations are further reinforced by the fact that where information was available concerning the 108 fire incidents 75 (or 71%) of properties did not have smoke alarms installed or if installed these were inoperative. Accordingly, vital warning of a developing fire was not available to a significant number of victims who may have survived if they had adequate warning of the impending threat. However, the effects of alcohol consumption may have adversely affected levels of arousal for some victims, even if smoke alarms had been activated.

A more important indication of the impact of alcohol consumption is shown when BAL measures are matched against general categories of victim behaviours in fire. The significance of alcohol as a mediating factor is presented in the following Table -

Behavioural Grouping	Number	Alcohol Affected[17]	% Alcohol Affected
Victim Not Aware in Time	51	23	54.1%
Victim Unable to Escape	26	0	0.0%
Victim Attempts Escape	23	10	43.5%
Victim Extricated/Escapes	14	1	7.1%
Victim Attempts To Fight Fire	7	6	85.7%
Victim Goes To Fire	5	4	80.0%
Victim Impaired by Disability	4	0	0.0%

These data indicates the effects of alcohol are strongly associated with high risk actions such as moving towards fires and attempting to fight fires. Alcohol consumption also was likely to impact on victim abilities to respond to fire cues. This is evidenced by the fact more than half those who were apparently unaware of the fire in time to escape were affected by alcohol consumption to some extent.

[17] Determined to have BAL above 80mg/100ml.

SECTION 6: DISCUSSION

The study broadly supports the findings of other research. However, the opportunity to assess victim behaviours from coronial records permits a deeper level analysis than that provided by purely descriptive accounts of fire events. It is apparent Brennan and Thomas's model has validity, as many victims were involved in fire causation (*albeit* unintentionally). However, a large number had minimal interaction with fire due to the speed it developed; these victims were usually asleep or otherwise unaware until escape was impossible. It is also evident that Rhodes and Reinholtd's model is useful in describing an aggregation of vulnerability factors which, when combined with fire hazards, contribute to fatal outcomes.

Consistent with wider international findings, alcohol consumption, unattended cooking, and smoking were identified as highly significant factors contributing to fire ignition and fatal outcomes.

An outstanding factor remains the role of alcohol consumption in these deaths, as manifested by measures showing high post-mortem BAL's, and in behavioural consequences such as slowed and inappropriate responses when alcohol affected victims were roused by fire. The consequences of alcohol consumption reach beyond the alcohol affected individual to secondary victims in the care of, or living with, such persons.

The study found many of those involved in fire were agents *in some capacity* of fire ignition, and their deaths a consequence of habitual behaviours, short term or chronic incapacity, and irrational behaviours that directly contributed to the fatal outcome. While a small number of deaths are reasonably attributed to "accidental" causation (ie. a result of environmental failures); most reflect a more direct involvement of human agency as a primary factor in fire ignition and subsequent fatalities. Some victims were unable to respond because of age or disability, while others engaged in interactions with fire to their ultimate peril. The question is posed as to what behavioural features are identified in the study that relate to risk factors reported in the literature?

6.1. BEHAVIORAL FEATURES

a). Panic as a Response to Fire

The study found very few instances where victims appeared to engage in panic or highly disorganised actions. Instead, as Proulx[18] (2002) observes, lethargic responses to smoke alarms, vocal instructions, and fire specific cues (eg. flames and smoke) were more likely responses. Significant numbers of victims were not responsive in the initial moments of a fire and many ignored or delayed their responses to fire cues until there was insufficient time to effect a safe escape.

The absence of panic and apparent lethargic responses to fire cues are doubtlessly a result of a complexity of behavioural factors. These include the effects of such mediating factors as levels of arousal (eg. those who were asleep), effects of alcohol or drug consumption, and toxicity of various gaseous fire products. However, taking the physiological effects of these factors into account, it is apparent panic as a general response to fire was not common; rather, lethargy and initial indifference seems to be a more appropriate behavioural description in these fatalities.

[18] See page 10.

b). Careless Smoking

As is consistently identified in numerous international reports, the consequences of careless smoking activities rates as a significant risk factor in this study, rating as the second highest causal factor in fire ignition. Inappropriate disposal of burning cigarettes and victims falling asleep while smoking were particularly risky activities. Of further concern was evidence that some victims had previously experienced fires caused by burning cigarettes or lived in high fire risk environments surrounded by litter that greatly potentiated fire ignition and spread.

The features of smoking-related fire deaths lends strong support to initiatives to require cigarette manufacturers to introduce RIP (Reduced Ignition Propensity) cigarettes which quickly burn out and do not smoulder (eg. Leistikow *et al*, 2000, Chapman & Balmain, 2004). This would provide a partial solution to risks from careless smoking through reduced flammability of discarded cigarettes, although the behaviours of careless smokers is not modified. It is significant that legislation requiring this standard for all cigarette sales was introduced in New York State in 2003 and Canada from 2005. Other jurisdictions are apparently contemplating similar regulations. Advantages of reducing the fire risk from burning cigarettes is evidenced by 17 fatalities reported in the study, including 2 secondary victims who perished because of this fire risk. The risks from careless smoking is the subject of **Recommendation 2**.

c). Alcohol, Drug & Substance Abuse

Evidence of the pervasive contribution of alcohol consumption as a contributive factor in fire fatalities is shown by the compelling BAL measures presented in **Figure 5.3b**. It is apparent a sizeable number of fire victims were impaired by alcohol (ie. **44** or **34%**) with many having BAL measures exceeding the legal driving limit, sometimes at a high level of intoxication. As reported in other studies, there is no doubt alcohol is a significant factor in precipitating fire ignition (usually due to reduced attention or sleepiness), and in affecting timely and appropriate responses to fire cues (largely due to torpor and disorientation). The impact of alcohol is compounded by the numbers of secondary victims (**14** or **11%**) who perished in fires ignited by those who were alcohol impaired. This included the largest multiple fatality involving 5 family members as casualties.

The role of drug and substance abuse in fire fatalities was not as significant as alcohol in the study; however, 14 deaths were associated with these factors. Cannabis was the main drug implicated in fire deaths, usually in conjunction with alcohol consumption. Abuse of volatile substances caused two fatalities, both involving highly flammable petrol vapour and smoking.

It is recommended that further targeted education initiatives be considered to address fire risks associated with alcohol, drug, and substance abuse. These should consider the principles of Drink-Drive campaigns to identify those particular messages that have effected permanent behavioural changes in the general and 'at risk' populations (see **Recommendation 3**).

d). Unattended Cooking

Unattended cooking was the highest risk factor identified in the study involving 22 fatalities (with alcohol consumption implicated in 12 of these). The circumstances of unattended cooking fires appear to be similar to those reported in a number of other countries, including chip pan or cooking oil fires as a particular risk. The fact that unattended cooking fires occur around a common place daily activity suggests any proposed safety educational programmes must reach across all groups in the general population given the ubiquity of this risk factor.

A feature affecting awareness of the risks of unattended cooking is the role of dangerous habitual behaviours in the home that are not readily amenable to external scrutiny and which individuals do not perceive as being problematic. Dangerous habitual behaviours also include other risks such as excessive alcohol consumption and careless smoking. These combine to create a hazardous environment that contributes to both fire ignition and ineffective escape responses. These risks require further study in order that effective education and prevention initiatives might be developed (see **Recommendation 4**).

e). Careless Heating Activities

The contribution of careless heating activities in fire fatalities is partially due to dangerous habitual behaviours noted in **6.1 d)** above, but also to poor care and maintenance of heating appliances and fire places. The study found a notable risk associated with misuse of electric blankets, especially when these were left on for extended times. This risk was also related to factors of aging, with the elderly being vulnerable to fires from this source - a finding noted in other studies (eg. Mah, 1998).

Heaters were also a risk when placed too close to furnishings or furniture, or when bedding was ignited while victims slept. Fatalities involving solid fuel or open fires were largely due to misuse causing fires to ignite, or because victims had disabilities preventing timely responses to potential fires. The elderly were also implicated as a vulnerable group in this regard, along with lower socio-economic groups. Again, these risks largely reflect dangerous habitual behaviours that result in fire ignition and by their circumstances may inhibit rapid and safe escape because a substantial number of victims are asleep when fires start.

A key feature of careless heating fires is that they are largely a consequence of dangerous habitual behaviours that are unique to the individual's home environment and which usually do not extend to the outside world. These dangerous habitual behaviours are usually confined to the one environment where individual's feel they have total control (ie. their private homes) and where there are strong barriers to the intrusion of other parties who may seek to modify risky activities.

The crux of the problem of dangerous habitual behaviours may reflect the intent of the old maxim "*A person's home is their castle*". This reflects a view of residential areas as a special personal territory in which individual freedom is manifested. Unfortunately, this individual freedom may include habitual behaviours that directly result in death and injury, including the risk of fire. In contrast, social behaviour in the external environment is generally governed by accepted regulatory rules (eg. responses to fire alarms, obeying red lights etc). In the home environment such constraints may not necessarily apply with a consequential increase in risks from dangerous habitual behaviours.

f). Children Playing with Flames

A tragic group of casualties were 12 deaths from children playing with flames. These were inevitably a result of children's lack of understanding of the dangers of their actions and a fascination with fire in this vulnerable group. Children's fascination with fire may reflect a primitive attachment humans have with fire (as noted by Brennan and Thomas). In normal development children grow out of this interest in fire, and (with the possible exception of arsonists) interest in fire is confined to caution and respect for its inherent dangers in all aspects of the living environment. The main problem with children playing with fire is their developmental immaturity which means it is difficult to forestall their interest in fire. The only effective prevention measures are careful supervision, and prevention of access to fire sources as far as is practicable.

A further feature of these deaths was the numbers of victims who, having ignited a fire, were unable to escape the scene, or who then hid from the fire to their mortal peril. It is noted most of the fires caused by children involved lighters or matches used by smokers. This again raises the role of dangerous habitual behaviours such as leaving lighters or matches in places where children can gain access to them. It is suggested the primary risk mitigation strategy for this risk factor is education programmes aimed at parents and care givers stressing the need for supervision and removal of access to fire sources.

g). Unattended Candles

Fire deaths from unattended candles were the third highest group identified in the study. This level of casualties indicates a significant problem from this source of fires. The prevalence of electric lighting for illumination raises a question as to why candles are such a particular risk? It is noted 4 of the 8 properties in which candle fires occurred were not supplied with electricity, either because of remote location or supply was disconnected for non-payment. All but one property were in the lower socio-economic grouping, and all victims were Maori. Unlike cases described in the literature, none of these fires were associated with festive or religious occasions – rather candles were the main source of residential lighting. The primary behavioural risk appeared to be leaving candles burning when the victims had gone to sleep and the candle flames then ignited furnishings or fell over with deadly consequences.

h). The Aged and Disabled

The study identified a significant vulnerability of the aged and disabled. Both appear to have particular risks associated with physical and psychological limitations of their conditions. This vulnerability is noted in the international literature.

Behaviourally, the risks for the aged includes consequences of physical and cognitive decline. This is often expressed as increasingly risky activities that potentiate fire ignition. Unlike the very young who have yet to learn of environmental risks and behaviours to remain safe, the aged may have an understanding of such but not a realistic appreciation of their vulnerability. While many may believe they are able to escape fire, they may significantly underestimate their abilities to engage in the strenuous actions required to do so. For example, the ability to crawl beneath a layer of smoke, to climb out of a window, or to negotiate around furniture while under the threat of fire may be physically beyond many victims. The need for decisive and speedy movement in a fire is an imperative that some aged people may not be able to achieve when a sudden demand is required.

Beyond physical limitations of the aged are the consequences of psychological decline expressed in cognitive processes, increased habitual behaviours, and failing memory. Such physical and psychological decline may be insidious and not recognised until there is an apparent need for the elderly person to be placed into care. Regretfully, a number of victims showed indications they should be in care, but for various reasons (including the reluctance of individuals themselves) they remained in self care with tragic consequences.

The extent of disabilities as a factor in these fire deaths is seen in the significant number of victims (**50** or **38.8**%) with pre-existing health conditions, including mobility difficulties, Alzheimer's disease, dementia, cardiovascular conditions, respiratory diseases, and sensory losses. These health conditions place the aged and disabled in a higher fire risk category and any prevention and safety strategies needs to take into account particular individual needs (eg. type of heating for those with limited mobility, oversight of those with emerging dementia or Alzheimer's disease, appropriate alarm systems for those with sensory losses).

The needs of such vulnerable groups are identified in a number of studies across several jurisdictions (eg. Notake *et al*, 2004; Sekizawa, 2004; Taylor *et al*, 2001; Loveridge, 1998). Sekizawa observes the challenge for advancing the safety for these vulnerable groups as –

"The issues for care of vulnerable populations to fires are in a huge variety of ways. And, one revolutionary idea alone is not able to solve these diverse problems all at once, but instead strenuous efforts are required multilaterally for solving problems."

i). Behaviour Under the Duress of Fire

An outstanding feature of many cases in the study was an apparent disjunction between the impending risk from the fire and a perceived inertia affecting escape responses. As noted in **6.1 a)**, predominant reactions appear to be more of a non-responsive or lethargic character than of alarm and quick actions. Perhaps the underlying bases for non-responsiveness may include significant behavioural differences which discriminate between those who die and those who survive fires?

The data in **Figure 5.3a** showing blood carbon monoxide saturation levels indicates a great risk from the consequences of inhaling toxic smoke products (and not just carbon monoxide). These toxic products may rapidly affect consciousness, rationality, and physical capacity to escape. This is further supported by the causes of death shown in **Table 5.3a** where smoke inhalation, hypoxia/asphyxia, and carbon monoxide poisoning emerge as highly lethal factors. All are associated with respiration, consequences of exposure to smoke and toxic gases, and lack of oxygen. Despite the lethal risks from breathing in this environment, many victims appeared to delay their escape until the incapacitating effects of such inhalation effectively ended their chances of survival.

In considering behaviour under the duress of a fire it is important to acknowledge the effects of alcohol as a mediating factor, along with sleep deprivation and fatigue that also influence arousal to fire cues. Recent research by Bruck *et al* (2004) on sleeping children, and Ball *et al* (2004) on sleeping young adults, has focused on the relationship between alarm stimuli and subsequent waking behaviour. These studies have built on other work examining the risks to various vulnerable groups from non-response to smoke alarms including children, the elderly, those affected by drugs and alcohol, and those who were sleep deprived (Bruck, 2002).

Of particular note is a finding that even small amounts of alcohol may significantly impact on responsiveness to auditory alarms, with BAL's as low as 50 mg/100 ml seriously affecting the ability of sleeping young adults to respond to smoke alarms. This lends experimental support to observations of victim behaviours in the present study. The adoption of 80 mg/100 ml legal driving standard appears to also be relevant as a benchmark in considering the impact of alcohol on responses to fire cues. This suggests further experimental studies of other factors that inhibit arousal and timely responses to fire cues in sleeping persons is required, especially consideration of the factors that promote lethargic non-responsiveness to fire development in the crucial minutes before toxic fumes and fire spread lead to incapacitation of victims.

Consideration of behaviour in fires leads to a conclusion that there is a complexity of factors that come into play which contribute to fire ignition and subsequent escape or fatality. It is evident there is a complex interplay between *environmental* factors (eg nature of the fire, its location, extent of smoke and fumes) and, *victim* factors (eg. alcohol and drug consumption, warning of fire cues, and impending risks). These interact with individual characteristics, such as habitual behaviours, disabilities, and cognitive processes to also affect potential survival or fatality.

6.2. THE QUESTION OF INTENTIONALITY

The study was predicated on a methodological requirement to investigate fatal residential fires determined to be *unintentional* in causation (see **Section 4.1.**). Accordingly, fires attributed to suicide or homicides were excluded from consideration. Exclusion of cases was based on coronial determination of intentionality as the benchmark. *Intentional* fires include homicide (ie. murder, manslaughter, arson) where the responsibility for the death is attributed to another party than the deceased; and suicide where the fatality is caused by the deceased. It is noted there are also cases of murder/suicide involving fire in some capacity, either to kill and/or to mask homicidal intent.

Identification of intentional fire deaths was not difficult, as coronial verdicts were founded in extensive forensic investigations which may have resulted in criminal proceedings depending on circumstances. However, it was apparent that a simple distinction between *intentional* and *unintentional* deaths was not always appropriate. 15 *borderline* cases were identified (ie. 11.5% of deaths) where determination of intent was unclear or ambiguous. Analysis of these cases suggests the distinction between *intentional* and *unintentional* fires is not a simple dichotomy; rather, the intermediate group of *borderline* cases reflect a more complex intentionality and suggests the issue of intent requires a conceptual review.

Figure 6.2a Intentionality, Harm, & Fire Causation (see page 74) presents a model which reflects Brennan and Thomas's assumption that victims *interact* with fire and may be involved in fire ignition and facilitation of fire growth. It is the nature of these interactions with fire, along with other factors involved in fire causation that highlights a need to review attributions of intentionality. The model distinguishes between *Intentional* and *Unintentional* fire causation and proposes an overlap between the two as *Borderline Cases*. Within these three elements are behavioural and environmental factors contributing to the complexity of the model –

Unintentional Causation: A continuum is suggested that progressively reflects ***Human Agency*** as a factor in fire ignition and spread. This ranges from –

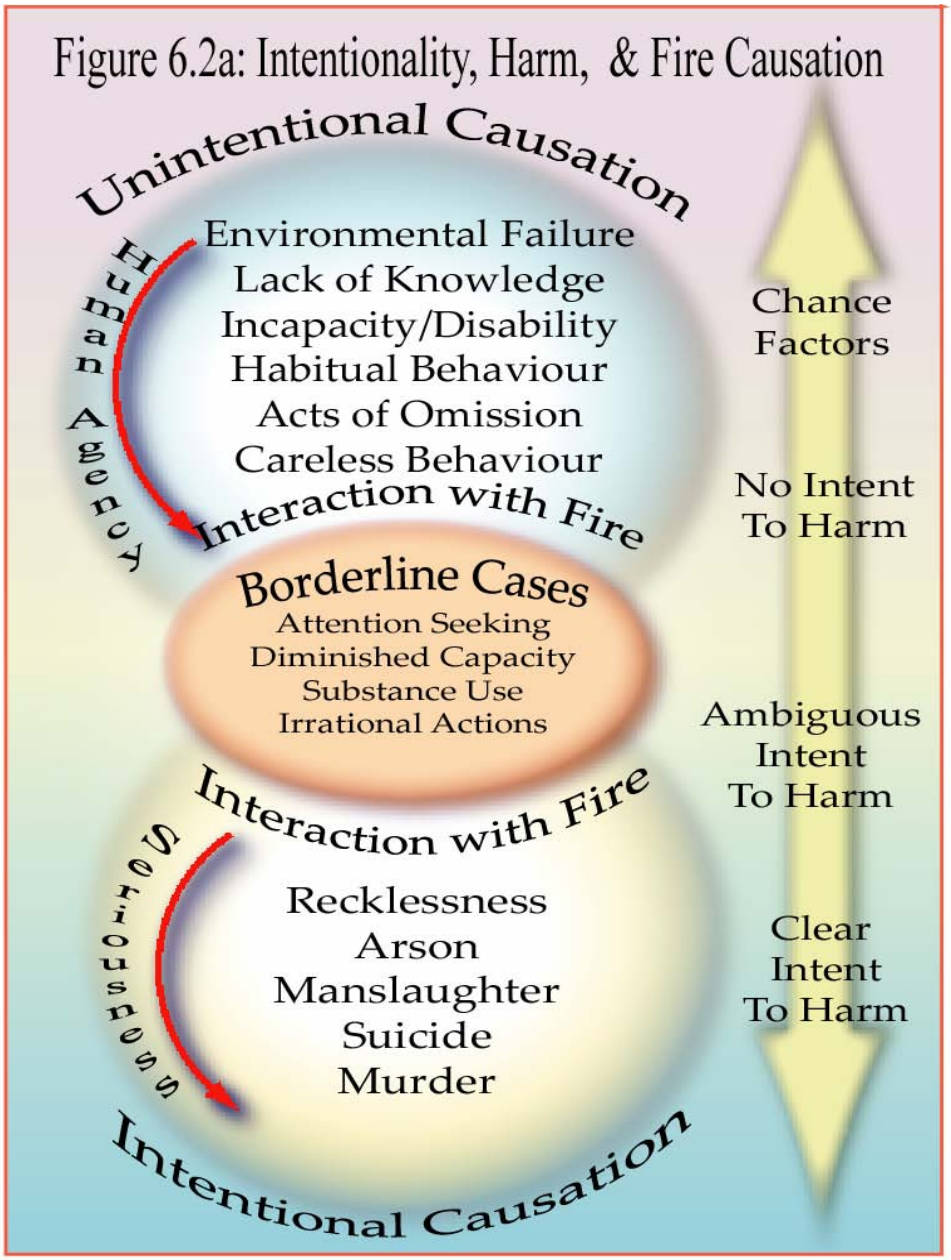
> ***Environmental Failure*** - accidents and consequences of chance (eg. fuel leaks, faulty electrical systems, inadvertent sparks, consequences of weather phenomena).
> ***Lack of Knowledge*** – fires arising from a genuine ignorance of the risk of ignition or fire spread.
> ***Incapacity/Disability*** – reflecting an inability to physically prevent fire ignition or spread (eg. falling over a heater, burning coals igniting clothing).
> ***Habitual Behaviour*** - risky habitual actions which ultimately result in fires (eg. leaving electric blankets and electric heaters on, lighting fires with accelerants).
> ***Acts of Omission*** – serious acts of omission leading to fires igniting and spreading (eg. unattended cooking, leaving children unattended).
> ***Careless Behaviour*** – careless actions that directly contribute to fire ignition and spread (eg. leaving lighters and matches in reach of children, careless disposal of burning cigarettes).

Intentional Causation: A related continuum increasingly reflects ***Serious Intent to Harm*** as a factor in fire ignition and spread, ranging from –

> ***Recklessness*** - foolish or reckless acts which results in fire ignition (eg. misuse of fire works, lighting fires as an ill-conceived joke).
> ***Arson*** - where setting fire to property or the environment is intentional but the objective to harm someone is unintentional or coincidental.
> ***Manslaughter*** - where intent to harm or injure is legally established but intent to kill is not.
> ***Suicide*** - where a clear intent to kill oneself is legally established using fire as a means of death or to disguise suicidal intent.
> ***Murder*** – where a clear intent to kill other person(s) is legally established.

Borderline Cases: Between *Intentional* and *Unintentional* causation falls *Borderline Cases* where behavioural determinations of intent are unclear or ambiguous. These behavioural elements include –

> ***Attention Seeking*** – risky behaviours designed to attract the attention of others for various reasons (eg. setting minor fires, threatening fire ignition).
> ***Diminished Capacity*** – fires ignited by persons with limited intellectual capacity or serious mental disorders that affect their appreciation of the risks involved.
> ***Substance Abuse*** – fires attributed to poor judgement and responsiveness due to the effects of substances that affect cognition, coordination, and emotionality.
> ***Irrational Actions*** –irrational behaviours contributing to fire ignition and spread, or subsequent fatality (eg. entering burning structures, opening volatile materials in the presence of flames).



The model proposes the notion of *intent to harm* may range across a continuum of *chance factors* to a *clear intent* (in the case of murder and suicide) with *no intent* and *ambiguous intent* forming an intermediary point between the two. The interplay between intent to harm and intent to cause fire provides a dimension for further behavioural analysis with a larger sample of cases. The results of the study suggest the Model of Intentionality, Harm, & Fire Causation has validity. However, the model requires further evaluation (especially a detailed analysis of intentional fire deaths) to determine its wider application. This may include consideration of non-fatal injury fires as a subsidiary area of study (see **Recommendation 1**).

6.3. IMPLICATIONS FOR INTERVENTION STRATEGIES

The impact of behavioural factors in fire fatalities suggests a need for specific and targeted strategies as a basis for fire safety and prevention interventions. It is apparent some gains can be achieved through recourse to engineering and technology as a means of solution. For example, internally wired smoke alarms may increase the chances of alerting residents of a potential risk; given an identified propensity to not replace batteries, or to remove these as they are deemed a nuisance in minor activation incidents. However, while technology provides a potential option, reports that many sleeping residents (especially those affected by drug or alcohol consumption) were not responsive to standard alarm cues suggest the behavioural assumptions underlying technological solutions may require revision (Bruck *et al,* 2004; Ball *et al,* 2004).

Rhodes and Reinholtd (1998) advocate a holistic approach to fire intervention strategies "*which recognises the complexity of the problem and employs a range of integrated measures to address the specific needs of vulnerable groups in the community*". In their approach four primary strategies are proposed –

1. **Identify the needs of high risk groups in the community.**

2. **Shift the focus from dealing with hazards agents to addressing vulnerability of high risk groups.**

3. **Employ a range of measures to address specific fire safety issues.**

4. **Develop an intersectoral approach to address community safety issues.**

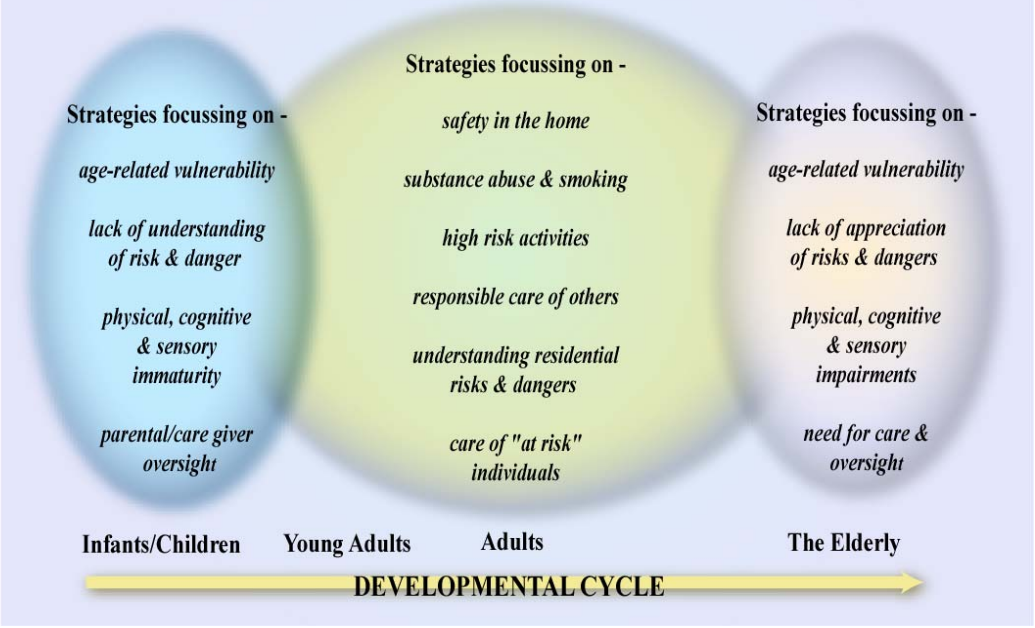
The findings of the study endorse this approach. It is noted this forms part of current NZFS intervention strategies, but it is suggested it may be further developed as a result of a closer focus on behavioural factors identified as being at issue in fire causation and consequences.

A fruitful area of consideration includes the study of individual cognitive processes that underlie a range of behaviours identified in the study as contributing to fire ignition and fatalities. These include dangerous habitual behaviours that are not always amenable to external scrutiny and which may not be perceived as problematic by those most at risk. Inappropriate assumptions about fire risks and individual contributions to potential (or actual) fire events clearly pose a challenge for fire safety and prevention initiatives. In this context it is important to identify differential vulnerabilities between various at risk groups to ensure such initiatives are tailored to the particular dimensions of each group as proposed by Rhodes and Reinholtd.

Consideration of inappropriate assumptions about fire risks may include formulations around the construct of *locus of control* (Rotter, 1960, 1966) as a starting point to consider ways in which more effective fire safety initiatives could be directed to particular at risk groups. This must necessarily focus on those in lower socio-economic groups who are disproportionately represented in the study and are identified in most developed countries as being at greatest risk of fire injuries and deaths, along with other measures of disadvantage and mortality.

A further formulation affecting fire safety and prevention initiatives involves differential strategies based on the human developmental cycle. Clearly, different strategies are required according to where an individual falls on this cycle, and the range of physical, intellectual and cognitive factors that apply at different points over the life span. This is summarised in **Figure 6.3a** as follows -

Figure 6.3a: Fire Prevention Strategies & the Developmental Cycle



It is concluded more effective fire safety and prevention interventions are likely to be founded in a deeper understanding of the behavioural processes underlying the types of actions identified in the study as contributing to fire ignition and subsequent injury or death. Such improvements must necessarily take into account the developmental cycle, cultural and social practices, and the particular and defining features of those vulnerable groups recognised as being at risk. While technological and engineering solutions will also contribute to such advances, these must accurately reflect the behavioural substrates in which so much fire risk is founded if further advances are to be achieved. Ultimately effective fire safety and prevention strategies must involve an amalgam of technological, environmental, engineering, and behavioural approaches applied to identified differential risks if enduring gains are to be made in reducing residential fire deaths and injuries.

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