Unintentional domestic injury from fire and flame in Aotearoa New Zealand

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Abstract

**Aim:** To contribute to improved household fire safety in New Zealand through better understanding of factors associated with unintentional injury from fire and flame in domestic locations.

**Methods:** Descriptive epidemiological analysis of collated data from New Zealand Fire Service, New Zealand Health Information Service and New Zealand Coroners’ Courts.

**Key results:** From 1991-1997 inclusive there were 184 deaths in 154 unintentional domestic fire incidents in Aotearoa New Zealand. From 1996-2000 inclusive there were 862 first admissions to hospitals in Aotearoa New Zealand for inpatient treatment of injury from fire and flame in a domestic location.

The highest age-specific mortality rates were observed among seniors aged over 64 years and pre-school children. The highest age-specific rates of admission to hospital for inpatient treatment of injury from fire and flame at home were observed among pre-school children, young people and adults aged 15-24 and 25-34 years, and seniors aged over 74 years. There was a slight excess of male deaths compared with female deaths, which was most marked for children aged under 5 years. Gender disparities, with excess male rates of admission to hospital for inpatient treatment of injury from fire and flame were most evident among young people and adults aged 15-24 and 25-34 years. Māori mortality rates were higher than non-Māori in all age groups, and this disparity was particularly marked among children. Māori rates of admission to hospital for inpatient treatment of injury from fire and flame were higher than non-Māori rates, and this disparity was most marked for children and for adults aged 25-44 years. Small area
analysis demonstrated a socio-economic gradient for fatal unintentional fire incidents with higher rates of fatal fire occurrence in households in relatively deprived census meshblocks.

Narrative data provided a wealth of information about fatal unintentional domestic fire-related scenarios. Alcohol was associated with a high proportion of such fatal fire incidents, particularly in the 15-64 age group. Disruptions to usual routines and children playing in stationary motor vehicles are factors identified through use of narrative data that were not obvious in the statistical datasets.

**Conclusion:** Improved household fire safety in New Zealand will require intervention programmes that operate at individual, household, community and national political levels. Community based fire safety programmes can have a significant impact at household level. Fire safety campaigns also need to recognise that households are not static entities, and include consideration of fire safety issues when away from home, and when having a party or guests in the home.
Acknowledgements

The work described in this thesis could not have been undertaken without support from The New Zealand Fire Service Contestable Research Fund. Individuals within the New Zealand Fire Service were outstanding in their provision of data and information, and sharing their professional knowledge and understanding of the issues. In particular I wish to thank Dr Paula Beever, Roger Chang, Jim Dance, Piki Thomas, Katherine Lawrence and Bill Butzbach for their valuable assistance.

Staff of the Coroners’ Office and the Injury Prevention Research Unit also provided data and advice regarding analysis and evaluation, in particular Craig Leahy, Shaun Stevenson and Jean Simpson. Many thanks.

Within the University my supervisors and advisory group members provided regular feedback and encouragement. Special thanks to Professor Alistair Woodward, Dr Michael Bates, Clare Salmond and Professor John Langley. Your patience and belief in the value of this work has provided the necessary impetus to make sure that the long gestation period actually produced a result. Professor Peter Crampton and Dr Charles Tustin provided sustained encouragement in completing amendments.

This work has also led on to new collaborative research initiatives and I thank Dr Colleen Wade, Des O’Dea, Dr Murray Laugesen and Trish Fraser for working with me on the projects described in the appendices. Dr Ian Miller continued analysis of fire fatality data from 1998 to provide further information to improve fire safety in New Zealand.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACC</td>
<td>Accident Compensation Corporation (New Zealand)</td>
</tr>
<tr>
<td>BRANZ</td>
<td>Building Research Association of New Zealand Limited</td>
</tr>
<tr>
<td>CDC</td>
<td>Centers for Disease Control and Prevention (United States of America)</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence interval (the range of values likely to include the true value)</td>
</tr>
<tr>
<td>dl</td>
<td>Deciliter (equal to 100 millilitres)</td>
</tr>
<tr>
<td>DTI</td>
<td>Department of Trade and Industry (United Kingdom)</td>
</tr>
<tr>
<td>Ecode</td>
<td>External cause of injury code used in ICD-9 (q.v.)</td>
</tr>
<tr>
<td>FIRMS</td>
<td>Fire Incident Reporting and Management System (NZ) (previously FIRS q.v.)</td>
</tr>
<tr>
<td>FIRS</td>
<td>Fire Incident Reporting System (New Zealand) (now FIRMS q.v.)</td>
</tr>
<tr>
<td>GB</td>
<td>Great Britain (England, Scotland and Wales)</td>
</tr>
<tr>
<td>GLR</td>
<td>Generalised Linear Regression</td>
</tr>
<tr>
<td>ICD-9</td>
<td>International Classification of Disease coding system (9th revision)</td>
</tr>
<tr>
<td>IPRC</td>
<td>Injury Prevention Research Centre (University of Auckland, New Zealand)</td>
</tr>
<tr>
<td>IPRU</td>
<td>Injury Prevention Research Unit (University of Otago, New Zealand)</td>
</tr>
<tr>
<td>LTSA</td>
<td>Land Transport Safety Authority (New Zealand)</td>
</tr>
<tr>
<td>NFPA</td>
<td>National Fire Protection Association (United States of America)</td>
</tr>
<tr>
<td>NPIPC</td>
<td>National Center for Injury Prevention and Control (United States of America)</td>
</tr>
<tr>
<td>NZ</td>
<td>New Zealand</td>
</tr>
<tr>
<td>NZFS</td>
<td>New Zealand Fire Service</td>
</tr>
<tr>
<td>NZHIS</td>
<td>New Zealand Health Information Service</td>
</tr>
<tr>
<td>mg</td>
<td>milligrams</td>
</tr>
<tr>
<td>OR</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td>RR</td>
<td>Relative Risk or Rate Ratio (see text for clarification of which term is relevant)</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom (England, Scotland, Wales and Northern Ireland)</td>
</tr>
<tr>
<td>US/USA</td>
<td>United States of America</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WRONZ</td>
<td>Wool Research Organization of New Zealand</td>
</tr>
</tbody>
</table>
1. Introduction

This thesis examines factors associated with unintentional injury from fire and flame in the domestic location which can inform the development of further strategies to reduce the incidence and impact of such injury.

The term ‘fire and flame’ is derived from the external cause of injury codes used to identify cases for the research project. The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) is based on the World Health Organization's Ninth Revision, International Classification of Diseases (ICD-9), and is the official system of assigning codes to diagnoses and procedures associated with hospital utilisation in the United States. The ICD-9 also has a system for coding the external cause of injury. This coding system consists of 5891 five digit codes which classify external causes of injury by intent, mechanism, circumstances and place of injury. Codes 890-899 include burn injuries where the agent was “fire and flame”. Within the code, the first three digits indicate the intent and mechanism of injury, as shown in Table 1-1. Within each mechanism of injury particular circumstances are distinguished by the fourth digit. For example injury resulting from conflagration in a private dwelling is subdivided into:

- Explosion caused by conflagration in private dwelling (8900)
- Fumes from combustion of p.v.c in conflagration in private dwelling (8901)
- Other smoke and fumes from conflagration in private dwelling (8902)
- Burning caused by conflagration in private dwelling (8903)
- Other accident resulting from conflagration in private dwelling (8908) and
- Unspecified accident resulting from conflagration in private dwelling (8909).
Table 1-1 Major categories of external cause of injury in the International Classification of Diseases 9th revision (ICD-9) with external cause of injury code.

<table>
<thead>
<tr>
<th>Mechanism or intent of injury</th>
<th>Ecode</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway accidents</td>
<td>800-807</td>
</tr>
<tr>
<td>Motor vehicle traffic accidents</td>
<td>810-819</td>
</tr>
<tr>
<td>Motor vehicle nontraffic accidents</td>
<td>820-825</td>
</tr>
<tr>
<td>Other road vehicle accidents</td>
<td>826-829</td>
</tr>
<tr>
<td>Water transport accidents</td>
<td>830-838</td>
</tr>
<tr>
<td>Air and space transport accidents</td>
<td>840-845</td>
</tr>
<tr>
<td>Vehicle accidents not elsewhere classifiable</td>
<td>846-848</td>
</tr>
<tr>
<td>Accidental poisoning by drugs, medicinal substances, and biologicals</td>
<td>850-858</td>
</tr>
<tr>
<td>Accidental poisoning by other solid and liquid substances, gases, and vapors</td>
<td>860-869</td>
</tr>
<tr>
<td>Misadventures to patients during surgical and medical care</td>
<td>870-876</td>
</tr>
<tr>
<td>Surgical and medical procedures as the cause of abnormal reaction of patient or later complication, without mention of misadventure at the time of procedure</td>
<td>878-879</td>
</tr>
<tr>
<td>Accidental falls</td>
<td>880-888</td>
</tr>
<tr>
<td>Accidents caused by fire and flames</td>
<td>890-899</td>
</tr>
<tr>
<td>Accidents due to natural and environmental factors</td>
<td>900-909</td>
</tr>
<tr>
<td>Accidents caused by submersion, suffocation, and foreign bodies</td>
<td>910-915</td>
</tr>
<tr>
<td>Other accidents</td>
<td>916-928</td>
</tr>
<tr>
<td>Late effects of accidental injury</td>
<td>929</td>
</tr>
</tbody>
</table>
Drugs, medicinal and biological substances causing adverse effects in therapeutic use  

Suicide and self-inflicted injury  

Homicide and injury purposely inflicted by other persons  

Legal intervention  

Injury undetermined whether accidentally or purposely inflicted  

Injury resulting from operations of war  

The research project reported in this thesis approaches injury from fire and flame from a public health perspective. A public health perspective uses the science of epidemiology to analyse aggregate rather than individual level data and describe the incidence and patterns of disease. A public health perspective is also interested in the influences of society on health, and what interventions at a population level might modify the incidence or impact of risk factors and thereby the incidence and severity of ill health. Injury prevention and treatment is a field of research and practice that draws together different disciplines including public health, engineering, and social science, and seeks to understand personal, mechanism related and environmental factors which affect the incidence and severity of human injury.

The motivation for this work was to better understand the complexity of interacting factors associated with fire-related injury. The candidate saw the issue as an important public health topic, ripe for detailed investigation, and providing a concrete example of factors to consider in the wider public health context of addressing disparities in health status.
This introductory chapter provides an overview of the concepts of public health and injury prevention, in preparation for the focus on fire-related injury in later chapters of the thesis. The introduction places injury from fire and flame within the broad context of injury in Aotearoa New Zealand, and provides particular reference to unintentional injury in the domestic location and characteristics of a healthy domestic environment. The existing literature on fire-related injury in the home is summarised and discussed in chapter 2. The focus of the thesis is on original research to collate information from the New Zealand Fire Service (NZFS), health service and coronial court system. The research design is outlined in chapter 3, with results of quantitative analysis and review of narrative data in chapter 4. Chapter 5 discusses the implications of the descriptive study findings with further reference to original research and international literature. The concluding chapter 6 draws together the key findings and implications of the studies included in the thesis, to comment on the surveillance and strategic prevention of fire-related injury in Aotearoa New Zealand. Appendix 1 presents the findings of an evaluation of a community-based fire safety intervention programme. Appendices 2 and 3 contain summary information about interdisciplinary fire safety studies, conducted subsequent to the work included in this thesis, considering regulation of consumer products to reduce fire-related injury.

1.1. Injury prevention

Injury prevention and treatment is a branch of public health that seeks to understand personal, mechanism related and environmental factors which affect the incidence and severity of human injury. Events which result in injury are subdivided into unintentional, self-inflicted and assault, with fatal outcomes in the latter two categories defined as suicide and homicide. Unintentional injury is the leading cause of death for
New Zealanders aged 1-34 years, and is overall the fourth leading cause of death in New Zealand, resulting in over 1000 deaths per annum. After 64 years of age non-injury causes of death become more common, however unintentional injury remains an important cause of death, in eighth place (Injury Prevention Research Unit, 2000a).

Table 1-2. Total number of deaths from all causes, and percentage of deaths due to injury in New Zealand 1994-1998, with ranking of injury as a cause of death (1\textsuperscript{st} = most common), by age group in years. Data Source: New Zealand Health Information Service.

<table>
<thead>
<tr>
<th>Age</th>
<th>Deaths (n)</th>
<th>Unintentional</th>
<th>Suicide</th>
<th>Homicide</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>1914</td>
<td>5.1% (4\textsuperscript{th})</td>
<td>-</td>
<td>0.9% (9\textsuperscript{th})</td>
</tr>
<tr>
<td>1-4</td>
<td>475</td>
<td>41.4% (1\textsuperscript{st})</td>
<td>-</td>
<td>2.9% (8\textsuperscript{th})</td>
</tr>
<tr>
<td>5-9</td>
<td>261</td>
<td>42.9% (1\textsuperscript{st})</td>
<td>-</td>
<td>3.8% (5\textsuperscript{th})</td>
</tr>
<tr>
<td>10-14</td>
<td>312</td>
<td>34.6% (1\textsuperscript{st})</td>
<td>12.8% (3\textsuperscript{rd})</td>
<td>2.6% (8\textsuperscript{th})</td>
</tr>
<tr>
<td>15-24</td>
<td>2454</td>
<td>44.8% (1\textsuperscript{st})</td>
<td>29.1% (2\textsuperscript{nd})</td>
<td>2.5% (7\textsuperscript{th})</td>
</tr>
<tr>
<td>25-34</td>
<td>2861</td>
<td>31.1% (1\textsuperscript{st})</td>
<td>23% (2\textsuperscript{nd})</td>
<td>2.8% (7\textsuperscript{th})</td>
</tr>
<tr>
<td>35-44</td>
<td>3819</td>
<td>15.6% (3\textsuperscript{rd})</td>
<td>11.6% (4\textsuperscript{th})</td>
<td>&lt;3.8% (&lt;10\textsuperscript{th})</td>
</tr>
<tr>
<td>45-54</td>
<td>7500</td>
<td>6.2% (3\textsuperscript{rd})</td>
<td>4.2% (4\textsuperscript{th})</td>
<td>&lt; 2.8% (&lt;10\textsuperscript{th})</td>
</tr>
<tr>
<td>55-64</td>
<td>14122</td>
<td>2.5% (5\textsuperscript{th})</td>
<td>1.5 (8\textsuperscript{th})</td>
<td>&lt; 1.6% (&lt;10\textsuperscript{th})</td>
</tr>
<tr>
<td>65+</td>
<td>103584</td>
<td>1.6% (8\textsuperscript{th})</td>
<td>&lt;1.6% (&lt;10\textsuperscript{th})</td>
<td>&lt; 1.6% (&lt;10\textsuperscript{th})</td>
</tr>
</tbody>
</table>
The impact of injury related deaths can also be assessed on the basis of potential years of life lost (PYLL) – which calculates the years the deceased would have contributed to society if they had lived to 75 years. In 1996 it was estimated that unintentional injury resulted in the loss of 32,415 potential life years (Injury Prevention Research Unit, 2000b). Within these data almost two thirds of the potential years of life lost resulted from motor traffic injuries (20162 PYLL; 62 per cent). Drowning accounted for a further 11 per cent (3676 PYLL). Unintentional injury from fire and flame accounted for the loss of 1464 PYLL (5 per cent of the total), a proportion similar to that contributed by falls (1517 PYLL; 5 per cent), suffocation (1325 PYLL; 4 per cent) and other transport injuries (1457 PYLL; 4 per cent). All other causes of injury combined accounted for the remaining nine per cent of unintentional injury related deaths.

Injuries are ubiquitous, affecting all human beings from a young age, and continuing to occur throughout the life course (Kraus, 1997). Despite their frequent occurrence, and significant contribution to death and disability, injuries were regarded for many years as the result of “accidents” which were in turn regarded as bad luck, or “acts of God”. The first formal safety organisation in the U.S. was not formed until 1913 (Peek-Asa, Dean & Kraus, 2002). Systematic study of injuries, with a view to identifying modifiable risk factors, has developed since the mid twentieth century. An early research project in the injury prevention literature used a classic epidemiological case-control approach to demonstrate that wearing of helmets reduced the incidence of head injuries among military motorcycle riders (Cairns & Holburn, 1943). Application of engineering skills to the epidemiological analysis of injury data led to significant advances, beginning with the contribution of DeHaven in 1941 (Peek-Asa, Dean & Kraus, 2002). Effectively enforced legislation can also contribute to reducing injury rates. Successful examples include traffic speed restrictions, graduated driver licensing systems, compulsory vehicle
safety checks, mandatory wearing of cycle helmets, regulation of children’s nightwear to reduce fire risk, and restrictions on firearm ownership and use.

Peek-Asa, Dean, & Kraus (2002) have identified the following key components in the development of policy, strategies and actions to prevent injury that are based on reliable evidence:

- A comprehensive surveillance system which includes ongoing monitoring of events, data analysis and interpretation to provide a systematic backbone for preventive strategy;
- Identification of risk factors for fatal and non-fatal injury in incidents; and
- The design, implementation and evaluation of intervention strategies.

The classic injury prevention strategies involve the following countermeasures originally proposed by Haddon to reduce the incidence and impact of injury (Kraus et al, 1997; Robertson, 1997).

- Prevent creation of the agent
- Reduce the amount of the agent
- Prevent release of the agent
- Modify the rate or spatial distribution of the agent
- Separate, in time or space, the agent and the susceptible host
- Separate the hazard and the susceptible host by interposition of a material barrier
- Modify relevant basic qualities of the agent
- Strengthen the susceptible host to improve resistance to damage from the agent
• Begin to counter the injury already done by the agent

• Stabilise, repair and rehabilitate the injured host

The Haddon matrix is a classic injury prevention model. Haddon proposed developing pre-event, event and post-event countermeasures for each injury scenario, related to the susceptible host, the vector or vehicle of injury, and the physical and social environments. In Table 1-3 the issue of motor vehicle crashes is used to illustrate the 12 cells of the matrix. The concepts of pre-event, event and post event interventions relate directly to primary, secondary and tertiary prevention of injury (Laraque, Barlow, & Durkin, 1999).

In primary prevention, eliminating the hazard is key. Secondary prevention attempts to modify the consequences of potentially injury-producing events, prevent the injury or reduce its severity.

Laraque, Barlow & Durkin (1999) page 557

Modification of Haddon’s matrix has been suggested to take account of the multiple influences on the prioritisation of the development and implementation of potential injury prevention strategies (Runyan, 1998). Such influences include cost-effectiveness, relative impact and competing intervention opportunities.
Table 1-3. Haddon matrix with potential interventions to reduce incidence and impact of motor vehicle crashes. Adapted from Peek-Asa, Dean & Kraus, 2002, p 1543.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Host</th>
<th>Vehicle</th>
<th>Physical environment</th>
<th>Social environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preinjury</td>
<td>Reduce alcohol use</td>
<td>Increase vehicle stability and visibility</td>
<td>Safe road structure</td>
<td>Consumer awareness of safety issues</td>
</tr>
<tr>
<td></td>
<td>Defensive driving training</td>
<td>Safe road structure and calming measures</td>
<td>Traffic controls</td>
<td>Community support for safety programmes</td>
</tr>
<tr>
<td>Injury</td>
<td>Use of seat belts</td>
<td>Vehicle frame designed to absorb energy</td>
<td>Energy-absorbing guard rails</td>
<td>Child restraint rental schemes</td>
</tr>
<tr>
<td></td>
<td>Use of correctly fitted child restraints</td>
<td>Air bags, shatterproof windshields, collapsible steering column</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postinjury</td>
<td>Stabilise serious injuries</td>
<td>Design for easy extraction</td>
<td>Well equipped emergency services</td>
<td>Emergency phone system (111)</td>
</tr>
<tr>
<td></td>
<td>Reduce bleeding</td>
<td></td>
<td></td>
<td>Provision of emergency and trauma care</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rehabilitation services</td>
</tr>
</tbody>
</table>
1.2. Injury in the home

Mood (1993) identifies four features of a healthy residential environment:

- Protection from physiological extremes (warm and dry)
- Protection from infectious disease (adequate space, clean food and water provision)
- Protection from physical injury (well-lit, fire-resistant materials, guards on stairs, etc) and
- Promoting mental and emotional well-being (adequate space for all occupants, adequate resources to meet daily needs)

Protection of occupants from fire-related injury, including death, is part of the third feature of healthy housing. Using the criteria proposed by Mood (1993) the issue of fire safety can be considered as one component of improving the health of households. Houses at increased risk of injury may also pose dangers to health in terms of damp, mould, lack of adequate sanitation, crowding and lack of aesthetics. Intersectoral action to improve housing standards and quality is likely to be necessary to impact significantly on the health of the occupants.

The Accident Compensation Corporation notes that 161 New Zealanders died as a result of unintentional injury at home in 2000 and go on to say:

*Home is a place we retreat to. It is a place of comfort, a place where we relax, a place where we feel safe. Where, every two days, somebody dies – needlessly, unnecessarily – from an accident. And home goes beyond the house and the backyard. It is our parks and playgrounds, our schools, our friend’s house next door. Places where we should be safe. And where we, quite clearly, aren’t.*

In order to examine the relative importance of fire-related injury in the home environment, data were obtained from the New Zealand Health Information Service concerning unintentional injury at home. The data provided consisted of all deaths with an external cause of injury code fifth digit indicating that the injury occurred at home, and all hospital inpatient first admissions with a primary diagnosis of injury and an external cause of injury code fifth digit indicating that the injury occurred at home. The data were likely to underestimate the number of deaths and hospital inpatient treatment events, because injuries with an unspecified location were excluded, as were intentional injuries (suicide and homicide), and injuries where the cause was undetermined. Data were examined by age group to determine the relative importance of injury from fire and flame, in relation to other causes of injury.

### 1.2.1. Fatal injury

Within the home environment fire-related injury is the leading cause of unintentional death from injury for New Zealanders aged 15-64 years (see Table 1-4). Among children aged less than 15 years injury from fire and flame is second to injury by suffocation as a cause of unintentional fatal injury at home. Although significantly outweighed by falls as a cause of fatal injury among adults aged over 64 years, injury from fire and flame remained the second leading cause of fatal injury in the domestic environment in this age group.

### 1.2.2. Hospital inpatient treatment

Compared with other causes of injury (such as falls, cutting or piercing, and poisoning) fire-related injury is a less significant cause of hospital inpatient admission for injury, accounting for around one per cent of such admissions coded to the International
Classification of Disease 9th edition (ICD-9) domestic location (see Table 1-5). The majority of hospitalisations for non-fatal thermal injury are the result of scalds (contact with hot objects and substances) rather than injury from fire and flame.

Table 1-4. Number and percentage of deaths as a result of unintentional injury at home, by age group and cause of injury, Aotearoa New Zealand 1996-1998. Data source: New Zealand Health Information Service.

<table>
<thead>
<tr>
<th>Age group</th>
<th>0-14 years</th>
<th>15-64 years</th>
<th>65+ years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>2 (3)</td>
<td>17 (19)</td>
<td>137 (77)</td>
<td>156 (45)</td>
</tr>
<tr>
<td>Suffocation</td>
<td>33 (42)</td>
<td>11 (13)</td>
<td>8 (5)</td>
<td>52 (15)</td>
</tr>
<tr>
<td>Fire and flame</td>
<td>20 (26)</td>
<td>19 (22)</td>
<td>10 (6)</td>
<td>49 (14)</td>
</tr>
<tr>
<td>Accidental Poisoning</td>
<td>2 (3)</td>
<td>20 (23)</td>
<td>2 (1)</td>
<td>24 (7)</td>
</tr>
<tr>
<td>Drowning</td>
<td>13 (17)</td>
<td>2 (2)</td>
<td>1 (1)</td>
<td>16 (5)</td>
</tr>
<tr>
<td>Motor Vehicle (not crashes)</td>
<td>4 (5)</td>
<td>2 (2)</td>
<td>2 (2)</td>
<td>8 (2)</td>
</tr>
<tr>
<td>Cutting or piercing</td>
<td>-</td>
<td>4 (5)</td>
<td>3 (1)</td>
<td>7 (2)</td>
</tr>
<tr>
<td>Natural or Environmental</td>
<td>-</td>
<td>2 (2)</td>
<td>5 (3)</td>
<td>7 (2)</td>
</tr>
<tr>
<td>Struck by or against</td>
<td>-</td>
<td>2 (2)</td>
<td>3 (2)</td>
<td>5 (1)</td>
</tr>
<tr>
<td>Hot object or substance</td>
<td>-</td>
<td>-</td>
<td>3 (2)</td>
<td>3 (1)</td>
</tr>
<tr>
<td>Machinery</td>
<td>-</td>
<td>1 (1)</td>
<td>-</td>
<td>1 (&lt;1)</td>
</tr>
<tr>
<td>Overexertion</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other injury at home</td>
<td>4 (5)</td>
<td>8 (9)</td>
<td>3 (2)</td>
<td>15 (4)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>78 (100)</td>
<td>88 (100)</td>
<td>177 (100)</td>
<td>343 (100)</td>
</tr>
</tbody>
</table>
Table 1-5. Number and percentage of cases receiving inpatient hospital treatment as a result of unintentional injury at home, by age group and cause of injury, Aotearoa New Zealand 1996-1998. Data source: New Zealand Health Information Service.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Cause of injury</th>
<th>0-14 years</th>
<th>15-64 years</th>
<th>65+ years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
<td>n (%)</td>
</tr>
<tr>
<td>Falls</td>
<td></td>
<td>3768 (41)</td>
<td>3044 (38)</td>
<td>9568 (83)</td>
<td>16380 (57)</td>
</tr>
<tr>
<td>Cutting or piercing</td>
<td></td>
<td>903 (10)</td>
<td>1768 (22)</td>
<td>282 (2)</td>
<td>2953 (10)</td>
</tr>
<tr>
<td>Accidental poisoning</td>
<td></td>
<td>1204 (13)</td>
<td>740 (9)</td>
<td>177 (2)</td>
<td>2121 (7)</td>
</tr>
<tr>
<td>Struck by or against</td>
<td></td>
<td>614 (7)</td>
<td>385 (5)</td>
<td>295 (3)</td>
<td>1294 (5)</td>
</tr>
<tr>
<td>Hot object or substance</td>
<td></td>
<td>871 (10)</td>
<td>269 (3)</td>
<td>78 (1)</td>
<td>1218 (4)</td>
</tr>
<tr>
<td>Overexertion</td>
<td></td>
<td>33 (&lt;1)</td>
<td>422 (5)</td>
<td>519 (5)</td>
<td>974 (3)</td>
</tr>
<tr>
<td>Motor Vehicle (not crash)</td>
<td></td>
<td>437 (5)</td>
<td>142 (2)</td>
<td>58 (1)</td>
<td>637 (2)</td>
</tr>
<tr>
<td>Natural or environmental</td>
<td></td>
<td>204 (2)</td>
<td>206 (3)</td>
<td>98 (1)</td>
<td>508 (2)</td>
</tr>
<tr>
<td>Fire and flame</td>
<td></td>
<td>134 (1)</td>
<td>226 (3)</td>
<td>46 (&lt;1)</td>
<td>406 (1)</td>
</tr>
<tr>
<td>Machinery</td>
<td></td>
<td>25 (&lt;1)</td>
<td>143 (2)</td>
<td>64 (1)</td>
<td>232 (1)</td>
</tr>
<tr>
<td>Suffocation</td>
<td></td>
<td>128 (1)</td>
<td>54 (1)</td>
<td>36 (&lt;1)</td>
<td>218 (1)</td>
</tr>
<tr>
<td>Drowning</td>
<td></td>
<td>66 (1)</td>
<td>3 (&lt;1)</td>
<td>1 (&lt;1)</td>
<td>70 (&lt;1)</td>
</tr>
<tr>
<td>Other injury at home</td>
<td></td>
<td>712 (8)</td>
<td>568 (7)</td>
<td>256 (2)</td>
<td>1536 (5)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>9099 (100)</td>
<td>7970 (100)</td>
<td>11478 (100)</td>
<td>28547 (100)</td>
</tr>
</tbody>
</table>
1.2.3. Fatalities relative to injury resulting in hospitalisation

The proportion of people experiencing a specified cause of injury who die from that injury is a further measure of the impact of a given cause of injury on a population. Hospitalisation data are used to indicate the prevalence of non-fatal injury in the community. The case-fatality rate is calculated from the number of deaths divided by the total number of deaths and hospitalisations. As seen in Table 1-6, approximately one per cent of people who are injured unintentionally in the home environment die from those injuries. Unintentional injury from fire and flame is more serious in impact, in that over 10 per cent of people experiencing such injury at home die as a result. Unintentional suffocation and drowning injuries at home show even higher case fatality ratios with almost 20 deaths for every 100 serious injuries.

Using the data in Table 1-6, the case-fatality ratios in different age groups were compared. Overall seniors aged over 65 years are more likely than younger adults aged 15-64 years to die after sustaining unintentional injuries at home (rate ratio 1.39; 95% CI 1.08-1.79). This pattern is particularly evident for unintentional injury from fire and flame in the home environment, where it is observed that adults aged over 64 years have a death rate per 100 injuries twice that of younger adults aged 15-64 years (rate ratio 2.3; 95% CI 1.1-4.7).

The data further suggest, but do not demonstrate with statistical certainty, that an overall tendency for children to be more resilient than adults aged 15-64 years after sustaining unintentional injuries at home (relative risk 0.8; 95% CI 0.6-1.1) is reversed in the case of injury from fire and flame (relative risk 1.7; 95% CI 0.9-3.0).
Table 1-6. Fatalities per 100 cases receiving inpatient hospital treatment for unintentional injury at home, by age group and cause of injury, Aotearoa New Zealand 1996-1998. Data source: New Zealand Health Information Service.

<table>
<thead>
<tr>
<th>Age group</th>
<th>0-14 years</th>
<th>15-64 years</th>
<th>Over 64 years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause of injury</strong></td>
<td><strong>Ratio (95% CI)</strong></td>
<td><strong>Ratio (95% CI)</strong></td>
<td><strong>Ratio (95% CI)</strong></td>
<td><strong>Ratio (95% CI)</strong></td>
</tr>
<tr>
<td>Suffocation</td>
<td>20.5 (14.3-26.7)</td>
<td>16.9 (7.8-26.0)</td>
<td>18.2 (6.8-29.6)</td>
<td>19.3 (14.6-24.0)</td>
</tr>
<tr>
<td>Drowning</td>
<td>16.5 (8.3-24.6)</td>
<td>40 (-2.9-82.9)</td>
<td>50 (-19.3-119.3)</td>
<td>18.6 (10.4-26.8)</td>
</tr>
<tr>
<td>Fire and Flames</td>
<td>13.0 (7.7-18.3)</td>
<td>7.8 (4.4-11.1)</td>
<td>17.9 (7.8-27.9)</td>
<td>10.8 (7.9-13.6)</td>
</tr>
<tr>
<td>Natural/Environmental</td>
<td>0</td>
<td>1 (-0.4-2.3)</td>
<td>4.9 (0.7-9.0)</td>
<td>1.4 (0.4-2.4)</td>
</tr>
<tr>
<td>Motor vehicle (not crash)</td>
<td>0.9 (0.0-1.8)</td>
<td>1.4 (-0.5-3.3)</td>
<td>3.3 (-1.2-7.9)</td>
<td>1.2 (0.4-2.1)</td>
</tr>
<tr>
<td>Accidental poisoning</td>
<td>0.2 (-0.1-0.4)</td>
<td>2.6 (1.5-3.8)</td>
<td>1.1 (-0.4-2.7)</td>
<td>1.1 (0.7-1.6)</td>
</tr>
<tr>
<td>Falls</td>
<td>0.1 (0.0-0.1)</td>
<td>0.6 (0.3-0.8)</td>
<td>1.4 (1.2-1.6)</td>
<td>0.9 (0.8-1.1)</td>
</tr>
<tr>
<td>Machinery</td>
<td>0</td>
<td>0.7 (-0.7-2.1)</td>
<td>0.4 (-0.4-1.3)</td>
<td>0.4 (0.0-0.7)</td>
</tr>
<tr>
<td>Struck By/Against</td>
<td>0</td>
<td>0.5 (-0.2-1.2)</td>
<td>1 (-0.1-2.1)</td>
<td>0.4 (0.0-0.7)</td>
</tr>
<tr>
<td>Hot Object/Substance</td>
<td>0</td>
<td>0</td>
<td>3.7 (-0.4-7.8)</td>
<td>0.2 (0.0-0.5)</td>
</tr>
<tr>
<td>Cut/Pierce</td>
<td>0</td>
<td>0.2 (0.0-0.4)</td>
<td>(1.1 (-0.1-2.2)</td>
<td>0.2 (0.1-0.4)</td>
</tr>
<tr>
<td>Overexertion</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0.6 (0.0-1.1)</td>
<td>1.4 (0.4-2.3)</td>
<td>1.2 (-0.1-2.5)</td>
<td>1.0 (0.5-1.5)</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td><strong>0.8 (0.7-1.0)</strong></td>
<td><strong>1.1 (0.9-1.3)</strong></td>
<td><strong>1.5 (1.3-1.7)</strong></td>
<td><strong>1.2 (1.1-1.3)</strong></td>
</tr>
</tbody>
</table>

NB 0 = no deaths from this cause of injury in the age group
2. Injury from fire and flame – review of literature

Injury from fire and flame is a significant cause of death and disability internationally, particularly among children and young people. International data for 1998 show injury from fire was one of the 15 leading causes of death for children aged 5-14 years in both high-income and low- and middle-income countries, and for younger children in high-income countries (infectious diseases were responsible for over two-thirds of the deaths among younger children in low- and middle-income countries) (Krug, Sharma, & Lozano, 2000). More recent international data show fire-related injury as a leading cause of death in the 5-14 and 15-29 year age groups, and a leading contributor to the burden of disease for children aged 5-14 years (Peden, McGee, & Krug, 2002). Most of the deaths and disability adjusted years of life lost in the tables collated by Peden, McGee & Krug (2002) were in low- and middle-income countries. It is estimated that, world-wide, 100,000 children die in fires every year (Roberts & DiGuiseppi, 1999). In Europe, from 1984 to 1993, 3602 children aged under 15 years died as a result of injury from fire and flame, which was the third most common cause of injury death and accounted for 6% of all such deaths (Morrison, Stone, & EURORISC Working Group, 1999). In New Zealand, injury from fire and flame has been identified as an injury prevention priority for Māori children aged 1-14 years (Feyer & Langley, 2000). Fire risk reduction has been identified as critical in protecting children with disability from unintentional injury (Gaebler-Spira & Thornton, 2002).

In order to understand what is already known about unintentional injury from fire and flame in domestic locations the published literature was searched to identify relevant papers. The search was undertaken electronically in the US National Library of
Medicine bibliographic database covering the fields of medicine, nursing, dentistry, veterinary medicine, the health care system, and the preclinical sciences (Medline), the cumulative index to nursing and allied health literature database (CINAHL), and the Evidence Based Medicine databases (EBM). Search terms were (house or residen$) and fire and (injury or fatal or death) and (epidemiology or prevention). A search of the New South Wales Fire Brigades library collection identified publications from the Fire Engineering literature on human behaviour in fire, a discipline which has become more developed following three international symposia since 1999. Further reports and papers were identified from the reference list in identified articles, and from internet searches, governmental web pages and personal communication with people who knew of the candidate’s research interest.

Section 2.1 of this chapter discusses descriptive epidemiological studies of fatal and non-fatal fire-related injury. Those studies referring to specific age groups are further discussed in chapter 5. In section 2.2 analytical studies are reviewed to identify risk factors for unintentional fire-related injury. Two New Zealand studies, which describe ways in which population groups are exposed to identified risk factors, are discussed in section 2.3. Review papers, and intervention studies are covered in section 2.4. In section 2.5, the focus broadens from the characteristics of the fire and the injured parties to the social and political circumstances in which fire incidents occur. Publications from the ‘human behaviour and fire’ literature within the discipline of Fire Engineering are reviewed in section 2.6. The final section highlights issues related to social and cultural disparities in fire-related injury rates with implications for policy development.
2.1. Descriptive studies

2.1.1. Fatal injury

Studies of thermal injury in New Zealand found that although scalds were the most common cause of thermal injury overall, injury from fire and flame was the most common cause of fatal thermal injury (Waller & Marshall, 1993; Waller, Marshall, & Langley, 1998). Similar observations have been made in the Netherlands (den Hertog, Blankendaal, & ten Hag, 2000), Denmark (Lyngdorf, Sorensen, & Thomsen, 1986) and Australia (Penny, 1992). Most fire-related fatalities are unintentional, and occur in the home (Baker, O'Neill, Ginsburg, & Li, 1992; Cropp, 1997; Goddard, 1997; Goddard & Poole, 1996; Istre, McCoy, Osborn, Barnard, & Bolton, 2001; Marshall et al., 1998; Penny, 1992). Collectively these studies identify characteristics of fire-related fatalities. Some characteristics relate to features of the fire itself and may help to identify appropriate preventive strategies. Others point to population groups with increased risk of fire-related injury and indicate social or economic barriers to fire safety which must be overcome through appropriate interventions.

For both males and females the highest house fire mortality rates are observed among young children and the elderly (Baker et al., 1992). Male rates exceed female rates, particularly among young children. However the male: female ratio for house-fire deaths is less than that for many other causes of injury (Baker et al., 1992).

Ethnic disparities in fire-related death rates have also been observed. In Alabama McGwinn, Chapman, Rousculp, Robison, & Fine (2000) found that fatality rates were more than three times higher for blacks than for whites, and the disparity was even greater for older adults. Other US studies have also shown increased fire fatality rates

There is a strong relationship between socio-economic deprivation and the risk of fatal or non-fatal injury in residential fires. In Oklahoma City, a central city area with four times the city-wide risk of fire-related injury was characterised by lower median income, lower property values, and poorer quality of housing than the rest of the city (Mallonee et al., 1996). Ballard et al (1992) observed that the annual median household income in households experiencing injury from fire and flame was over $10,000 lower than the median estimate of household income in the same county. Fourteen per cent of the households in King County who experienced a residential fire resulting in injury were excluded from participating in the research conducted by Ballard et al (1992) because they did not have a telephone. Although no data on telephone ownership was provided, it is probable that such ownership was much higher in the general population than among households who experienced fires with health consequences. In Dallas, Texas from 1991-1997 Istre et al. (2001) found “a strong inverse relation between the median income in a census tract and the rate of injury” (page 1913). Tracts with extremely low median incomes had rates of injury 20 times higher than tracts with high median incomes. The injury rate per 100,000 population, the rate of house fires per 1000 houses, and the rate of injuries per 100 fires were all higher in census tracts with a median income below $20,000 per year.

Poor children are particularly vulnerable to injury (Rivara, 1999). In the United Kingdom the death rate from injury from fire and flame for children in social class V is
over 16 times the rate of children in social class I (Roberts, 1997). Roberts states that the explanation that is best supported by research evidence for the socio-economic gradient in childhood injury mortality is the differential exposure of disadvantaged children to health-damaging physical and social environments. “For fire deaths this entails exposure of children to temporary accommodation and substandard housing (p. 335).” Social stress also plays a role in injury rates as parents who lack basic resources to meet the demands of day-to-day life may be less able to provide continuous and vigilant oversight of their children (Townsend, Davidson, & Whitehead, 1992).

Approximately 25 per cent of residential fires in Alabama between 1992 and 1997 occurred in mobile homes, and the mobile home fatality rate was more than twice the rate for other residential structures (McGwin et al., 2000). Runyan, Bangdiwala, Linzer, Sacks, & Butts (1992) also noted increased risk of fire-related death for occupants of mobile homes, with such homes particularly hazardous for children aged under 5 years and persons living with disability.

Overall, McGwin (2000) found that smoke alarms were present in 32.5% of fatal residential fires, although in approximately two-thirds of these situations the alarm was not properly installed. Smoke alarms were more common in urban areas (41.8%) compared with rural areas (20.8%), and in rural areas smoke alarms were more commonly present in incidents involving whites (sic) (32.5%) compared with blacks (sic) (2.4 per cent).

Studies in the UK and USA have reported that common heat sources for fatal fires include discarded cigarettes, heaters, cooking appliances, and electric appliances including electric blankets (Baker et al., 1992; DiGuiseppi, Edwards, Godward, Roberts, & Wade, 2000). Similar heat sources were observed in a New Zealand case series
These studies also reported that items commonly ignited in fatal residential fire incidents include bedding, upholstered furniture, and highly flammable substances such as petrol or solvents. Although ignition of structural components (12.9%) and cooking materials (10.6%) account for a significant proportion of fatal fires; they account for an even greater proportion of all fires (Cropp, 1997).

2.1.2. Non-fatal injury

Non-fatal thermal injury is more likely to result from contact with hot objects or substances than from fire and flame. There have been fewer studies describing non-fatal injury from fire and flame, than those describing fatal injury.

Rapkin (1983) cites a 1974 National Household Fire Survey in the USA, covering 33,000 households, which showed that approximately one-half of all fire injuries or fire losses of more than $200 were not reported to the Fire Service.

Ballard et al (1992) included non-fatal injury in their descriptive account of unintentional residential fire injuries in King County. The non-fatal injury rate was highest in the 20-44 age group. Only 19 per cent of the 128 persons with non-fatal injury were hospitalised with 26 per cent treated at the scene and 55 per cent treated as outpatients. The latter two groups experienced less severe injury that would not have been identified by usual data sources such as death records or hospitalisation data.

The annual British crime survey (BCS) includes questions about fires in the home. Analysis of the 2000 survey by Aust (2001) indicated that three per cent of British households experienced at least one fire in 1999, with 11 per cent of these households reporting two or more fires. Eleven per cent of fires reported in the BCS resulted in personal injury, including four per cent resulting in injury requiring medical attention.
and three per cent resulting in injury requiring hospital treatment. Fires started by electrical equipment or wiring (including electric blankets), cigarettes, or cooking were most likely to result in personal injury.

It is possible to identify people seeking emergency department or hospital treatment for injury from fire and flame, using the records kept by those institutions. A population based study in inner London, UK, identified 131 people with intentional and unintentional fire-related injuries from 1 June 1996 to 31 May 1997. Two of these people died at the scene, 129 were seen in the emergency department, and 41 were admitted to hospital. One of those admitted to hospital later died, and four were transferred to specialised burn centres. Use of hospital discharge records alone identified only 23 (56%) of those admitted to hospital. Two of the three deaths were identified from the coroner’s log. Rates of injury were highest among those aged over 85 years and under 5 years, with no gender differences. Children aged under 15 years and adults aged over 64 years were more likely to be hospitalised than injured adults aged 25-64 years. The most common heat sources were cooking, cigarettes or lighters, electric blankets or other electric appliances, and arson (DiGuiseppi et al., 2000).

Review of New Zealand hospital discharge data from 1988-1995, for injuries from fire and flame in the domestic location, found the highest rates of admission for inpatient treatment among adults aged over 75 years, and children aged under 15 years. Māori rates exceeded nonMāori in all age groups, with an overall threefold excess (RR 3.3; 95% CI 1.7-2.1) (Duncanson, Woodward et al., 2000).

Keane, Brennan, & Pickett, (2000) and Keane, Jepson, Pickett, Robinson, & McCorkle, (1996) investigated experiences of survivors of residential fires, and found that distress persisted for at least six months following the fire incident. Qualitative analysis of
transcripts from survivors identified needs for tangible specific social assistance, for psychological or spiritual assistance, and for other types of non-specific assistance. Parents also requested psychological assistance for their children following a household fire.

2.2. Risk factors for fire-related injury

Risk factors for fire-related injury have been identified chiefly in case-control studies of affected cases and non-affected controls. The landmark analytical study in relation to death as a result of injury from fire and flame in a domestic location compared 151 fatal fires in North Carolina in 13 months from 1 January, 1988 to 31 January 1989, with 283 non-fatal fires randomly selected from fire department records over the same time period (Runyan et al., 1992). The strongest independent risk factor for fatal fires was the presence of a person impaired by drugs or alcohol in the dwelling (OR 7.5; 95% CI 4.5-12.2). Fatal fires were more likely than non-fatal fires to occur late at night or early in the morning, that is between 10 p.m. and 5.59 a.m. (OR 4.1; 95% CI 2.7-6.2), and to occur over a weekend, that is between 6 p.m. Friday and 5.59 a.m. Monday (OR 1.8; 95% CI 1.2-2.7). Dwelling factors associated with an increased risk of fatal fire incidents were lack of a smoke alarm (OR 3.4; 95% CI 2.1-5.6); mobile compared with permanent homes (OR 1.7; 95% CI 1.1-2.6); houses with fewer than two exits (OR 2.1; 95% CI 1.3-3.4); houses more than 20 years old (OR 2.0; 95% CI 1.3-3.1); houses without a telephone (OR 3.2; 95% CI 2.0-5.3); and rented houses (OR 2.0; 95% CI 1.3-3.1). Presence of people with specific characteristics was associated with varying risk of fatalities occurring. Fatalities were more likely to occur in households where there was a person at home alone (OR 2.2; 95% CI 1.5-3.3); persons aged under 5 years (OR 1.7; 95% CI 1.0-2.9); persons aged over 64 years (OR 2.4; 95% CI 1.5-4.4); or a person
living with disability (OR 2.5; 95% CI 1.5-4.4). Stratified analysis showed that a smoke alarm was more than five times as likely to be absent in fatal fires where there were no occupants impaired by alcohol or drugs than in similar non-fatal fires, and that an alarm was seven times more likely to be absent in fatal fires where there were no occupants living with disability. The absence of a smoke detector was associated more strongly with fatal outcome in households with children, compared with adult only households.

In a different application of case-control methods, Marshall et al. (1998) compared those who died in “multiple persons home” (MPH) fires with those who survived. The study design, by definition, excluded incidents where the deceased was at home alone. Of the 254 individuals in dwellings when a fire started 112 (44%) died, 60 (42%) sustained a non-fatal injury, and 82 (32%) sustained no injury. Those more likely to die were aged under 5 years or over 63 years, lived with a physical or cognitive disability, or were impaired by alcohol or drugs. For this high vulnerability group, the presence of an adult with no physical or cognitive disability, who was not impaired by drugs or alcohol, reduced the risk of death (adjusted OR 0.49; 95% CI 0.24-0.99). Overall the presence of a functioning smoke alarm lowered the risk of death by around 60 per cent (adjusted OR 0.39; 95% CI 0.18-0.83) with no statistical difference between low- and high-vulnerability groups.

Smoking is an identified risk factor for fatal residential fire-related injury, with households where 10-19 cigarettes were smoked per day having an eight-fold increase in likelihood of a fire resulting in personal injury (OR 8.3; 95% CI 3.7-18.7) (Ballard, Koepsell, & Rivara, 1992). Ignition by smoking materials was five times as common in fatal fires in the USA than in non-fatal fires (Runyan et al., 1992). Up to 39 per cent of people who die in cigarette initiated fires in the USA are not the smokers of the
cigarette, and may even live in a different household occupying an adjoining apartment (Mierley & Baker, 1983).

### 2.3. Exposure to activities associated with risk of fire-related injury

Harre (1998) conducted a survey with 421 school children aged 7-13 years in Auckland, New Zealand, and found that even at a young age children engaged in household tasks that carried a burn or scald risk. Involvement in risky activities increased with age, and differed by ethnicity, with Māori and Pacific children reporting higher risk involvement. There were no gender differences in the number of risky activities engaged in by children in the study sample. Thomas, Rayner, & Moroney (2000) conducted a face-to-face survey among Māori in the Bay-Waikato fire region and found that the sample differed from an earlier mainstream telephone sample on several fire safety parameters. In comparison with the mainstream sample, households including Māori were less likely to keep lighters and matches out of reach of children, to be aware of kitchen fire hazards, to have smoke alarms installed, or to have an escape plan in case of fire. Households including Māori were more likely to use candles, gas, or spirit lanterns for lighting (in rural areas this was often stated to be only when they had power cuts which reportedly occurred frequently). Over one-quarter (27%) of the households interviewed by Thomas, Rayner & Moroney (2000) reported ever having a cooking fire. When shown pictures of two potentially hazardous conditions (children unaccompanied by adults in a kitchen, and a child reading in bed using a candle) a high proportion of respondents said the scenarios were common in their homes.
2.4. Interventions to reduce fire-related injury

One of the key findings from the case-control study reported by Runyan et al. (1992) was the significance of absence of a smoke alarm as a risk factor for fire-related death. Distribution of smoke detectors in the population is uneven, with those at most risk least likely to have an early warning system (Roberts, 1996). Mallonee et al. (1996) report an intervention study in which smoke detectors were distributed door to door in a target area within Oklahoma City identified as having a high rate of injuries from residential fires. The annualised injury rate fell from 15.3 per 100,000 population to 3.1 per 100,000 population during the four years after the intervention. Surveys of samples of homes which received smoke detectors at three and twelve months revealed that alarms were properly installed in over 50 per cent of the homes; at 48 months 45 per cent of the alarms were still functioning. The distribution of detectors was accompanied by a publicity campaign and education about fire prevention which may have contributed to the reduction in injury rates. A later economic evaluation estimated total discounted net savings to society of over US$15 million, and total discounted net savings to the health system of almost US$1 million (Haddix, Mallonee, Waxweiler, & Douglas, 2001).

Door to door distribution has subsequently been shown to be the most cost effective method of smoke detector distribution (Douglas, Mallonee, & Istre, 1998).

Distribution of domestic smoke alarms has been a mainstay of fire prevention activities, based principally on the findings of uncontrolled studies. Systematic review of interventions to increase smoke alarm use has identified that potential sources of error in the results of such studies include uncontrolled confounding and regression to the mean (DiGuiseppi & Higgins, 2000). A randomised controlled trial of smoke alarm distribution in two inner London communities showed no benefit from the intervention.
(DiGuiseppi et al., 2002). This result was surprising given the earlier studies showing absence of a smoke alarm to be a risk factor for fatalities, and presence of a smoke alarm a protective factor. Review of the study design has shown that although alarms were distributed to householders, they were not installed as a part of the programme.

Interest in a fire-safe cigarette goes back to the 1920s, and production of cigarettes with reduced potential for ignition has been shown to be possible (Botkin, 1988). Cigarette manufacturers have resisted attempts to improve the safety of cigarettes for many years (Barillo, Brigham, Kayden, Heck, & McManus, 2000). Reducing ignition potential of abandoned cigarettes is likely to be a cost effective fire safety strategy. A US study estimated the unit cost to be $US0.0001 per pack of cigarettes, and the total benefits per pack to be $US0.05 – a benefit-cost ratio of 505, the highest benefit-cost ratio of 84 injury prevention measures reviewed by Miller & Levy (2000). A key advantage of regulating cigarettes is their short life span since they are manufactured to be consumed and replaced constantly (Halbert, 1999). Thus any impact of reducing ignition potential would be reflected in fire incidence within a relatively short time frame. Legislation in New York State required all cigarettes to meet a fire safety standard from 2003, and has set a precedent for other jurisdictions.

2.5. Social and political factors

*Students of urban affairs have long felt that fire was an ecological phenomenon associated with the characteristics of structures or their occupants. In evaluating the social costs of slums it has been asserted that dilapidated dwellings had a higher incidence of fire loss expressed in death, injury and property destruction and that the public cost of the eradication of slums would be offset by reduced expenditure for fire prevention and control.*

(Rapkin, 1983)
Rapkin (1983) edited a series of papers detailing the social and economic consequences of fires. The papers range from first-hand accounts and informed expert comment to analytical experimental studies. This combination of perspectives ensures emergence of both qualitative and quantitative findings, with a personal dimension captured by the anecdotal accounts.

Munson & Oates (1983) conducted cross-sectional surveys in Charlotte, Carolina, in New Jersey and in 54 large US cities to determine any association between likelihood of fire and structural, climatic and socioeconomic factors. They found an inverse relationship between likelihood of fire and income, with an increase in median family income of $1,000 associated with approximately 10 per cent decrease in fire incidence rate. They also found fire incidence was lower in communities where a relatively high proportion of housing units were owner occupied, and higher in communities with relatively high unemployment rates and in communities with larger black populations. Housing condition was determined using the variables ‘percentage of dwelling units lacking some or all plumbing’ and ‘percentage of units built before 1940’: both were associated with increased fire incidence. More densely populated cities had more fires per capita than those less densely populated, and census tracts in Charlotte with higher degrees of crowding within dwelling units were associated with higher rates of residential fires. The authors concluded: “Fire is clearly not a purely random phenomenon: the physical structure of a city and the characteristics of its population will have much to do with its fire experience” (p.72).

Wallace & Wallace (1999) have made an important contribution in considering the broader social context of domestic fire incidents. “Benign neglect” and “planned shrinkage” slum clearing policies in New York city, instituted during the Nixon presidency, are linked by Wallace and Wallace to an epidemic of structure fires, urban
decay and ultimately to epidemics of infectious disease. Using analysis of documents obtained under official information legislation, and other data sources, Wallace and Wallace (1999) illustrate the important point that social and economic policy has profound and far reaching effects on human health. A combination of policy and operational decisions contributed to the increase in fire damage in poor areas of New York.

A key strength of Wallace & Wallace (1999) is the linking of well being with the social capital that people derive from living in a particular community, and the harm that ensues when policy decisions destroy the physical infrastructure, and then the relational networks, of those communities.

The buffer, the poor person’s equivalent of savings in the back for a rainy day, is the community network. Thus, social capital compensates for lack of purely economic capital.

Wallace & Wallace (1999) page 58

2.6. Human behaviour in fire

The fire engineering literature has a sub-section ‘Human Behaviour and Fire’ which seeks to understand how human behaviour and environment interact to result in casualties, and test design and engineering interventions which could mitigate the effects of fire. O’Connor (2005) notes that

To address the fire safety of occupants in a building, it is important to understand and consider the factors that may influence the responses and behaviors of people in threatening fires...Although the current understanding of human behavior in fire is limited compared to other areas of fire protection engineering ... (p.1)

Brennan and Thomas (2001) reviewed ten years of US Fire data from 1983-1993 (excluding 1986) and concluded that there are important differences between residential
fires resulting in non-fatal injury, and those resulting in fatalities. In support of the argument that these outcomes represent two distinct types of fire, they noted that 96% of fires resulting in injury were non-fatal fires, and that 68% of fatal fires had no recorded non-fatal injuries. However they also noted that fatality rates are disproportionately high in fires that result in non-fatal injury (39 deaths per 1000 non-fatal injury fires compared with 6 fatal fires per 1000 fires).

Hasofer et al (2005) used results from an earlier study to develop a model for the effect of alcohol and sound intensity on response to fire alarms. In this earlier study Ball & Bruck (2004) carried out a study with 14 young adults aged 18-25 years. These subjects were tested with on three non-consecutive nights, with different blood alcohol concentrations (no alcohol; 0.05g per decilitre; 0.08 g per decilitre), using the following three alarms:

- Female actor’s voice warning of danger due to fire
- Australian Standard Alarm (high-pitched)
- International Standard 8201 alarm (lower pitch)

The behavioural response time was the interval between the first sound, and the time the subject roused and pressed a button on the bedside. They found that overall the behavioural response time for women was shorter than for men (i.e. women woke sooner), and that alcohol affected both men and women resulting in a longer behavioural response time.

Bruck and Ball (2005) also investigated factors associated with residents failing to wake to a functioning smoke alarm. They estimated that in the USA 770 persons per annum die in such circumstances. They observed that children and adults aged over 60 years
were the population age-groups who most often stayed asleep in the presence of a functioning alarm. Other factors that were commonly observed in this situation were:

- High levels of background noise
- Being a heavy sleeper
- Sleep deprivation
- Sleeping tablets
- Alcohol (even moderate use with blood alcohol concentration 0.05g per decilitre)
- Hearing impairment.

In laboratory settings the investigators observed the pitch and intensity of sound required to wake people of varying ages. Only 57 per cent of children aged 6-10 years woke to the standard 3000Hz signal at 89dB usual in domestic smoke alarms. In contrast 94 per cent of the children in this age group woke to a lower pitched (500-2580 Hz) alarm, and to their mother’s voice or a female actor’s voice saying the child’s name every 6 sec. (all stimuli at 89dB). With the frequency stable at 3000 Hz, the average auditory arousal threshold for participants was over 100 dB for children aged 5-7 years, and 97 dB for children aged 13-16 years. Adults aged 20-24 years woke at an average threshold of 67.8 dB. These observations are important. However any change to the standard alarm parameters will need to ensure that the current efficacy of alarms for the adult population is not compromised in any way (Lee, Midgett & White, 2004).

Fraser-Mitchell (2004) informed his colleagues of the complexity required in modelling human behaviour in fire. Given the uncertainties and variabilities in the way that individuals respond, he emphasised the importance of sensitivity analysis in any model.
He also points out that the probabilities of certain actions, for example moving towards or into smoke, have not been determined for different actions and motivations. The probabilities may differ depending on whether the action is investigation, fire-fighting by a member of the public, warning or rescuing others.

2.7. Summary

International data, and previous New Zealand studies, identify injury from fire and flame as a significant contributor to potential years of life lost and to the burden of disability. The observed disparities in injury rates show that there are groups within populations with different risks of fire-related injury. In the case of fire-related injury, the very old and very young, the socio-economically disadvantaged, and some ethnic groups carry a disproportionate burden of death and nonfatal injury. In addition to characteristics of the injured persons, understanding of factors associated with fire-related injury also requires consideration of household and neighbourhood characteristics, and the wider social environment. Advances in fire engineering have the potential to improve the effectiveness and impact of early warning systems such as domestic smoke alarms.

Key areas for further investigation in the New Zealand context include the extent to which patterns are similar, or dissimilar, to those observed in other countries. The extent of the socio-economic gradient with respect to risk of fire-related injury has important implications for fire safety policy. Obligations of the Crown to Māori, with respect to the Treaty of Waitangi, make quantification and understanding of any ethnic disparities in fire-related injury rates an important aspect of enquiry.
3. Descriptive study research design

3.1. Aim

The aim of the study was to improve household fire safety in New Zealand through better understanding of factors associated with unintentional injury from fire and flame in domestic locations.

3.2. Objectives

- To identify and collate existing information about unintentional domestic fire incidents in Aotearoa New Zealand resulting in death, or in injury requiring treatment in a public hospital (serious non-fatal injury);
- To describe personal, fire-related, social and physical environmental factors associated with fatal or serious non-fatal injury in unintentional domestic fire incidents in Aotearoa New Zealand relevant to prevention policy; and
- To investigate the potential effectiveness of intervention strategies to modify factors associated with fatal or serious non-fatal fire-related injury so as to reduce the incidence and impact of such injury.

3.3. Definitions

The study population was the group of individuals who could be identified from existing data sources, who had died or were admitted to hospital as a result of unintentional injury from fire and flame in a domestic environment.
Injury from fire and flame includes injuries with ICD-9 codes 890-899. These codes indicate that the injury occurred in an accident caused by:

- Conflagration in private dwelling
- Conflagration in other and unspecified building or structure
- Conflagration not in building or structure
- Ignition of clothing
- Ignition of highly inflammable material
- Controlled fire in private dwelling
- Controlled fire in other and unspecified building or structure
- Controlled fire not in building or structure
- Other specified fire and flames
- Unspecified fire

The domestic environment is a private residential dwelling (rented or owner-occupied) and the immediate environs. Fires occurring in outbuildings such as detached garages or sheds, outdoors, or in stationary vehicles on private residential property were included as occurring in the domestic environment. Fires occurring in commercial premises (e.g. hotels, motels), institutions (e.g. rest homes, prisons), workplaces including farms, and public places were excluded from the study.
The study was concerned with unintentional injury. Intentional fires, intentional injury (homicide, suicide, assault and self inflicted injury) and injury resulting from illegal activity were also excluded.

### 3.4. Data sources

The data sources used in this study were the New Zealand Fire Service Fire Incident Reporting System (FIRS), New Zealand Health Information Service mortality and morbidity data (NZHIS) and coronial files. These datasets are systematic national collections with some identifying data. Emergency departments and primary care providers also collect data about injury, but at the time the research reported in this thesis was undertaken, there was no national collection of such data. Aggregate data from the Accident Compensation Corporation (ACC) were used in the cost-benefit study (Appendix 2). Individual level data from ACC were unlikely to add value to the study and were not sought.

#### 3.4.1. Fire Incident Reporting System

During the study period FIRS data were compiled manually by the fire-fighter at the scene and then sent in hard copy to the national office. Data entry staff then entered the details into an electronic database. The electronic database included a field for ‘casualties’ with variables indicating whether the casualty was a fatality, life-threatening, severe, moderate or minor injury. Subsets of FIRS data were provided for the study by extracting details of all fatalities recorded in the database, and secondly extracting details of all casualties recorded in the database. Separate line entries were available for each casualty in each incident.
Data provided for the study included name, age and gender of the deceased, the address where the fire incident occurred and details of the fire incident listed in the FIRS incident database.

3.4.2. New Zealand Health Information Service

The National Minimum Dataset (NMDS) mortality and morbidity data are the official sources of cause of death and hospitalisation data in Aotearoa New Zealand. The mortality data are derived from the legal death certificate or coroner's report, together with autopsy reports. Information collected includes the underlying cause of death, and demographic information about the deceased (e.g., ethnicity, age, sex, domicile). Information about all day-patients and inpatients discharged from public hospitals is supplied directly to the NMDS by hospital-based computer systems. The data collected include information on diagnoses, diagnostic and therapeutic procedures, and external cause of injury as well as demographic information about the healthcare user.

3.4.3. Coroners’ records

Throughout New Zealand there are over 70 coroners. In most cases the coroner is a lawyer practicing in the community, and the coronial work is conducted part–time as required. The coroner completes a finding for each case following an inquest (Form Cor.7). Where an inquest is not held, the coroner completes a notification (Form Cor.2) certifying the cause of death based on personal inquiries and post-mortem examination (if held). Hard copies of notifications and findings are sent to the Coroners’ Office in Wellington where they are indexed on an electronic database. Fields in the electronic index to coronial files include surname and given names, date of death, and a code which broadly categorised the cause of death. There were only seven separate codes at
the time of data collection for this study. Injury from fire was included in a broad category labeled ‘other’, which included all deaths as a result of unintentional injury other than drowning and motor vehicle crashes. As a result records of deaths from injury from fire and flame could not be extracted without information identifying the individual.

Hard copies of coroners’ files contained narrative information about the circumstances of death of the named individual, and measurements of blood alcohol levels and other laboratory investigations, when these were undertaken.

3.4.4. Fire Investigation Reports

Fire Safety Officers of the New Zealand Fire Service undertake investigations of serious fire incidents. This definition includes all fires which result in one or more fatalities, together with industrial and other fires which result in extensive property damage. These reports contained narrative data about the fatal fires. Fire Investigation reports were historically stored at a local or regional level. Many were lost during successive restructurings of the Fire Service. Fire Investigation reports were requested from the appropriate region for all fatal fires identified from FIRS and NZHIS data. Reports for some more recent incidents were obtained from a central location in the national office of the Fire Service. Fire Investigation reports were also often included in coronial files.

3.5. Linking of mortality records

FIRS fatality records and NZHIS mortality data were entered into a Microsoft Access relational database and assigned identification numbers. Initial manual linkage of NZHIS and FIRS data was completed using combinations of name, age, sex, and date of
death. Visual scanning of unmatched data suggested that spelling differences (e.g. Jeff or Geoff, McDonald or Macdonald) were common. Phonetic matching systems were then employed to maximise the linkage. Linked FIRS/NZHS cases, together with cases in each dataset which were not linked, were then linked with the names in the index to the coronial files. Manual inspection of the coronial files was undertaken to obtain further details of the deceased and the circumstances of death. This new information was then applied to the original datasets to enable new linkages to be made. For example a coronial file linked to an NZHS case may state the date and address of the fire incident, and these details could then be linked with details in FIRS data.

In the time period 1991-1997 a total of 293 fire-related deaths were identified from the fire service and health service data sources. There were 246 deaths recorded in FIRS fatality data from 1991 to 1997. These data included deaths in structural fires, and in mobile property fires. In the earlier years in the series caravan and mobile home fires were coded as mobile property fires. NZHS mortality data identified 192 deceased who were recorded as dying from injuries from fire and flame in the domestic location. An additional 26 deaths from fire and flame were identified from NZHS data with other location codes. A further 23 deceased were identified by searching the NZHS intentional injury mortality dataset for codes that could be used for fire-related injury, and 19 by searching text fields for the words fire/ignition/burns/conflag/smould. Coronal files were sought for all those with an NZHS diagnosis of injury from fire and flame (ICD-9 external cause of injury codes 890-899), together with cases identified in the subsequent searches of NZHS data where review of the text field EVENTDES could not exclude an unintentional domestic fire incident. One final case was identified in NZHS data using personal identifying information derived from FIRS data and from a coronial file.
As shown in Figure 3-1, the iterative linking process resulted in 232 (79 per cent) of the 293 deceased being linked in the two datasets. Thirty-three deceased were identified from the FIRS data but not linked with NZHIS data, and 28 deceased were identified from NZHIS data but not linked to FIRS data. Coronial records were identified for 276 (94 per cent) of the total 293 deceased. In six of these cases with no coronial file death could not be confirmed. In the remaining 11 cases the death was identified in both FIRS and NZHIS data. Failure to link with a coronial file may have been because no inquest was held, or because the identifying details were inadequate. The electronic index to the coronial database was incomplete, with fields for the coronial file number and names of the deceased the only fields with data entered for each record. Thus if different names were entered in the various datasets, for example aliases or misspellings not picked up by phonetic matching, there were usually no alternative fields available to link records. Despite these limitations, coroners’ records were found for 183 (96 per cent) of the deceased in the study group. Five of the remaining 8 deceased were recorded in both NZHIS and FIRS data, and three in NZHIS data alone, but with sufficient detail to
classify them as unintentional domestic incidents. Eligibility for inclusion in the study was determined from coronial files. Where no coronial file was found, eligibility was determined by examining relevant fields in the source data. More complete details of the data linking process are shown in Table 3-1.
Table 3-1. Data linkages process for linking of New Zealand Fire Service Fire Incident Reporting System (FIRS), New Zealand Health Information Service (NZHIS) and Coronal files, with number of deceased found to be eligible for inclusion in study. Eligibility determined from coronial file, event description in NZHIS data, and FIRS data.

<table>
<thead>
<tr>
<th>Stage 1. Linking FIRS records with NZHIS records</th>
<th>Linked files</th>
<th>Coronal files</th>
<th>Eligible</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZHIS data for deaths from fire and flame in domestic location linked with 160 FIRS fatality records. Coronal files found for 156 of these fatalities. Exclusions: Intentional (9), Hotel/motel/boarding house (10), Farm (1), Medical cause (1).</td>
<td>160</td>
<td>156</td>
<td>139</td>
</tr>
<tr>
<td>NZHIS data for deaths from fire and flame with a non-domestic location code (including unspecified location) included 15 of remaining 86 FIRS fatalities. Coronal files found for all 15 of these fatalities. Exclusions: Intentional (1), Hotel/motel (2), Rest Home (6), MV explosion (1).</td>
<td>15</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>NZHIS relevant codes (e.g. self-immolation or assault by fire, explosions etc) included 21 of remaining 71 total fatalities. Coronal files found for all 21 of these fatalities. Exclusions: Intentional (16), Occupational (3).</td>
<td>21</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>NZHIS text search included 16 of remaining 49 fatalities. Coronal files found for all 16 of these fatalities. Exclusions: Intentional (1), Motor vehicle crash or explosion (14), Occupational (1).</td>
<td>16</td>
<td>16</td>
<td>0</td>
</tr>
</tbody>
</table>
Search of NZHIS data by name found 1 person coded as scald from contact with hot object. Coronal file found for this fatality.

Stage 2. Linking NZHIS data with FIRS data

FIRS Structure Fire data linked with 19 additional fatalities identified from NZHIS data (all codes). Coronal files found for all 19 of these fatalities. One homicide excluded from study.

Stage 3. Unlinked data

33 fatalities were recorded in only the FIRS fatality dataset. Coronal files were found for 27 of these deceased, who all died in motor traffic crashes. For the remaining 6 death could not be confirmed.

28 fatalities were recorded only in NZHIS data (all codes). Coronal files found for 25 of these deceased. Exclusions: Illegal activity (1), Institutional (4), Public place (1), Medical cause (1), Motor vehicle crash (2). For the remaining 3 deceased the text field EVENTDES provided sufficient information for inclusion.

Total 293 279 184
3.5.1. Identifying domestic unintentional fire-related deaths

Of the 293 identified fire-related deaths, 184 were eligible for inclusion in the study. As shown in Table 3-2 most of the remainder were deaths attributable to motor vehicle crashes or explosions, intentional deaths, and deaths in commercial premises, institutions, workplaces, public places or farms. Coroners’ verdicts for seven of the deceased indicated that they died of medical causes. In two cases the inquest details clearly describe a fire incident preceding the death from complicating medical causes, and in these cases have been included in the mortality dataset. In two cases it was clear that the fire occurred subsequent to the death (i.e. a fire occurred after sudden death because the deceased was unable to attend to a heat source. For example a person may have died from a medical cause while preparing a meal. The abandoned cooking source then resulted in a house fire). In the remaining three cases the coroner’s verdict has been accepted, although the lack of inquest details make it difficult to be certain of the course of events. Two of these three cases were coded as domestic deaths from fire and flame in NZHIS data, and it is possible that a medical cause of death was ascribed by a coroner despite a history of a preceding fire incident.

Six fatalities recorded in FIRS data could be linked with neither a coronial record nor a health mortality record. A search of current health service data indicated three of these people had current health identifiers and were likely to be still alive (one had a recent admission to hospital). The remaining three could not be linked by date of death or by address with any record in the combined NZHIS dataset (i.e. the dataset including all relevant codes and all incidents identified by a text search). All six were therefore excluded from the study, as the deaths could not be confirmed. It may seem surprising that a fatality database includes “false positives”. However it is possible that the
attending officer believed them to have been deceased if unconscious at the scene, and rapidly removed by emergency services. Also the use of a single casualty field in FIRS data means that a data entry error could result in a casualty being classified as a fatality rather than a non-fatal injury.

Table 3-2. Number and percentage (rounded to nearest whole number) of fire-related deaths in Aotearoa New Zealand 1991-1997 with inclusion and exclusion details, as identified from New Zealand Fire Service Fire Incident Reporting System and New Zealand Health Information Service data.

<table>
<thead>
<tr>
<th>Details</th>
<th>Number of fatalities</th>
<th>Percentage of fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic fire incident</td>
<td>184</td>
<td>65</td>
</tr>
<tr>
<td>Motor Vehicle crash or explosion</td>
<td>39</td>
<td>13</td>
</tr>
<tr>
<td>Intentional</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>Suicide</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Homicide/arson/illegal activity</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Hotel/Motel/Boarding House</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Institutional</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Workplace/farm/public place</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Medical cause</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Death not confirmed</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>293</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

3.5.2. Comparison of data sources

Obtaining data from separate sources allows assessment of the accuracy and completeness of these data sources. As shown in Table 3-3, most of the study deceased
were linked in FIRS and NZHIS datasets. Over three-quarters were linked in the two primary datasets, with a further 5 per cent linked when wider criteria were used for NZHIS data. Later sections of this chapter describe the proportion of eligible cases captured by each source, and the proportion of cases in the dataset which are eligible for inclusion.

Table 3-3. Number and percentage of fatalities occurring as a result of injury from fire and flame in the domestic location, Aotearoa New Zealand 1991-1997 that were identified and linked in each data source. Data sources: New Zealand Health Information Service (NZHIS), New Zealand Fire Service Fire Incident Reporting System (FIRS), Coronial files.

<table>
<thead>
<tr>
<th>NZHIS codes</th>
<th>890-899, domestic location</th>
<th>890-899, other location</th>
<th>Other codes, any location</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRS fatality data</td>
<td>139 (76)</td>
<td>5 (3)</td>
<td>3 (2)</td>
<td>147 (80)</td>
</tr>
<tr>
<td>FIRS structure fire data</td>
<td>18 (10)</td>
<td>-</td>
<td>-</td>
<td>18 (10)</td>
</tr>
<tr>
<td>Attended by Fire Service</td>
<td>4 (2)</td>
<td>1 (1)</td>
<td>5 (3)</td>
<td></td>
</tr>
<tr>
<td>Not attended by Fire Service</td>
<td>7 (4)</td>
<td>7 (4)</td>
<td>-</td>
<td>14 (7)</td>
</tr>
<tr>
<td>Total</td>
<td>168 (91)</td>
<td>12 (7)</td>
<td>4 (2)</td>
<td>184 (100)</td>
</tr>
</tbody>
</table>

3.5.2.1. FIRS fatality data

FIRS fatality data included 147 (80 per cent) of the 184 domestic deaths as a result of unintentional injury from fire and flame in the present series. FIRS fatality data also included 37 deaths resulting from motor vehicle crashes and explosions, 51 deaths in
non-domestic or intentional fire incidents, four deaths attributed by the coroner to a medical cause and six individuals for whom death could not be confirmed.

Fourteen fatalities that were identified from NZHIS mortality data occurred in single fatality incidents that were not attended by the New Zealand Fire Service (the Fire Service). The Fire Service therefore attended 140 (90 per cent) of the 154 unintentional domestic incidents in this series, and 170 (92 per cent) of the 184 fire-related fatalities included in the study.

FIRS fatality data included records for 120 (86 per cent) of the 140 study incidents attended by the Fire Service, and for 147 (86 per cent) of the 170 study fatalities that occurred in those incidents. In one incident there was a second fatality that was not recorded in FIRS fatality data. A further 15 unintentional fire incidents that resulted in 17 fatalities were found in the FIRS structural fire dataset, although the occurrence of fatalities was not recorded in FIRS. These structural fire incidents were found by manually linking information abstracted from NZHIS and coronial files with FIRS data. The five fatalities attended by the Fire Service that were not included anywhere in FIRS structure fire data occurred in single fatality incidents in remote areas (3), or where death occurred later, in hospital, after a fire incident that was attended by the fire service, but did not require intervention because the flames had been contained by household members before the Fire Service arrived (2).
Ethnicity was not recorded in FIRS data. Other recorded demographic details were generally consistent for the 147 unintentional domestic fatalities included in both FIRS and NZHIS datasets. Gender was the same for 144 (98 per cent) of the deceased; FIRS data incorrectly recorded two females as male, and one male as female. Age was recorded in 146 of the 147 fatalities in the FIRS fatality dataset. In 114 (78 per cent) of these entries recorded age was within one year of the age in NZHIS data. In a further 25 (17 per cent) age was within 8 years of the age recorded in health data. For the final 7 (5 per cent) the age entered in FIRS differed from the age in NZHIS data by more than 10 years. In five of these entries FIRS data recorded the deceased as aged over 90 years of age, when the age in NZHIS data was under 65 years, and review of the data suggests that an abbreviation for the year of death may have been entered in the age field in error. In the remaining two records FIRS data incorrectly recorded an adult aged over 65 years as an adult 15-64 years, and a young person or adult aged 15-64 years as a child aged under 15 years.

3.5.2.2. NZHIS mortality data

All of the 184 deceased in the final dataset were recorded in health data with 168 (95 per cent) correctly coded as deaths occurring in a domestic location with fire and flame as the external cause of injury. This domestic coding group also included 11 intentional deaths, and 13 deaths which occurred in non-domestic locations such as boarding houses and hotels (10), farms (1), or were determined by the coroner to be a medical cause (2). Of the total 192 NZHIS records of fire and flame related domestic deaths, 168 (88 per cent) were eligible for inclusion in the study.

NZHIS data included a further 12 deaths (7 per cent) eligible for the study dataset as a result of injury from fire and flame, but not with a domestic location code. The non-
domestic group included 21 deaths which were not eligible for inclusion in the study; 18
deaths were correctly coded to a non-domestic location, two resulted from intentional
fires, and one from a motor vehicle explosion.

In this series use of the NZHIS codes 890-899, with all location codes, would have
identified 98 per cent of the unintentional domestic fire deaths in the time frame. Of the
total 218 records with NZHIS coding as deaths with fire and flame as the external cause
of injury, 180 (83 per cent) were eligible for inclusion in the study.

A search of the free text field in NZHIS data found 42 records which included the word
fire or flame. The remaining four deceased (2 per cent) were found in these NZHIS data
with codes representing injury from explosion, fire or burning in a boat, from explosive
gases, or from contact with a hot object.

3.5.2.3. Coronal files

The electronic index to the coronial database was incomplete, with fields for the
coronial file number and names of the deceased the only fields with data entered for
each record. This was the principal reason for needing to use identifying data to link
records. Despite these limitations, coroners’ records were found for 177 (96 per cent) of
the 184 deceased in the study group. Four of the remaining 7 deceased were recorded in
both NZHIS and FIRS data, and three in NZHIS data alone, but with sufficient detail to
classify them as unintentional domestic incidents.

3.5.2.4. Sensitivity and predictive value

The data descriptions in sections 3.5.2.1 to 3.5.2.3 can be summarised using the
epidemiological terms sensitivity and positive predictive value, as shown in Table 3-4.
The former is an indicator of the completeness of the dataset. It indicates how many of
the eligible cases are included in the dataset. The latter is a measure of the accuracy of the dataset. It indicates how many of the cases in the dataset were eligible for inclusion in the study. In a descriptive study of this type, the ideal dataset would have both high sensitivity and high predictive value. Such a dataset is likely to contain a high proportion of all eligible cases, with relatively few misclassified ineligible cases.

Table 3-4. Sensitivity (proportion of eligible cases that were included) and predictive value (proportion of cases in dataset that were eligible) of data sources used to identify unintentional domestic fire-related deaths in Aotearoa New Zealand 1991-1997. Data sources: New Zealand Health Information Service (NZHIS), New Zealand Fire Service Fire Incident Reporting System (FIRS).

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Sensitivity</th>
<th>Predictive value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRS fatality data</td>
<td>80%</td>
<td>57%</td>
</tr>
<tr>
<td>NZHIS Ecodes 890-899 with 5th digit = 0</td>
<td>92%</td>
<td>91%</td>
</tr>
<tr>
<td>NZHIS Ecodes 890-899 all location codes</td>
<td>98%</td>
<td>86%</td>
</tr>
</tbody>
</table>

The FIRS fatality data sensitivity of 80 per cent was a result of not attending all fatal incidents, and failing to record all fatalities in incidents attended. The relatively low predictive value was principally because FIRS data included deaths following motor vehicle crashes. The dataset therefore included a high proportion of cases which were not eligible for the study. Limiting FIRS data to residential fires would slightly reduce sensitivity by excluding the cases of children playing with smoking materials in a parked car, but increase predictive value by removing motor vehicle crashes.

NZHIS data showed higher sensitivity and higher predictive value than FIRS data. Where the fifth digit of the external cause of injury code indicated that the injury occurred at home (5th digit = 0), the dataset included some misclassified cases, and missed cases with unspecified or incorrect location codes. Widening the search to all
unintentional injuries from fire and flame improved retrieval of cases, with an improvement in sensitivity from 92 to 98 per cent, but also increased the proportion of ineligible cases and thus reduced predictive value to 86 per cent.

3.6. Data linkage non fatal injury

In the years 1996 to 2000, New Zealand Health Information Service data identified 1570 first admissions to hospital with an external cause of injury code indicating injury from fire and flame. The location of the incident was coded in the fifth digit in the external cause of injury code (0 = home, 1 = farm, 2 = mine or quarry, 3 = industrial place, 4 = place for recreation and sport, 5 = street or highway, 6 = public building, 7 = residential institution, 8 = other specified place, 9 = unspecified place). NZHIS data also contained a field ‘edesc’, which is a free text field containing a brief account of the incident resulting in injury. More recently this field seems to have been filled in automatically using the full text for the ICD 9 CM numerical code. However where the field is used as free text some useful information can be extracted, for example the entry ‘INHALED SMOKE IN HOUSE FIRE’ was interpreted as a domestic incident. In the same time period FIRS data recorded 1830 non-fatal casualties (excluding motor vehicle crash fires). Of the FIRS non-fatal casualties, 1512 were recorded as occurring in private residential structures (flats, apartments, houses and mobile homes). Using the process described previously, there were 93 linkages by date and name or street address, and 121 linkages by date and two or more other variables.
As shown in Figure 3-2, there was minimal overlap between the NZHIS and FIRS datasets. The 179 linked records represented only 11 per cent of the 1570 hospitalisations as a result of injury from fire and flame recorded in NZHIS data, and 10 per cent of the 1830 non-fatal injury records in FIRS, in the study period. There are several possible explanations for this lack of overlap:

- The datasets capture different events. It was seen in the mortality data that not all fire-related fatalities were attended by the Fire Service. It is likely that even more non-fatal fire-related injuries are not attended by the Fire Service, as many injuries resulting in hospitalisation may occur in incidents where no or minor property damage occurs, therefore not resulting in a call out to the fire service. Conversely, many injuries recorded by the Fire Service may not result in admission to hospital, and thus not be captured in NZHIS data.

- Deficiencies in the datasets may mean that some injuries were not recorded or were miscoded. Fire Service data were gathered at the scene and may not have included all injured persons. NZHIS data were obtained using the ICD-9 coding system.
Miscoding of external cause of injury would mean eligible cases were not retrieved. For example if injury from fire and flame was coded as injury from some other cause, the inpatient discharge would not have been identified from health data with the specific codes used in this study.

- The linking process may not recognise that two records refer to the same person. This failure of the linking process could occur where identifying information was missing from the FIRS data, or where the address of the fire incident (recorded in FIRS data) differs from the current residential address of the injured person (recorded in NZHIS data). Names were included in only 218 (14 per cent) of the 1512 FIRS private residential entries; these records were often incomplete with surname or given name only. Although addresses were entered for all FIRS entries, linking of addresses proved to be difficult. The address at which the fire occurred might not be the usual residential address of the injured person (which is the address entered into NZHIS data). For example the injured person may have been injured while staying with relatives in Dunedin, but their usual residential address in Oamaru would be entered into the NZHIS data base. In addition if the injured person moved since the injury occurred, the NZHIS record contained the new and not the previous address. For example if a person was injured in their own home in Pukekohe in 1997, but subsequently moved to live in Kaikohe, the latter address would be the one recorded in NZHIS data. It was noted that FIRS data included a field ‘familiarity’, which detailed the length of time the casualty had resided in the affected dwelling. This field could potentially provide some additional information about whether the location of the fire was the usual residential address of the casualty. However there were missing entries in over 50 per cent of the non-fatal domestic casualties (816 casualties; 54 per cent). One fifth of the domestic
casualties where the familiarity field was completed had been present in the
dwelling for less than three months, and 12 per cent for less than one week.

This lack of overlap was partly anticipated on first viewing of the datasets, when the
absence of personal identifying data in FIRS was noted. The lack of overlap has
important implications for injury surveillance, as it was not possible to collate the
detailed information about the fire, contained in FIRS, with the personal information in
NZHIS data. Use of a common identifier by both health and fire services would enable
such collation, and better understanding of the factors associated with such injury.
However the culture of the fire service is determined by their particular skills in fire
engineering and understanding of fire dynamics. Gathering detailed personal data may
not be a realistic option. It is also likely that similar issues exist for other safety
organisations such as the land transport safety authority and water safety bodies. The
New Zealand government has implemented a national injury prevention strategy.
Appointment of a national injury data manager is a part of this strategy. The post will
take responsibility for collection and collation of data concerning all aspects of injury
and injury events, and thus comprehensive surveillance data to inform injury prevention
practice. On the basis of a pilot study, the injury data manager role is concentrating on
NZHIS and ACC data without reference to other data collections (Statistics New
Zealand, 2004). This is less comprehensive than the candidate had hoped for, but is still
a move in the right direction in relation to injury statistics in New Zealand.
3.6.1. Identifying domestic unintentional non-fatal fire-related injury

As shown in Table 3-5, just over half of the inpatients (862, 55 per cent) were eligible for inclusion in the study. For linked cases the FIRS specific property type field was used to ascertain the location of the incident. In almost one quarter of the cases (375 inpatients, 24 per cent) the location of the incident was unspecified. It is probable that some of these cases were eligible, however this could not be confirmed using available data. Of the remainder, 250 injuries occurred in non-domestic settings such as farms, public places, workplaces, or residential institutions and 35 inpatients (2 per cent) had a primary diagnosis other than injury. This latter group included incidents where a person made contact with a heat source in the course of an epileptic seizure or stroke, or where the primary reason for admission was a medical condition such as angina. It also included admissions for late stage complications of burn injuries (for example cellulitis and gangrene), where it was uncertain whether or not the injury was the primary reason for admission.
Table 3-5. Number and percentage of inpatients admitted to hospital in New Zealand 1996-2000 with external cause of injury code 890-899 by description of fire incident.

*Data sources: New Zealand Health Information Service, New Zealand Fire Service*

<table>
<thead>
<tr>
<th>Description of fire incident</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Fire</td>
<td>862 (55)</td>
</tr>
<tr>
<td>Outdoor Fire – location not specified</td>
<td>86 (5)</td>
</tr>
<tr>
<td>Occupational Fire</td>
<td>68 (4)</td>
</tr>
<tr>
<td>Public Place (Recreation/ Sport/ Street/ Highway/ Public Building)</td>
<td>38 (2)</td>
</tr>
<tr>
<td>Farm</td>
<td>33 (2)</td>
</tr>
<tr>
<td>Residential Institution</td>
<td>26 (2)</td>
</tr>
<tr>
<td>Intentional or medical event preceded fire incident</td>
<td>35 (2)</td>
</tr>
<tr>
<td>Other specified</td>
<td>47 (3)</td>
</tr>
<tr>
<td>Unspecified</td>
<td>375 (24)</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>1570 (100)</strong></td>
</tr>
</tbody>
</table>
3.6.2. The scenario data subset

The key reason for the linkage was to obtain more comprehensive data concerning the fire incidents resulting in non-fatal injury. Information concerning the heat source and item ignited was of particular interest in understanding fire incidents leading to hospital inpatient treatment. Information regarding heat sources and items ignited was determined from FIRS data for linked records, and from the event description free text field in NZHIS data. Only those records where information about the heat source or item ignited was available were included; these 512 cases represented 59% of the 862 study inpatients.

The implications of using subsets for analysis depend principally on the extent to which the subset is similar to or differ from the group from which it is derived. Demographic details were used to compare the linked subset with the overall unintentional domestic fire-related injury hospitalisation data. As shown in Table 3-6 the inpatients in the two data sets were so similar in terms of demographic details that statistical analysis was not undertaken. Thus it is proposed that the subset can, with caution, be considered representative of the whole dataset.

This subset was used to identify scenarios, or sequences of events, associated with non-fatal fire-related injury. Development of scenarios is a recognised way of bringing together the factors identified in injury prevention research, and has been used by Waller et al (1998) and Marshall et al (1998) among others. The analysis was qualitative and sought to gather additional information about the circumstances of non-fatal injury. These factors were not quantified as the data available were not collected in a systematic or consistent way.
Table 3-6. *Inpatients in unintentional domestic inpatient dataset and scenario data subset by median age, and percentage values for gender and ethnicity variables. Data sources: New Zealand Health Information Service (NZHIS), New Zealand Fire Service*

<table>
<thead>
<tr>
<th></th>
<th>NZHIS data set (n=862)</th>
<th>Scenario subset (n=512)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age</td>
<td>24</td>
<td>25</td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>69%</td>
<td>68%</td>
</tr>
<tr>
<td>Female</td>
<td>31%</td>
<td>32%</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Māori</td>
<td>22%</td>
<td>21%</td>
</tr>
<tr>
<td>Pacific</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>Other</td>
<td>71%</td>
<td>71%</td>
</tr>
<tr>
<td>Not stated</td>
<td>2%</td>
<td>2%</td>
</tr>
</tbody>
</table>

3.7. Analysis

3.7.1. *Demographic data*

New Zealand mean population figures from the 1991 and 1996 censuses, together with intercensal estimates provided by Statistics New Zealand, were used to calculate age-specific mortality and hospital inpatient treatment rates. Trends over time were assessed using crude mortality or morbidity rates for each calendar year. Changes to death registration requirements in 1995, and to the ethnicity question in the 1996 census have made it difficult to analyse trends in the Māori population over time. The wording of the 1996 ethnicity question encouraged people to give multiple responses. As a result
neither the sole Māori, nor the Māori ethnic group (MEG) 1996 denominator is comparable with denominator data from earlier years. The 1996 ‘sole Māori’ group is significantly smaller than expected, and calculations using this denominator give higher rates than those calculated for earlier years. The widespread use of multiple ethnicity responses in 1996 means that the MEG denominator is larger than expected, and thus rates calculated using this denominator are lower than rates calculated for earlier years (Statistics New Zealand, 2001). Ethnicity data for 1991-1994, and 1995-1996 were therefore analysed separately. The ‘sole Māori’ denominator data from the 1991 census and intercensal estimates was used to calculate Māori and non-Māori rates in the time period 1991-1994. A proxy sole Māori denominator, calculated by extrapolating intercensal estimates from the 1991 census, was used for the 1996-1997 analysis. However changes in the collection of numerator data from 1995 also mean that the 1996-1997 data cannot be directly compared with the 1991-1994 data. Age-standardised rates were calculated using Segi’s world population, and used to compare mortality and hospitalisation rates by gender and by ethnicity.

3.7.2. Narrative data

Narrative data were used to add understanding of the circumstances in which fatal fire incidents occurred. Copies of coronial files and Fire Investigation Reports were read by the thesis author to identify themes and scenarios. Excerpts related to recurring themes were abstracted and used to add depth to the descriptive analysis. As these data were not collected systematically, it was not possible to precisely quantify the effect of factors such as social disruption on fatal fire-related injury in the home.
4. Descriptive study results

4.1. Fatal injury

Collated data sources for the seven years of the study identified 184 deceased persons, who died in 154 unintentional fire incidents in a domestic location in Aotearoa New Zealand from 1991 to 1997 (inclusive). There were between 23 and 29 deaths per annum (average 26.3); crude annual mortality rates varied from 0.6 to 0.9 deaths per 100,000 person years, with no linear trend over time (Chi squared test for trend 0.011, p=0.9). These deaths occurred in between 19 and 25 incidents per annum, with an average of 22 incidents per annum.

4.1.1. Host characteristics

The highest rates of unintentional domestic fire deaths were observed among adults aged over 65 years and children aged under 5 years, as shown in Table 4-1. The age structure of the population meant that despite the high rates among seniors, the greatest number of deaths occurred among youth and adults aged 15-64 years. In this series 78 of the deceased (42 per cent) were aged under 25 years, and almost three-quarters (135 deceased; 73 per cent) were aged under 65 years.
Table 4-1. Number and percentage of unintentional domestic fire-related deaths, age-specific and age standardised mortality rates per 100,000 person years with 95% confidence interval, Aotearoa New Zealand 1996-2000. Data sources: New Zealand Health Information Service, New Zealand Fire Service.

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Deaths n (%)</th>
<th>Rate (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>35 (19)</td>
<td>1.7 (1.1-2.3)</td>
</tr>
<tr>
<td>5-14</td>
<td>16 (9)</td>
<td>0.4 (0.2-0.6)</td>
</tr>
<tr>
<td>15-24</td>
<td>27 (15)</td>
<td>0.7 (0.4-1.0)</td>
</tr>
<tr>
<td>25-34</td>
<td>19 (10)</td>
<td>0.5 (0.3-0.7)</td>
</tr>
<tr>
<td>35-44</td>
<td>19 (10)</td>
<td>0.5 (0.3-0.7)</td>
</tr>
<tr>
<td>45-54</td>
<td>7 (4)</td>
<td>0.2 (0.1-0.4)</td>
</tr>
<tr>
<td>55-64</td>
<td>12 (7)</td>
<td>0.6 (0.3-0.9)</td>
</tr>
<tr>
<td>65-74</td>
<td>15 (8)</td>
<td>0.9 (0.4-1.3)</td>
</tr>
<tr>
<td>75 – 84</td>
<td>22 (12)</td>
<td>2.4 (1.4-3.3)</td>
</tr>
<tr>
<td>85+</td>
<td>12 (7)</td>
<td>4.8 (2.1-7.5)</td>
</tr>
<tr>
<td><strong>Total/Overall</strong></td>
<td><strong>184 (100)</strong></td>
<td><strong>#0.7 (0.6-0.8)</strong></td>
</tr>
</tbody>
</table>

*Rate per 100,000 person years

#Age-standardised rate per 100,000 person years

Differences were observed between mortality rates by gender and by ethnicity. Age-standardised rates for males exceeded rates for females by a factor of about 1.5 (RR 1.5; 95% CI 1.3-1.8). This gender disparity was most marked among children aged under 5 years (RR 2.7, 95% CI 1.3-5.8), and in the 25-54 age groups (RR 2.5; 95% CI 1.3-4.8).
Figure 4-1. Age specific mortality rates for death as a result of injury from fire or flame in unintentional domestic fire incidents, Aotearoa New Zealand, 1991-1997, by gender. Data sources: New Zealand Health Information Service, New Zealand Fire Service, Statistics New Zealand. Error bars represent 95% confidence intervals.

The greatest disparity of all was observed between mortality rates for Māori and non-Māori New Zealanders. From 1991 to 1994, using coronial files as well as health data to determine ethnicity as accurately as possible, the age-standardised rates for Māori exceeded rates for non-Māori by a factor of almost 7 (RR 6.9; 95% CI 5.1-9.3). The Māori-non-Māori disparity in age-standardised mortality rates was most marked among children aged under 5 years (RR 13.2; 95% CI 6.4-27.2).

Changes in the collection of both numerator and denominator data in 1995 and 1996 mean that later ethnicity data must be considered separately. The changes in ethnic identification in the 1996 census were so marked that Māori health researchers developed a denominator figure based on 1991 census data, using methods similar to intercensal estimate calculation, for use in analysis. Separate analysis of 1996-1997
data using this proxy sole Māori denominator showed that the age-standardised unintentional domestic fire mortality rates for Māori exceeded rates for non-Māori by a factor of almost 10, although the confidence interval is large due to the lower numbers of deceased in this time frame (RR 10.4; 95% CI 5.9-18.1). The Māori-non-Māori disparity in age-specific mortality rates for 1996-1997 was most marked among children aged under 15 years (RR 17.2; 95% CI 6.7-44.3). In the under 15 age group in 1996-97 the number of Māori deceased (15) was two and a half times the number of non-Māori deceased (6).

**4.1.2. Vector characteristics**

Data concerning the 154 unintentional domestic fire incidents which resulted in one or more fatalities were obtained from FIRS, from the coronial reports, and to a more limited extent from the event description free text field in NZHIS data. Extensive damage to dwellings often meant that the heat source and items ignited could not be identified.

**4.1.2.1. Heat source**

Heat sources were aggregated into five functional categories and analysed by the overall proportion of incidents, and the number of fatalities and the age of the deceased, as shown in Table–4-2. The ‘cigarette or smoking materials’ category includes incidents where the most likely heat source was an abandoned cigarette, matches or cigarette lighter. The heating equipment category includes electric, gas and kerosene heaters, solid fuel burners and open fires. The cooking equipment category includes electric and gas stoves and ovens, coal ranges and barbecues. The
‘other electric appliance’ category included electric blankets, televisions, stereos, video cassette recorders, irons, electric jugs and deep fryers.

Among New Zealanders aged under 65 years the most common ignition source was cigarettes or smoking materials. Play with matches or lighters accounted for over one third (19 fatalities; 36 per cent) of the 51 deaths of children aged under 15 years. Abandoned cigarettes or smoking materials were the heat source in a similar proportion (32 per cent) of the 89 deaths of young people and adults aged 15-64 years. Abandoned cigarettes or smoking materials accounted for around one fifth (19 per cent) of the fatal unintentional domestic fire incidents involving adults aged over 64 years and were the second most common heat source in this older age group. Among adults aged 15-64 years and over 64 years abandoned cigarettes accounted for 25 of the 36 deaths in the ‘cigarettes or smoking materials’ category; matches or lighters accounted for 3 of these deaths. Among the remaining 8 deaths the exact heat source could not be determined, however for four of these deaths the heat source was most probably an abandoned cigarette, matches or lighter, and in 4 cases smoking materials was a probable heat source although other heat sources such as candles or incense could not be excluded.

Heating equipment was the most common ignition source for New Zealanders aged over 64 years and accounted for almost half the deaths in this age group (23 fatalities: 47 per cent). Heating equipment was the second most common heat source for fire-related fatalities among New Zealand children aged under 15 years. For adults aged 15-64 years heating equipment and cooking equipment each accounted for 18 fatalities (21 per cent).
Cooking equipment was the third most common heat source overall. Two cooking related fire incidents resulted in five child deaths. Of all heat sources, incidents started from abandoned cooking had the highest number of child fatalities per incident. The cooking related fire incidents were associated with alcohol consumption by adults in the household.

Alternative classification of heating and cooking appliances by fuel source showed that electric heaters accounted for 33 deaths (18 per cent), electric stoves and ovens for 26 deaths (14 per cent), solid fuel burners for 17 deaths (9 per cent) and gas or kerosene heaters for 4 deaths (2 per cent).

**4.1.2.2. Items ignited**

Items ignited were determined from FIRS data and from documents in the coronial files. In many cases the item ignited was recorded simply as ‘combustible materials’. These items have been qualified by the room of origin of the fire (where known). Items ignited were aggregated into categories based on the nature of the item and/or the room in which the fire began, and analysed by age of the deceased as shown in Table–4-3. The interior structure/ furnishings category includes incidents where the heat source ignited the structure of the dwelling or materials attached to the structure such as carpets, curtains, wall coverings or attached joinery. Upholstered furniture refers to household furniture manufactured using foam and covered with fabric and includes sofas, armchairs and mattresses. Motor vehicle and mobile home interiors are considered separately, although they share some characteristics in common with upholstered furniture. The flammable gas or liquid category includes all incidents where a flammable gas or liquid accelerated combustion, and all of these incidents involved secondary ignition of clothing.
Bedding or combustibles in the bedroom was the most commonly ignited group of materials in the study sample.


<table>
<thead>
<tr>
<th></th>
<th>Number (%) of fatalities by age group in years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-14</td>
</tr>
<tr>
<td>Cigarettes or smoking materials</td>
<td>19 (37)</td>
</tr>
<tr>
<td>Matches/lighter</td>
<td>18 (35)</td>
</tr>
<tr>
<td>Cigarette</td>
<td>-</td>
</tr>
<tr>
<td>Smoking materials</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Heating equipment</td>
<td>11 (21)</td>
</tr>
<tr>
<td>Cooking equipment</td>
<td>5 (9)</td>
</tr>
<tr>
<td>Other electric appliance</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Candle or other naked flame</td>
<td>7 (13)</td>
</tr>
<tr>
<td>Unknown</td>
<td>7 (13)</td>
</tr>
<tr>
<td>Total</td>
<td>51 (100)</td>
</tr>
</tbody>
</table>
Table 4-3. Item(s) ignited in unintentional domestic fire incidents which resulted in one or more fatality in Aotearoa New Zealand 1991-1997 by age group. Data sources: New Zealand Fire Service, New Zealand Health Information Service, Coronial files.

<table>
<thead>
<tr>
<th>Probable item ignited</th>
<th>0-14</th>
<th>15-64</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedding/ combustibles bedroom</td>
<td>22 (43)</td>
<td>24 (29)</td>
<td>16 (33)</td>
<td>62 (34)</td>
</tr>
<tr>
<td>Upholstered furniture/ combustibles lounge</td>
<td>8 (16)</td>
<td>12 (14)</td>
<td>5 (10)</td>
<td>25 (14)</td>
</tr>
<tr>
<td>Food cooking</td>
<td>5 (10)</td>
<td>15 (18)</td>
<td>1 (2)</td>
<td>21 (11)</td>
</tr>
<tr>
<td>Interior structure/ furnishings</td>
<td>8 (16)</td>
<td>8 (10)</td>
<td>2 (4)</td>
<td>18 (10)</td>
</tr>
<tr>
<td>Clothing</td>
<td>-</td>
<td>3 (4)</td>
<td>12 (24)</td>
<td>15 (8)</td>
</tr>
<tr>
<td>Combustibles kitchen/garage/other</td>
<td>-</td>
<td>6 (7)</td>
<td>7 (14)</td>
<td>13 (7)</td>
</tr>
<tr>
<td>Flammable gas or liquid</td>
<td>1 (2)</td>
<td>4 (5)</td>
<td>1 (2)</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Motor vehicle interior</td>
<td>6 (12)</td>
<td>-</td>
<td>-</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Unknown</td>
<td>1 (2)</td>
<td>12 (14)</td>
<td>5 (10)</td>
<td>18 (10)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>51 (100)</strong></td>
<td><strong>84 (100)</strong></td>
<td><strong>49 (100)</strong></td>
<td><strong>184 (100)</strong></td>
</tr>
</tbody>
</table>

4.1.3. Physical Environment

Aspects of the physical environment in the 154 fatal unintentional domestic fire incidents in the study time frame were determined from FIRS data and coronial records.
4.1.3.1. Dwelling type

Dwelling type was determined from FIRS data, from Fire Investigation Reports, and from coronial records. Dwellings were categorised as permanent private dwellings if they were detached single dwellings, or blocks of apartments, constructed of permanent materials. The category temporary dwelling included caravans, sheds and other structures built of non-permanent materials and being used as private dwellings. At the time of the 1996 census there were 7335 New Zealand households living in caravans or temporary accommodation, less than one per cent of private dwellings nation-wide. Non-structure fires included fires in stationary motor vehicles parked on private residential property, and outdoor rubbish or cooking fires on private residential property that resulted in fatal or non-fatal injury.

Table 4-4. Number and percentage of fatal unintentional fire incidents in Aotearoa New Zealand by dwelling type and age group. Total differs from sum of row data because some incidents involved more than one age group. Data sources: New Zealand Fire Service, Coronial files.

<table>
<thead>
<tr>
<th>Dwelling type</th>
<th>00-14</th>
<th>15-64</th>
<th>65+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary dwelling</td>
<td>9 (24)</td>
<td>8 (11)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Permanent dwelling</td>
<td>23 (61)</td>
<td>68 (89)</td>
<td>43 (90)</td>
</tr>
<tr>
<td>Non-structure fire</td>
<td>6 (16)</td>
<td>-</td>
<td>1 (2)</td>
</tr>
<tr>
<td>Grand Total</td>
<td>38 (100)</td>
<td>76 (100)</td>
<td>48 (100)</td>
</tr>
</tbody>
</table>

*Some incidents involved more than one age group
Fire incidents occurring in temporary accommodation were particularly common among children aged under 15 years. Such incidents disproportionately resulted in multiple fatalities. Almost one third of the child fatalities in this time frame (16 deaths, 31 per cent) occurred in temporary dwellings. The proportion of households with children under 15 years living in temporary accommodation is not known. However the relative risk of a fatal fire for such households must be extremely high. Based on census data for all households, it is likely that the risk of a fatal fire for a household with children living in temporary accommodation is at least twenty times the risk experienced by households in permanent accommodation.

Almost one fifth of fatal domestic fire incidents in the 15-64 year old age group occurred in flats or apartments. This reflects lifestyle choices and available options, particularly for younger people. However there are particular risks associated with multi household dwellings, particularly where compliance with the Building Act is not achieved.

### 4.1.3.2. Room of Origin

There were missing data on room of origin for 15 (10 per cent) of the 154 fatal incidents. Forty-six fatal incidents (30 per cent) began in a bedroom, 36 incidents (23 per cent) in a kitchen or dining room, 28 incidents (18 per cent) in a lounge or sitting room and four incidents (3 per cent) in other rooms such as laundry or garage. The remaining incidents occurred in caravans (9 incidents, 6 per cent), one room dwellings (8 incidents, 5 per cent) or stationary motor vehicles (7 incidents, 5 per cent). One incident resulted from an outdoor fire used for cooking.
4.1.3.3. Domestic smoke alarms

The FIRS field related to smoke alarm presence and function was characterised by substantial missing data. Further details regarding presence or absence of smoke alarms were derived from Fire Service investigation reports and coronial records. However there were no data about presence or absence of smoke alarms in 69 (45 per cent) of the 154 fatal incidents. Functioning alarms were present in 2 incidents, non-functioning alarms in 5 incidents, and no alarm present in the remaining 78 (51 per cent) of incidents.

4.1.3.4. Lack of telephone

Presence or absence of a telephone was not systematically recorded in the data. However it has been noted by other researchers that this may be a risk factor for fatal fires. The practical implications of having no telephone were illustrated in the following excerpt from a coronial file:

...I awoke and there were smoke and flames coming from my son’s room. I ran to his open bedroom door to find his room well alight. I could not enter through the blaze ... As I did not have a phone I ran outside to summon help from the neighbours. In doing so the front door slammed behind me and I had to smash the glass to get back in.

4.1.4. Social Environment

Aspects of the social environment were abstracted from FIRS data and coronial records. The day of the week, and time of day, when fatal unintentional domestic fire incidents occurred were not evenly distributed. Where data were available, they suggested a significant role for alcohol in such incidents. Fatal fire incidents also appeared to be associated with disruption to the usual routine of a household. A
gradient of increased rates of unintentional fire-related injury with increasing levels of social and material deprivation at small area level was also observed.

4.1.4.1. Timing of incident

In contrast with all fires, which occur most commonly in the early evening, fatal fires occurred most commonly in the early hours of the morning (see Figure 4-2). This trend was particularly noticeable for young people and adults aged 15-64 years among whom over 60 per cent of fatal incidents occurred between midnight and 6 a.m.

The smaller peak between 8 and 10 a.m. was contributed to particularly by fatal fires involving children aged under 15 years. This seemed to be a time when caregivers were occupied with household activities, and children were playing without direct supervision (see section 4.2.1 on page 78 for narrative details).

![Figure 4-2 Number of unintentional fatal domestic fire incidents by time of incident, Aotearoa New Zealand 1991-1997. Data source: New Zealand Fire Service Fire Incident Reporting System.](image-url)
Month and day for all fatal incidents were determined from coronial records and FIRS data, with use of a multi-year calendar where necessary. Overall, fatal fire incidents were more likely to occur on weekends (26% on Sunday, 21% on Saturday and 18% on Friday) compared with an average of 9% each day Monday to Thursday. This trend was especially marked in the 15-64 age band, among whom over two-thirds of fatal incidents occurred over a weekend.

There was also a seasonal pattern to fatal fire incidents in the study group. Fatal fire incidents occurred most commonly in winter and spring, with over 70 per cent of the incidents occurring between June and November, compared with 28 per cent from December to May.

### 4.1.4.2. Alcohol and drugs

Alcohol levels were available for two-thirds of the deceased (see Table 4-5). Alcohol was considered to be associated with fatal fire incidents when a deceased person had a blood alcohol level over 80 milligrams per decilitre, or where there was a confirmed history of excessive alcohol consumption by the deceased in the hours immediately preceding the fatal fire incident. For those 117 deceased where information about alcohol consumption was available, and using the criteria above, alcohol was associated with 63 (54 per cent) of the deceased overall, and with 58 (83 per cent) of the 70 deceased aged 15-64 years. Among such young people and adults alcohol was disproportionately associated with fires started by abandoned or unattended cooking sources, cigarettes, electrical appliances, fireplaces, and solid fuel burners. In addition there was a confirmed history of excessive alcohol use by caregivers of seven (14 per cent) of the 51 children who died in domestic fire incidents. These seven children died in three unintentional domestic fire incidents.
Table 4-5  Involvement of alcohol in fatal unintentional domestic fire incidents

<table>
<thead>
<tr>
<th>Alcohol blood levels</th>
<th>0-14</th>
<th>15-64</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5 mg/dl</td>
<td>22 (43.1)</td>
<td>12 (14.3)</td>
<td>19 (38.8)</td>
<td>53 (28.8)</td>
</tr>
<tr>
<td>20-59 mg/dl</td>
<td>0</td>
<td>1 (1.2)</td>
<td>2 (4.1)</td>
<td>3 (1.6)</td>
</tr>
<tr>
<td>100-199 mg/dl</td>
<td>0</td>
<td>26 (31.0)</td>
<td>2 (4.1)</td>
<td>28 (15.2)</td>
</tr>
<tr>
<td>&gt;200 mg/dl</td>
<td>0</td>
<td>9 (10.7)</td>
<td>0</td>
<td>9 (4.9)</td>
</tr>
<tr>
<td>Confirmed history*</td>
<td>7 (13.7)*</td>
<td>22 (26.2)</td>
<td>1 (2.0)</td>
<td>30 (16.3)</td>
</tr>
<tr>
<td>Unknown</td>
<td>22 (43.1)</td>
<td>14 (16.7)</td>
<td>25 (51.0)</td>
<td>61 (33.2)</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td>51 (100)</td>
<td>84 (100)</td>
<td>49 (100)</td>
<td>184 (100)</td>
</tr>
</tbody>
</table>

*Confirmed history refers to caregiver using alcohol for children aged 0-14 years

Results of testing for other drugs were not systematically reported in the data sources, however blood levels of prescribed and other drugs sufficient to impair judgement, or a history of such drug consumption, were reported for eight of the deceased (9 per cent) aged 15-64 years. The substances listed included promethazine, toluene, benzene, cannabis, benzodiazepines, morphine, dextropropoxyphene, norpropoxyphene and unspecified ‘medication for epilepsy’. Sniffing petrol or glue
also contributed directly to at least two incidents by increasing the fire load and increasing the likelihood of ignition.

4.1.4.3. Disability

Information about disability was not recorded systematically. However there was mention that ten of the deceased (11 per cent) were living with disability at the time of the fatal fires which claimed their lives. Disabilities included restricted mobility, intellectual disability, psychiatric disability, and significant chronic medical conditions. Three of the deceased living with disability had no detectable blood alcohol, and for the remaining four the alcohol level was not recorded. None of the deceased living with disability had a history of alcohol consumption prior to the incident. Medication prescribed for the condition giving rise to disability may have impaired response for two of the deceased. Four of the ten deceased living with disability died in fires where the likely heat source was discarded cigarettes or smoking materials.

4.1.4.4. Socio-economic deprivation

The New Zealand Index of Deprivation (NZDep96) has been developed and validated in New Zealand as a measure of socioeconomic disadvantage relative to the wider society at small area level. The index combines nine variables from the 1996 census that reflect eight dimensions of deprivation. Demographic factors such as age, gender and ethnicity, are also correlated with adverse outcomes, but are not direct markers of deprivation, and thus not included in the index. Such factors need to be considered alongside socioeconomic deprivation in understanding patterns of disease and injury in a community, and in resource allocation decisions.
NZDep96 provides a deprivation score for each census meshblock in New Zealand. A meshblock is a geographical unit defined by Statistics New Zealand, containing a median of 90 people. The NZDep96 scale runs from 1 to 10, so that a value of 10 indicates the meshblock is in the most deprived 10 per cent of small areas in New Zealand, and a value of 1 indicates the meshblock is in the least deprived 10 per cent of small areas in New Zealand. Area based indices also have the advantage of being applicable to all cases for whom an accurate address is available. In contrast occupational based indices of socioeconomic status require information which is often not available in routinely collected data.

NZDep96 is derived from data in the 1996 census of the New Zealand population. Thus analysis using this tool was restricted to the years closest to the census year, i.e. to the years 1993 to 1997 inclusive. Addresses of the 104 dwellings where fatal unintentional domestic fire incidents occurred in New Zealand from 1993 to 1997 were obtained from the New Zealand Fire Service, and from coroners’ files for incidents not attended by the Fire Service. One hundred (96 per cent) of these addresses were able to be geocoded to census meshblock level and assigned to a decile of socio-economic deprivation using NZDep96. The number of private dwellings at each level of socio-economic deprivation was calculated using data in Supermap2 (Statistics New Zealand, undated) as a denominator. Over the five year period the rate of fatal unintentional fire incidents in the most deprived decile was five times the rate in the least deprived decile, as shown in Figure 4-3.
Figure 4-3. Rate of fatal unintentional fire incidents per 100,000 private dwellings Aotearoa New Zealand 1993-1997 by decile of deprivation as assessed using New Zealand Index of Deprivation 1996. Error bars represent 95% confidence interval.

Data sources: New Zealand Fire Service, Coronal files, Statistics New Zealand

The socio-economic gradient was observed in all age groups, but was less marked for adults aged over 64 years. In the study data set 56 per cent of fatal incidents involving children, 47 per cent of incidents involving adults aged 15-64 years, and 27 per cent of incidents involving adults aged over 65 years occurred in dwellings in the quintile of meshblocks with the highest relative socio-economic deprivation, as assessed by NZDep96.

The question arises as to whether this observation reflects the prevalence of fires per se, or a differential severity of fire outcome. From 1995 to 1997 there were 9345 unintentional residential structural fire incidents recorded in FIRS, of which 79 resulted in one or more deaths, an overall residential structure fire fatality rate of 8.5 deaths per 1000 fires (95% CI 6.6-10.3). Of the 9345 fires, 9320 (99 per cent) were able to be geocoded to census meshblock level and assigned to a decile of socio-
economic deprivation using NZDep96. This time frame was chosen because the New Zealand Fire Service began geocoding all such incidents in 1995. These data used the Fire Service definitions of residential structure, which included dwellings and structures (like caravans) being used as a dwelling. There was a socio-economic gradient for occurrence of residential structure fires in New Zealand between 1995 and 1997 (see Figure 4-4).

Figure 4-4 Rates of unintentional structural residential fire incidents per 100,000 private dwellings Aotearoa New Zealand 1995-1997 by decile of socioeconomic deprivation as assessed using New Zealand 1996 Index of Deprivation. Data sources: New Zealand Fire Service Fire Incident Reporting System, Statistics New Zealand.

For each decile of relative socio-economic deprivation the rate of fatal fires per 1000 unintentional residential structure fires was calculated. As shown in Table 4-6, there was no socio-economic gradient in terms of the fatal outcome per 1000 residential structure fires (p=0.4). The mortality gradient may be explained by a gradient in the overall occurrence of structure fires, rather than a gradient in the severity of such fires.

<table>
<thead>
<tr>
<th>Decile of deprivation</th>
<th>Fatal fires per 1000 structure fires (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.2 (1.9-16.6)</td>
</tr>
<tr>
<td>2</td>
<td>1.6 (-1.6-4.8)</td>
</tr>
<tr>
<td>3</td>
<td>11.1 (3.4-18.7)</td>
</tr>
<tr>
<td>4</td>
<td>8.7 (1.8-15.6)</td>
</tr>
<tr>
<td>5</td>
<td>6.7 (0.8-12.6)</td>
</tr>
<tr>
<td>6</td>
<td>10.6 (4.1-17.2)</td>
</tr>
<tr>
<td>7</td>
<td>3.7 (0.1 – 7.3)</td>
</tr>
<tr>
<td>8</td>
<td>5.2 (1.0 – 9.3)</td>
</tr>
<tr>
<td>9</td>
<td>10.9 (5.2-16.6)</td>
</tr>
<tr>
<td>10</td>
<td>10.4 (5.2-15.7)</td>
</tr>
</tbody>
</table>
4.2. Narrative data

Qualitative research adopts an holistic perspective that preserves and seeks to understand the complexities of human behaviour (Black, 1994). Qualitative methods complement quantitative ones, in helping to “understand social phenomena in natural (rather than experimental) settings, giving due emphasis to the meanings, experiences, and views of all the participants.” (Pope & Mays, 1995). In the context of this study, qualitative analysis allowed for consideration of the wealth of non-quantifiable information contained within the coronial records.

Data used in the descriptive mortality analysis were interrogated more fully to provide greater understanding of the issues involved in unintentional domestic injury from fire and flame. Narrative data in coronial files and Fire Investigation Reports were reviewed in broad age bands to identify issues that might not have been apparent in the quantitative analysis. The narrative data also allowed identification of the most common scenarios resulting in death in unintentional domestic fires in each age group. Quotes from the files are included in the text where relevant to illustrate or identify issues related to the specific demographic group. In order to maintain confidentiality these quotes are identified by the relationship of the speaker to the deceased and the year of the incident. The issue of disruption to usual routine in association with a fatal fire incident was identified in all age groups, and is discussed separately.

4.2.1. Children aged under 15 years

A total of 51 unintentional deaths of children aged under 15 years occurred in 39 unintentional domestic fire incidents from 1991 to 1997. Eleven of these incidents
resulted in multiple child fatalities. Five incidents resulted in multigenerational fatalities where children and at least one parent, grandparent or other adult died in the same incident.

A recurrent theme in accounts of fire incidents involving children was the rapidity with which the fire took hold. Nine children were playing, reading or watching television with a caregiver in close proximity, yet even in these circumstances a fire could take hold to the extent that evacuation of the children was impossible. Caregivers with more than one child were often able to evacuate one or two, but then be unable to return for any children remaining in the dwelling.

*It was quiet, so I thought I would go and check on the children. They had been alone in my room for about seven minutes. In that time I had done some dishes and checked on the washing machine...When I went to my bedroom I could see a lot of black smoke. I couldn’t see any of the children.*

*Caregiver 1993*

*This ugly flame just swept across real fast between me and my children. My children were gone in front of my eyes. I was so close, so close and yet so far.*

*Caregiver 1998*

### 4.2.1.1. Matches and lighters

Between one and three fatal incidents per year had lighters or matches as the ignition source, with an average of two incidents per year. The six fatal fire incidents in stationary motor vehicles occurred when children were playing during the day, and all resulted from play with matches or lighters. A further eight incidents resulted from children playing with matches or lighters in permanent or temporary private dwellings. In five of the 14 incidents where the presumed heat source was matches or lighters there were comments in the files that the deceased or a sibling had previously been known to play with matches or lighters. As this information was not gathered
systematically it is possible that previous play with matches or lighters also occurred in other incidents. Coronial files also indicated that even very young children are capable of striking a match, particularly if they live in a household where matches or lighters are frequently used. Nine of the 14 fatal fire incidents involving children under 15 years which were started by matches or lighters were in households including a smoker; in four incidents the smoking status of the household could not be determined, and one occurred in a non-smoking household. Although in many cases the deceased, or a sibling of the deceased, found the matches or lighters “lying about” in easy reach, the narrative data showed that children had often searched for the ignition source in bedroom or kitchen drawers, or behind drawn curtains.

For some time now I have had a problem with M playing with matches and cigarette lighters. He has a bad habit of playing with them. I have tried to stop him but he keeps doing it. There are several cigarette lighters in the house and although I have been trying to keep them out of his way, he still manages to find them sometimes.

Witness at inquest 1992

The only question then remaining was could a child aged 18 months be capable of lighting a match. There had been a directly related case only one month earlier...the Fire Service attended a fire in a motor vehicle which had been caused by a child of a similar age lighting matches. While many children of this age would be incapable of striking a match this other case was direct evidence that it was possible and it is assumed from enquiries that children brought up in an environment where they have an opportunity to regularly observe adults using matches or cigarette lighters are easily capable of learning the procedure involved.

Witness at inquest 1996

4.2.1.2. Warm but unsafe

Over one quarter of the fatal incidents involving children resulted from heating appliances. The majority of these appliances were electric heaters, but there were also defective fireplaces and gas heaters in the sample. Each year in the series there was at
least one fatal fire involving children under 15 years with a heating appliance as the heat source. The majority of unintentional fatal domestic fire incidents where a heater was the presumed heat source resulted from the heater being in close proximity to combustible materials, usually in a bedroom. Heaters were associated with three of the four fatal caravan fires involving children aged under 15 years. In two cases the heater had been recently purchased from a second-hand dealer, with the presumed intention of making the dwelling warmer, drier and healthier for the children and other members of the household.

*Before I went to sleep I turned the small bar heater on and put it at the foot of the beds. I had recently purchased the heater about two weeks ago from the second hand shop...*

*Caregiver 1991*

4.2.1.3. **Candles**

Candles were associated with five fatal incidents and the deaths of seven children. Three of these incidents associated with use of a candle were in structures without an electricity supply.

4.2.1.4. **Cooking**

Two cooking related fire incidents resulted in five child deaths. Of all heat sources, incidents started from abandoned cooking had the highest number of child fatalities per incident. The cooking related fire incidents involving children were both associated with alcohol consumption by adults in the household.
4.2.1.5. Household composition

Information about household composition was abstracted from coronial files. Adults were present in most of the households when fatal incidents occurred. There were two incidents in which information about household composition could not be obtained. In two incidents the household was crowded, with multiple adults staying overnight. There were 12 incidents (31 per cent) where there was no adult in the same dwelling space as the child fatalities; in eight of these incidents there was at least one adult in an adjacent building. Examples of this were when three children were in a temporary dwelling with a grandparent in a caravan beside the dwelling, or where children were sleeping in a shed or car, with caregivers in an adjacent dwelling.
Table 4-7. Number and percentage of fatal unintentional domestic fire incidents involving New Zealand children aged under 15 years 1991-1997, with number and percentage of deaths in this age group by degree and proximity of caregiver presence. Data sources: New Zealand Fire Service Fire Investigation Reports, Coronal files.

<table>
<thead>
<tr>
<th>Adults present</th>
<th>Number of incidents (%)</th>
<th>Number of fatalities (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 adult in dwelling</td>
<td>11 (28)</td>
<td>18 (34)</td>
</tr>
<tr>
<td>2-3 adults in dwelling</td>
<td>12 (31)</td>
<td>16 (30)</td>
</tr>
<tr>
<td>Many adults in dwelling</td>
<td>1 (1)</td>
<td>1 (2)</td>
</tr>
<tr>
<td>1 adult in adjacent dwelling</td>
<td>4 (10)</td>
<td>6 (11)</td>
</tr>
<tr>
<td>2-3 adults in adjacent dwelling</td>
<td>4 (10)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>No adults in or near dwelling</td>
<td>4 (10)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Unknown</td>
<td>2 (5)</td>
<td>2 (4)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38 (100)</strong></td>
<td><strong>51 (100)</strong></td>
</tr>
</tbody>
</table>

4.2.1.6. Fire scenarios resulting in child fatalities

For the 34 incidents where both the presumed heat source and presumed item ignited were determined, scenarios were developed and ranked according to the number of incidents and the number of fatalities. Scenarios for unintentional childhood death from fire and flame in a domestic location in New Zealand 1991 to 1997 are listed below with the first six scenarios accounting for over three-quarters of the fatalities where both the heat source and item ignited were determined:

- Matches or lighter igniting bedding or combustible materials in dwelling
- Matches or lighter igniting motor vehicle interior
• Heater igniting bedding or combustible materials in dwelling

• Candle igniting bedding or combustible materials in dwelling

• Stove top igniting abandoned cooking materials

• Unsafe discarding of cigarettes or smoking materials with ignition of bedding or combustible materials in a bedroom

• Unsafe construction or maintenance of fireplaces with ignition of wall linings and dwelling structure

• Use of flammable materials such as petrol to revive a dying fire with ignition of clothing

• Overloading of electrical outlets or use of unsafe electrical appliances with ignition of furniture or combustible materials in dwelling.

4.2.2. Youth and adults aged 15-64 years

Although rates of fire-related mortality were lower in the 15-64 age group, this is the age group with the greatest number of fire-related deaths. In the years 1991 to 1997, the study process identified 84 unintentional deaths in 77 unintentional fire incidents, in private dwellings or on private residential property. Seven incidents resulted in multiple fatalities in this age group. Deaths occurred disproportionately among the younger members in this age group, with two-thirds of the 84 adolescents and adults who died aged 15-44 years, and only one-third in the older age group of 45-64 years.

4.2.2.1. Cigarettes and smoking materials

Almost one-third of the incidents, and over a third of the fire-related fatalities involving New Zealanders aged 15-64 years occurred in fires started by cigarettes or
smoking materials. A cigarette was considered the most likely heat source in 19 of the 24 incidents started by cigarettes or smoking materials. For the remainder the broader category ‘smoking materials’ describes the situation where it could not be determined if the cigarette, lighter or matches started the fire. In three incidents incense sticks, electric blanket or a naked flame light source could not be discounted as possible alternative heat sources. Fires ignited by smoking materials were typically preceded by a period of slow smouldering prior to the flaming stage.

*It was suggested by the presence of lighters, ashtrays and cigarettes that the victim was a smoker. As there were no appliances at the point of fire origin, and the point of fire origin was in the approximate area of the victims head, the assumed cause of the fire was that the victim fell asleep with a lit cigarette. In its early stages the fire was of a slow smouldering type ...The smouldering process would have preceded a free burning, flaming fire by no more that 15 minutes.*

*Fire Investigation Report 1997*

*A smouldering cigarette could have been dropped unintentionally on the clothes and smouldered away, then catching fire and spreading to other combustibles in the room. This would account for the deep burning down into the floor boards.*

*Fire Investigation Report 1995*

*The supposed cause I concluded was that the deceased had fallen asleep while smoking a cigarette. The cigarette had then smouldered amongst bedding, releasing large quantities of toxic smoke.*

*Witness testimony 1992*

**4.2.2. Stove tops or ovens**

Over one fifth of the fatal fire incidents and one fifth of fatalities from injury from fire and flame among New Zealanders aged 15-64 years were associated with cooking sources. In three incidents the deceased was directly involved with the fire and in the remainder the cooking source had been abandoned, often while the deceased was
asleep. Alcohol use, confirmed by post-mortem blood alcohol levels or a confirmed history, was associated with 14 of the 17 cooking related fires in this age group (82 per cent).

_It would appear that a pot of food has been put on the stove to heat up. The deceased appears to have fallen asleep. The pot has boiled dry and overheated. The wall lining adjacent has ignited spreading up the wall across the ceiling. There would have been quite a lot of smoke generated by the burning food and also the lining adjacent to the stove._

*Fire Investigation Report 1991*

... *they left the hotel and attended a party before returning home in the early hours of the morning. It appears that they prepared something to eat before going to bed.*

*Fire Investigation Report 1997*

4.2.2.3. Heaters

Almost one fifth of the fatal fire incidents, and a fifth of the fire-related fatalities involving New Zealanders aged 15-64 years resulted from heating appliances. The majority of these appliances were electric heaters, but there were also defective fireplaces, kerosene and solid fuel burners in the sample. One heater was noted to have been purchased second hand shortly before the fatal fire incident. The majority of unintentional fatal domestic fire incidents where a heater or solid fuel burner was the presumed heat source resulted from the heating appliance being in close proximity to combustible materials, usually in a bedroom. In other incidents poor fireplace construction was associated with slow burning of the dwelling structure over time, and inappropriate disposal of solid fuel resulted in ignition of dwelling contents.
...the man returned home about midnight and turned on his two-bar, electric “old-fashioned” heater, which was placed only millimetres from his bedding. “The most likely scenario is that he fell asleep and the squab he was sleeping on caught fire”.

Media report 1994

It was found that some structured timber directly beneath the fireplace had burnt away. This burning had occurred over a period of time. Although the timber was under a concrete fire pad there were cracks in the concrete which permitted transfer of the heat. At some stage of the evening the timber beneath the fireplace began to smoulder. Later on in the evening the smouldering timber reached ignition temperature and began to flame. The V patterns traced the movement of the fire back to beneath the fireplace.

Witness testimony 1993

4.2.2.4. Other electrical appliances

A variety of electric appliances, other than heaters, collectively contributed to around one tenth of the fatal unintentional domestic fire incidents involving New Zealanders aged 15 – 64 years. Such incidents resulted from appliances being left unattended (irons, electric blankets, electric jugs or deep fryers), from kinking of the electric appliance cords, or from some other cause such as overloading of electricity outlets. In one incident slow burning from a faulty electric light fitting had probably been occurring for some time prior to the fire incident.

I believe that the iron was left ‘on’, while it was on the ironing board, it heated to melting point, with the heat from the iron being conducted to the ironing board… I believe the deceased either used the iron and left it ‘on’, or as it was a cold night, put the iron plug in thinking it was the heater; as the remains of the heater were found alongside the iron.

Fire Investigation report 1996

The only probable ignition source in this area was the television set. The extent of burn damage to the set is indicative of a fire having started in the set or in very close proximity to it.

Fire Investigation report 1997
Pursuant to section 15 (1)(b) of the Coroners Act 1988 I make the following recommendations or comments: that purchasers of all electrical appliances should be warned of the potential danger of fire from electric cables which may have been folded for some time prior to purchase.

Coroner 1997

We now know that the downlight had been illuminated for several days leading up to the time of the fire. Given the fact that there is a probability of pyrolising activity under way for some days prior to the fire, the light, having been left on for an extended period, would have been virtually the straw that broke the camel’s back and ignition commenced.

Witness testimony 1997

4.2.2.5. Candles

Candles were the most likely heat source for three incidents. Two of the three incidents occurred in dwellings without an electricity supply. A further incident in a dwelling without electricity, in which smoking materials were considered the most likely source of ignition, could also possibly have been caused by a naked flame light source.

...because the mains power was not connected to the house, candles etc were being used for lighting.

Fire Investigation report 1993

A candle was always taken to the tent for lighting purposes.

Fire Investigation Report 1993

4.2.2.6. Alcohol

As noted in section 4.1.4.2, alcohol was involved in a high proportion of fatal fire-related incidents in this age group. Narrative data provided additional understanding of the way in which alcohol may have influenced the scenario that unfolded by
impairing judgement and abetting the ignition of the fire and by limiting the capacity to take appropriate action once the fire had taken hold (also see section 4.2.4.2).

4.2.2.7. Household composition

Information about household composition was abstracted from coronial files and Fire Investigation Reports. An adult or young person aged over 15 years was recorded as being home alone if this information was clearly recorded in the file. In 33 (43 per cent) of the 76 fatal unintentional domestic fire incidents involving New Zealanders aged 15-64 years the deceased was known to be at home alone at the time of the incident. Other household members were apparently present in most of the remaining incidents. In 1996 23 per cent of the total New Zealand population lived alone. Data for the 15-64 age group could not be obtained separately, as Statistics New Zealand does not cross-tabulate personal demographic and household data for this age group (personal communication, Joanne Alexander, Statistics New Zealand). Three incidents occurred in dwellings which were crowded – with more than five adults present at the time of the fire.
4.2.2.8. Fire scenarios resulting in fatalities aged 15-64 years

For the 65 incidents where both the presumed heat source and presumed item ignited were determined, scenarios were developed and ranked according to the number of incidents and the number of fatalities. Scenarios for unintentional death from fire and flame in a domestic location in New Zealand 1991 to 1997 for adolescents and adults aged 15-64 years are listed below with the first three scenarios accounting for 60 per cent of all fatalities. The disproportionate number of fatalities resulting from smoking materials is observed principally because of the multiple fatality incident in which 5 deaths occurred.

- Cigarettes or smoking materials igniting bedding or combustible materials in dwelling (21 incidents, 26 adult fatalities)
- Stove top or oven igniting unattended cooking materials (14 incidents, 15 adult fatalities)
- Heater or solid fuel burner placed too close to combustible materials and resulting in ignition of bedding or combustible materials in dwelling (10 incidents, 12 fatalities)
- Unattended or malfunctioning electric appliances igniting furnishings or other combustibles in dwelling (7 single fatality incidents)
- Ignition of flammable gas or liquid by naked flame or heat from cigarette lighter, candle, barbecue, or heater (5 single fatality incidents)
- Unsafe construction or maintenance of fireplaces with ignition of wall linings and dwelling structure (2 incidents, 3 adult fatalities)
- Clothing ignitions from cooking or heater (3 single fatality incidents)
- Candle igniting bedding or combustible materials in dwelling (2 incidents, 3 fatalities)
- Unsafe installation or maintenance of electrical wiring with ignition of wall linings and dwelling structure (1 single fatality incident).

4.2.3. Adults aged over 64 years.

There were 49 deaths of people aged 65 and over, as a result of injury from fire and flame in 48 unintentional domestic fire incidents from 1991-1997. These deaths occurred predominantly in the 75-84 age group, although rates were highest among those aged over 85 years.

Among seniors who died in unintentional fire incidents in the study period the most important social factors appeared to be household composition, habitual behaviour, and social and material deprivation. Alcohol did not appear to be a significant issue in this age group, and information on pre-existing disability or use of psychotropic medication was not gathered systematically.

4.2.3.1. Household composition

Almost half of the deceased lived alone (23 people, 47 per cent). In the 1996 census 28 per cent of New Zealanders over the age of 65 years lived alone, suggesting that living alone may be associated with risk of death as a result of injury from fire and flame.
4.2.3.2. Heating appliances

The most striking finding was the high proportion of fires resulting in the death of people aged over 64 years in which the source of ignition was a heating appliance. The vast majority of these fires were started by an electric heater (19 incidents, 40 per cent), with a further three incidents (6 per cent) caused by a gas heater or open fire. In one coronial verdict the coroner highlighted “the dangers of radiant bar heaters, this being the third such fatality in [this local authority] over the last three years” (Coroner September 1995).

4.2.3.3. Impaired judgement

In several instances it was noted that those associated with the deceased had noticed increased fire risk in the dwelling prior to the fatal incident. This applied particularly to regular lifestyle patterns such as smoking in bed, placing heaters close to combustibles such as upholstered furniture or bedding, or placing laundry directly in front of heater to dry. Cigarettes accounted for 18 per cent of the fatal incidents among seniors in this age group and the deceased had often been smoking in bed. Interventions had been limited to a personal level, with advice to desist from the practice. No cases mentioned environmental changes to minimise risk from habitual behaviour.

[Home help provider] advised that [deceased] was forever smoking in bed and it was not uncommon to find upward of 10 cigarette butts in his bedding when she changed the linen.

Fire Service Investigation 440

On past occasions [neighbour] had found cigarettes left lying about the dwelling, which were still alight, that [deceased] had forgotten about.

Fire Service Investigation 446
[Deceased] was a smoker and there had been previous instances of bedding either smouldering or catching fire...

Witness testimony 449

The narrative accounts of incidents indicate that unconventional and inappropriate use of electrical appliances is not uncommon. Examples of such use include leaving an electric blanket switched on (after removing it from a bed before retiring for the night) and leaving it folded on the floor, wrapping oneself in an electric blanket to stay warm while sitting in a lounge chair and falling asleep, using a portable oven as a heat source, and using an electric heater to dry clothing. Such activities may be associated with social and material deprivation through lack of access to affordable or appropriate means of heating.

Post-mortem blood alcohol levels, or verified histories of alcohol consumption on the day of death, were available for 37 (77 per cent) of the deceased. Alcohol was detected in only four of these cases, and then at relatively low levels (less than 100 mg per decilitre). Results of testing for other drugs were not systematically reported in the data sources. However levels of benzodiazepine sleeping medication sufficient to cause drowsiness, or a history of use of sleeping medication were recorded in two cases.

4.2.3.4. Flammable fabrics

Clothing ignitions accounted for one sixth of the fatalities in this age group. Over one third of the fatal fire incidents in this series resulted from ignition of bedding or other combustible materials in a bedroom. Heaters and smoking materials were the most common heat sources.
4.2.4. Social disruption

The term disruption has been coined to describe a theme which recurred throughout the records of fatal fire incidents. Although this information was not gathered systematically, it was inherent within the statements about owners and occupants of dwellings included in most coronial reports. Such circumstances are of course common place, and may have occurred by chance in association with fatal fire incidents. However they may also contribute to risk of death in a fire incident through distraction of adults, through use of makeshift sleeping arrangements (e.g. in stationary vehicles) and through lack of familiarity with the dwelling and means of escape.

4.2.4.1. Children

Eleven of the reports indicated that the household composition or circumstances at the time of the fatal fire incident involving children aged under 15 years were changed from the usual circumstances. These 11 incidents resulted in the deaths of 13 children. Five of the deceased children died in four fire incidents where they were away from their home (staying with friends or relatives). In other cases there were visitors to the family home at the time of the fatal incident.

4.2.4.2. Young people and adults

In the 15-24 age group the term disruption included partying, returning after midnight from social activities, being away from home or having guests staying overnight, or being at home alone because usual household members were absent. Many of these ‘disruptions’ were associated with alcohol consumption.
...deceaseds (sic) had been drinking in company with some friends...They then left the residence of their friends and went a short distance to a cottage where they were living. It then seems that sometime later a fire broke out in this cottage...the fire could have been the result of a cigarette. The deceaseds (sic) appear to have become aware of their predicament, aware of the fire and tried to exit the dwelling. ...at that stage they were both to some degree intoxicated and no doubt also affected by the very volatile situation that they found themselves in, the very stressful situation and the smoke, fire that sort of thing. Unfortunately they did not manage to exit the building.

*Coroner 1994*

The evacuation was slow and disorderly. Three of the four occupants had been drinking heavily prior to the fire. The two male occupants were not familiar with the layout of the premises. All three occupants who were intoxicated had difficulty in escaping. The deceased was trying to evacuate the building, became disoriented and was trapped in the bedroom

*Fire Investigation report 1992*

### 4.2.4.3. Seniors

Disruption was not so evident among seniors, all but one of whom died in their own home. However in this age group recent illness or surgery was noted for three of the deceased.

### 4.2.5. Cooking fires

The unintentional domestic fatal fire series included 20 incidents where food left on a stove top or in an oven ignited. These incidents resulted in 25 deaths, or 14 per cent of the 184 unintentional fatalities from 1991-1997. The deceased were in all age groups from children to seniors. Three of the twenty incidents resulted in multiple fatalities, and two of these multiple fatality incidents involved deaths of children. Rates for males were over two and a half times the rates for females. The excess male deaths occurred predominantly in the 25-64 age group, and the deceased in this age group were predominantly non-Māori. Rates for Māori were eleven times rates for
nonMāori. Māori fatalities occurred disproportionately at younger ages, with seven of the 11 Māori deceased aged under 25 years.

Twelve of the 20 adult deceased lived alone. Almost all of these were males aged over 20 years. Adults were present in all the households where children under 15 years died in fire incidents resulting from ignited cooking materials.

The number of fatal fire incidents caused by abandoned cooking materials has been relatively constant over time, with between one and five incidents per year. Incidents occurred predominantly in the night or early morning (10 p.m. to 6 a.m.) towards the end of the week. There was no seasonal pattern apparent.

In 14 of the 20 fatal incidents there was no functioning smoke alarm in the dwelling. The presence of a smoke alarm was unknown in the remaining six incidents.

In four incidents the burn injuries that led to death were sustained as a result of inappropriate action in dealing with ignited cooking materials. The deceased was in the room at the time, or returned after a brief absence, to find the cooking materials alight. Typically the deceased tried to move the ignited cooking materials, and was burnt by the billowing flames. In the remaining 16 incidents the deceased were thought to have been asleep at the time of the fire, and were often recorded as having impairment or disability limiting ability to detect and contain the fire. In 13 of the 20 fatal incidents the alarm was raised by a neighbour or passer-by when the fire was sufficiently established to be obvious from the outside.

Alcohol was known to be a factor in 12 of the 20 fatal incidents, and in all three of the multiple fatality incidents. Eight of the 15 adult deceased had post-mortem blood alcohol levels in excess of 100 mg per decilitre, and a further four had a confirmed
history of alcohol consumption immediately prior to the fire incident. In addition there was a history of alcohol consumption by the caregivers of all five children who died in fires caused by abandoned cooking materials.

Cooking practices were not recorded systematically. However in eight of the twenty incidents associated with cooking, it was believed that the abandoned cooking had involved cooking with oil or fat. In two cases the abandoned cooking utensil was noted to be an aluminium pot. It is probable that cooking with fat or oil, and using aluminium cooking utensils, pose particular fire risks, especially if household occupants have excess blood alcohol. This assumption is based on observation of the high flammability of fats and oils, and the relatively low temperature at which aluminium melts compared with stainless steel. These factors should be considered separately. Ignition of fat or oil is relatively fast, no matter what type of pot is used; melting and ignition of aluminium utensils occurs more slowly and generally involves food which is being boiled or stewed.
4.3. Non-fatal injury

The demographic details in this section are derived from the complete unintentional domestic fire-related injury hospitalisation dataset. Age and gender data are from the full five years of the study (1996-2000). Due to the limited availability of sole Māori denominator data the calculation of rates by ethnicity is limited to the first three years of the study (1996-1998). Information about the fire incident was available only for cases in the scenario subset (see section 3.6.2 on page 56 for further information about these data). The scenario subset was analysed for the vector characteristics section. Both datasets were analysed for the environmental sections, using in each case the dataset with the most complete information. The specific dataset is named in the text.

The NZHIS data source identified 862 persons admitted to a New Zealand hospital for treatment of injury from fire and flame in the domestic environment, from 1996-2000 inclusive.

4.3.1. Host characteristics

The highest hospitalisation rates for unintentional domestic injury from fire and flame were observed amongst children aged under 5 years, young people and adults aged 15-24 and 25-34 years, and older adults aged over 74 years. Age-standardised male hospitalisation rates for unintentional domestic fire-related injury were at least twice female hospitalisation rates (RR 2.2; 95% CI 1.9-2.5). As shown in Figure 4-5, the disparity between male and female hospitalisation rates was most marked among young people and adults aged 15-24 and 25-34 years and was not statistically significant for adults aged 64-75 and over 75 years.
As can be seen in Table 4-8, almost one third (32 per cent) of the 862 inpatients were children aged under 15 years, half (50 per cent) were aged under 25 years and almost all (91 per cent) of the inpatients were aged under 65 years.

There were also disparities between Māori and nonMāori rates of first admission to hospital for injury from fire and flame at home. From 1996-1998 (using sole Māori denominator), Māori hospitalisation rates were approximately two and a half times those of nonMāori (RR 2.4, 95% CI 1.9-2.9). The disparity between Māori and nonMāori hospitalisation rates for unintentional domestic fire-related injury was most marked for children aged under 15 years and adults aged 25-34 and 35-44 years. Numbers of Māori inpatients aged 45-54 years, 55-64 years and over 65 years were too small in this three year period to calculate stable rates.

Figure 4-5. Age-group specific hospitalisation rates per 100,000 person years for unintentional domestic fire-related injury in Aotearoa New Zealand 1996-2000 by gender. Data sources: New Zealand Health Information Service, Statistics New Zealand
Table 4-8. Number and percentage of age-group specific hospitalisations and age standardised hospitalisation rates per 100,000 person years for unintentional domestic injury from fire and flame resulting in hospital inpatient treatment Aotearoa New Zealand 1996-2000. Data source: New Zealand Health Information Service

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Hospitalisations n (%)</th>
<th>Rate (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>143 (17)</td>
<td>9.9 (8.3-11.5)</td>
</tr>
<tr>
<td>5-14</td>
<td>128 (15)</td>
<td>4.4 (3.6-5.1)</td>
</tr>
<tr>
<td>15-24</td>
<td>164 (19)</td>
<td>6.1 (5.2-7.0)</td>
</tr>
<tr>
<td>25-34</td>
<td>170 (20)</td>
<td>5.9 (5.0-6.8)</td>
</tr>
<tr>
<td>35-44</td>
<td>99 (11)</td>
<td>3.4 (2.7-4.0)</td>
</tr>
<tr>
<td>45-54</td>
<td>43 (5)</td>
<td>1.8 (1.3-2.4)</td>
</tr>
<tr>
<td>55-64</td>
<td>39 (5)</td>
<td>2.4 (1.7-3.2)</td>
</tr>
<tr>
<td>65-74</td>
<td>25 (3)</td>
<td>2.0 (1.2-2.8)</td>
</tr>
<tr>
<td>75+</td>
<td>51 (6)</td>
<td>5.3 (3.9-6.8)</td>
</tr>
<tr>
<td>Total/Overall</td>
<td>862 (100)</td>
<td>4.9 (4.6-5.2)*#</td>
</tr>
</tbody>
</table>

*Rate per 100,000 person years #Age-standardised rate per 100,000 person years

4.3.2. Vector characteristics

4.3.2.1. Heat source

The source of ignition was unable to be determined in 129 (25 per cent) of the 512 inpatients in the scenario data subset. Among incidents where the most likely cause was determined, the most common heat sources for unintentional domestic fire-related hospitalisations in Aotearoa New Zealand 1996-2000 were heating appliances (including electric heaters, gas heaters, solid fuel burners and open fires), stove tops or
ovens, lighters or matches, and other electric appliances such as electric blankets, toasters or lamps. Outdoor fires, including the use of incinerators were associated with 31 hospitalisations, and outdoor cooking fires such as barbecues, hangi, and fish smokers were associated with a further 14 hospitalisations. Together these outdoor heat sources accounted for 9 per cent of the hospitalisations. Home use of service or maintenance equipment such a welding irons and gas torches (often associated with a workplace rather than a home), also contributed to the unintentional domestic fire-related injury toll, accounting for 6 deaths (1 per cent), as shown in Table 4-9.
Table 4-9. Number and percentage of unintentional domestic fire-related hospitalisations by age group and presumed heat source, Aotearoa New Zealand 1996-2000. Data sources: New Zealand Fire Service, New Zealand Health Information Service

<table>
<thead>
<tr>
<th>Heat source</th>
<th>Under 15</th>
<th>16-64</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stove top/ oven</td>
<td>25 (17)</td>
<td>69 (22)</td>
<td>8 (17)</td>
<td>102 (20)</td>
</tr>
<tr>
<td>Heater/ solid fuel burner/ open fire</td>
<td>21 (14)</td>
<td>55 (17)</td>
<td>12 (25)</td>
<td>88 (17)</td>
</tr>
<tr>
<td>Lighter/ matches</td>
<td>28 (19)</td>
<td>36 (11)</td>
<td>2 (4)</td>
<td>66 (13)</td>
</tr>
<tr>
<td>Other electric appliance/ wiring</td>
<td>9 (6)</td>
<td>20 (6)</td>
<td>6 (13)</td>
<td>35 (7)</td>
</tr>
<tr>
<td>Outdoor fire</td>
<td>10 (7)</td>
<td>20 (6)</td>
<td>1 (2)</td>
<td>31 (6)</td>
</tr>
<tr>
<td>Other open flame</td>
<td>10 (7)</td>
<td>10 (3)</td>
<td>1 (2)</td>
<td>21 (4)</td>
</tr>
<tr>
<td>Cigarette</td>
<td>3 (2)</td>
<td>14 (4)</td>
<td>3 (6)</td>
<td>20 (4)</td>
</tr>
<tr>
<td>Outdoor cooking</td>
<td>7 (5)</td>
<td>4 (1)</td>
<td>3 (6)</td>
<td>14 (3)</td>
</tr>
<tr>
<td>Fuelled or power equipment</td>
<td>-</td>
<td>5 (2)</td>
<td>1 (2)</td>
<td>6 (1)</td>
</tr>
<tr>
<td>Unknown</td>
<td>33 (23)</td>
<td>85 (27)</td>
<td>11 (23)</td>
<td>129 (25)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>146 (100)</strong></td>
<td><strong>318 (100)</strong></td>
<td><strong>48 (100)</strong></td>
<td><strong>512 (100)</strong></td>
</tr>
</tbody>
</table>

4.3.2.2. Item ignited

The item ignited was available for almost all (90 per cent) of the 512 hospital admissions for unintentional domestic fire-related injury in the scenario data subset (see Table 4-10). Clothing ignitions (160 inpatients; 30 per cent) or direct contact with the heat source (43 inpatients; 8 per cent) accounted for over one third of such injuries. One fifth (115 inpatients, 22 per cent) of the 512 hospitalisations involved
flammable gas or liquid; 60 (12%) directly and 55 (11%) also involving clothing. Cooking materials were the item ignited in a further 81 inpatients (16 per cent), with the use of cooking oil or fat noted in the event description field in almost half of these inpatients (34 inpatients; 42 per cent of cooking material ignitions). Other items frequently ignited were bedding materials and other bedroom combustibles, combustible materials in lounge including upholstered furniture, and interior fitted furnishings such as carpets, curtains or wall linings.
### Table 4-10. Number and percentage of unintentional domestic fire-related hospitalisations by age group and item first ignited, Aotearoa New Zealand 1996-2000. Data sources: New Zealand Fire Service, New Zealand Health Information Service

<table>
<thead>
<tr>
<th>Item ignited</th>
<th>Under 15</th>
<th>16-65</th>
<th>65+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clothing</td>
<td>45 (31)</td>
<td>102 (32)</td>
<td>13 (27)</td>
<td>160 (31)</td>
</tr>
<tr>
<td>Cooking material</td>
<td>19 (13)</td>
<td>54 (17)</td>
<td>81 (17)</td>
<td>81 (16)</td>
</tr>
<tr>
<td>Flammable gas or liquid</td>
<td>23 (16)</td>
<td>34 (11)</td>
<td>3 (6)</td>
<td>60 (12)</td>
</tr>
<tr>
<td>Direct contact</td>
<td>17 (12)</td>
<td>21 (7)</td>
<td>5 (10)</td>
<td>43 (8)</td>
</tr>
<tr>
<td>Bedding/combustibles bedroom</td>
<td>7 (5)</td>
<td>22 (7)</td>
<td>6 (13)</td>
<td>35 (7)</td>
</tr>
<tr>
<td>Other combustibles</td>
<td>10 (7)</td>
<td>20 (6)</td>
<td>2 (4)</td>
<td>32 (6)</td>
</tr>
<tr>
<td>Structural/interior furnishings</td>
<td>8 (5)</td>
<td>14 (4)</td>
<td>5 (10)</td>
<td>27 (5)</td>
</tr>
<tr>
<td>Upholstered furniture/combustibles lounge</td>
<td>3 (2)</td>
<td>8 (3)</td>
<td>1 (2)</td>
<td>12 (2)</td>
</tr>
<tr>
<td>Non upholstered furniture</td>
<td>1 (1)</td>
<td>6 (2)</td>
<td>-</td>
<td>7 (1)</td>
</tr>
<tr>
<td>MV interior</td>
<td>2 (1)</td>
<td>3 (1)</td>
<td>-</td>
<td>5 (1)</td>
</tr>
<tr>
<td>Unknown</td>
<td>11 (8)</td>
<td>34 (11)</td>
<td>5 (10)</td>
<td>50 (10)</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>146 (100)</strong></td>
<td><strong>318 (100)</strong></td>
<td><strong>48 (100)</strong></td>
<td><strong>512 (100)</strong></td>
</tr>
</tbody>
</table>

#### 4.3.3. Physical environment

The physical environment influences the potential for an unintentional domestic fire to start, the spread of the fire and the ability of dwelling occupants to evacuate and avoid serious injury. Key aspects of the physical environment are the outdoor climate and
the presence or absence of domestic smoke alarms which could alert dwelling occupants to fire in the initial stages.

4.3.3.1. Climate

Climate was inferred from the month of occurrence of the fire incidents resulting in unintentional domestic fire-related injury. Seasonal variation in hospitalisation rates for unintentional domestic injury from fire and flame was not marked, although there were slightly more study inpatient admissions in the winter months June-August compared with other months.

4.3.3.2. Domestic smoke alarms

Data concerning the room of origin of the unintentional domestic fire incident, and data concerning smoke alarms, were available only in the FIRS database. The findings are therefore based only on the actual linked data (175 domestic inpatients). Information about the presence or absence of smoke alarms was entered in FIRS data for only eight inpatients, and mentioned in one NZHIS record. It was reported that domestic smoke alarms alerted occupants in 5 unintentional domestic fire incidents resulting in hospital inpatient treatment of a household member. In one further case an alarm operated but did not alert the occupants. There were three incidents where an installed alarm did not function. The reason for such non-function was not specified. In the remaining 166 cases (95 per cent) no information about alarm presence or performance was recorded.
4.3.4. Social environment

Over half the 175 linked unintentional domestic fire-related injuries resulting in hospitalisation occurred on a weekend. Unintentional domestic fire-related injuries also occurred more commonly in the night and evening, with one fifth of the injuries occurring between midnight and 3 a.m., and one sixth between 9 p.m. and midnight.

4.3.4.1. Alcohol misuse

There was little information concerning alcohol involvement entered into the NZHIS injury records. However in 23 of the 862 study inpatients (4 per cent) a diagnosis indicating current misuse of alcohol was included in the record. It is very probable that this is a considerable underestimate, bearing in mind that alcohol was involved in 30 per cent of fire-related fatalities.

4.3.4.2. Tobacco use

As noted in the fire characteristics section, cigarettes were the heat source for 4 per cent of the hospitalisations in the scenario data subset. In 99 (11 per cent) of the 862 inpatients the NZHIS inpatient record included a diagnosis of current tobacco use. This does not necessarily imply that the tobacco use was relevant to the admission, nor to the event resulting in injury. As with alcohol, it is almost certainly an underestimate of the prevalence of tobacco use among those injured by fire and flame. In the 1996 census 25 per cent of adults reported that they were regular smokers.

It is also important to note that tobacco use in a household increases the availability of matches and cigarette lighters, which were a principal heat source for unintentional domestic fire-related injury among children aged under 15 years.
4.3.5. Fire scenarios resulting in non-fatal injury

Identification of scenarios, similar to that undertaken for fatal injury, was undertaken for the subset of hospitalisation data that could be linked to FIRS records, using the free text field in the NZHIS data. There was no source of more detailed narrative data for nonfatal injury. Scenarios describing the heat source and item ignited were developed and ranked according to the number of casualties requiring hospitalisation. Scenarios could be broadly grouped into those where the casualty was in immediate contact with the heat source or item ignited, and those where neither the heat source nor the item ignited was in immediate contact with the casualty. Almost half (47 per cent) of the 512 inpatients in the scenario subset were injured through direct contact or contact of clothing with the heat source. In 18 cases a fall was noted as integral to the fire-related injury. For example the injured person fell into burning embers or fell against a solid fuel or electric heater. Incident scenarios for study inpatients are listed below.

The largest single group of admissions was clothing ignitions with unspecified heat source (100 admissions, 20 per cent).

Stovetop or oven igniting cooking materials accounted for 79 hospitalisations (15 per cent). In two cases the heat source for ignition of cooking materials was unknown. Cooking with fat or oil was specifically mentioned in 34 (42 per cent) of the cooking fires.

- Heater causing burn through direct contact or ignition of clothing accounted for 49 (10 per cent) of hospitalisations.
• Naked flame from matches, lighters or candles igniting bedding, upholstered furniture, curtains or motor vehicle interiors accounted for 36 hospitalisations (7 per cent).

• Outdoor fires for rubbish, warmth or cooking causing burns through direct contact or ignition of clothing accounted for 30 hospitalisations (6 per cent). Misuse of flammable gas or liquid (most commonly petrol) was specifically mentioned in 21 (70 per cent) of the hospitalisations as a result of outdoor fires. There were an additional two incidents where barbecues ignited the exterior wall of the dwelling.

• Means of heating (electric or gas heater, solid fuel burner or open fire) igniting bedding, upholstered furniture, carpet or other combustibles accounted for 24 hospitalisations (5 per cent).

• Naked flame from matches, lighters or candles causing burn through direct contact or ignition of clothing accounted for 23 hospitalisations (4 per cent).

• Naked flame from matches or lighters igniting flammable gas or liquid accounted for 18 hospitalisations (4 per cent).

• Electrical appliances other than heaters (e.g. electric blankets or lamps) igniting bedding, upholstered furniture or other combustible accounted for 19 hospitalisations (4 per cent).

• Stovetops or toasters causing burns through ignition of clothing or direct contact accounted for 18 hospitalisations (4 per cent).

• Cigarettes igniting bedding, upholstered or non-upholstered furniture or other combustibles accounted for 14 hospitalisations (3 per cent).
• Means of heating igniting flammable gas or liquid accounted for 10 hospitalisations (2 per cent). It is probable that some of these were malfunctioning gas heaters, and in other cases solvents were being used in proximity to the heat source.

• Cigarettes caused burns through ignition of clothing or direct contact in 5 incidents (1 per cent)

• Fuelled equipment such as welding torches or electric grinders igniting flammable gas or liquids, or other combustibles, accounted for 3 hospitalisations (1 per cent).

• Stove tops igniting flammable liquids or other combustibles led to 3 admissions (1 per cent).
5. Discussion of descriptive study findings

5.1. Principal findings

From 1991-1997 inclusive there were 184 deaths in 154 unintentional domestic fire incidents in Aotearoa New Zealand. From 1996-2000 inclusive there were 862 first admissions to public hospitals in Aotearoa New Zealand for inpatient treatment of injury from fire and flame in a domestic location.

Disparities in fire-related injury rates were observed at an individual level related to age, gender and ethnicity.

The highest age-specific mortality rates were observed among seniors aged over 64 years and pre-school children. The highest age-specific rates of admission to hospital for inpatient treatment of injury from fire and flame at home were observed among pre-school children, young people and adults aged 15-24 and 25-34 years, and seniors aged over 74 years.

There was a slight excess of male deaths compared with female deaths, which was most marked for children aged under 5 years. Gender disparities in rates of admission to hospital for inpatient treatment of injury from fire and flame were most evident among young people and adults aged 15-24 and 25-34 years, with an excess of males compared with females.

There was a marked difference between Māori and nonMāori mortality rates, which was particularly marked among children. Māori rates of admission to hospital for
inpatient treatment of injury from fire and flame were higher than non-Māori rates, and this disparity was most marked for children and for adults aged 25-44 years.

Small area analysis demonstrated socio-economic gradients for occurrence of residential structure fires, and for rates of fatal unintentional fire incidents per 100,000 private dwellings with higher risk of fatal residential fire incidents in areas of relative socio-economic deprivation.

In the New Zealand context, the most common items directly linked to the occurrence of unintentional domestic fire incidents resulting in fatal injury were smoking materials (including matches, lighters, and discarded cigarettes), heaters and open fires, cooking appliances, other electric appliances and candles. The latter were particularly important as a heat source among children living in dwellings without an electricity supply. However the most common heat sources for fatal fires involving children were matches and cigarette lighters. Six such incidents occurred when a child was playing with smoking materials in a stationary motor vehicle.

The same items were linked to the occurrence of unintentional domestic fire incidents resulting in non-fatal injury. However almost half of the admissions to hospital resulted from direct contact with fire and flame, or clothing ignitions. Care must be taken in the interpretation of this observation, as it is based on a subset of 512 cases, only 59 per cent of the cases hospitalised. Misuse of petrol, or other highly flammable substances was also strongly associated with unintentional, non-fatal, domestic injury from fire and flame.
5.2. Strengths and weaknesses of the study

The collation of disparate data sources is a key strength of the mortality component of this study. Combining records in this way resulted in a more comprehensive dataset than was available previously, and reduced error. For example, review of coronial files enabled independent assessment of the cause of death. The inclusion of data extracted from the coroners’ files provided important information that would not otherwise have been available. In particular, data on alcohol blood levels and alcohol misuse was recorded only in the coroners’ files. Another feature of this study was the inclusion of narrative data, which enabled a depth of understanding that would not have been achieved by analysis of numerical data alone. The observations concerning disruption to usual routine and children playing in stationary motor vehicles with smoking materials were made only through perusal of narrative data.

The rich detail available about each fatal fire incident provided the opportunity to look at fatal incidents from different vantage points. This detail allows tailoring of fire safety campaigns not only by age group, but also to address specific issues, such as cooking, or heating, or play with matches.

Data issues also contribute to weaknesses of the study. Missing data in all datasets mean that the magnitude of observed differences is subject to possible selection bias. The almost complete lack of data concerning presence or absence of a smoke alarm in affected dwellings means it was not possible to make any comment on the effectiveness of the key fire safety strategy promoted in New Zealand. Data about smoke alarms in fatal fires will be even more important in future, as smoke alarm prevalence rises and consideration will need to be given not only to presence or absence of an alarm, but to the relative benefits of different types of alarm.
The inability to link hospitalisation data with fire service data significantly limited the depth of analysis of the non-fatal injury data. Reviewing these data also underscored the value of the narrative data available for fatal injury. With the short free text field in NZHIS data as the only available narrative information about the circumstances leading to non-fatal injury from fire and flame there was a noticeable deficit in the quality of the information obtained.

The descriptive nature of the study is a further key limitation. For factors such as age, gender and ethnicity, census data provide a total population control for analytic purposes. With other factors there are no control data, and thus limited capacity to be analytic. It is uncertain whether or not the observed behaviours are more common among those who experience fire-related injury, compared with members of the same population groups who do not experience such injury. Further analytic studies (case-control or case-crossover) could be designed to test hypotheses generated from this descriptive study. In the context of limited research resources, however, it is arguable that investment must also be placed in prospective studies to determine which interventions are most effective in reducing injury. This can be an iterative process, testing interventions on the basis of current knowledge and then developing new approaches as new information becomes available.

5.3. Relationship to other studies

5.3.1. Child deaths

The pattern of increased mortality risk among pre-schoolers has been noted internationally (Barillo & Goode, 1996; Marshall et al., 1998; Mierley & Baker, 1983;
As such young children are unable to initiate improved fire safety practices themselves, it is essential that passive intervention strategies continue to be developed to prevent deaths and injuries of these youngest citizens. For very young children the gender disparities in fire-related injury rates are consistent with the observation that male children are at greater risk of death from all causes of injury in developed countries.

...being born male or female can be an even bigger factor in the risk of injury death than the country of birth. A boy born in the United States or New Zealand, for example, has a higher chance of dying from injury in childhood than a girl born in Mexico.

UNICEF, 2001

Some recent interesting work from the USA has noted increased use of fire and flames in the marketing of toys to boys but not to girls (Curri et al., 2003). Although a review of injury prevention messages (positive or negative) in ‘family movies’ did not include consideration of fire safety (Pelletier et al., 2000), personal observation by the author, sensitized as a result of this doctoral work, has identified instances of directed, destructive and/or uncontrolled fire being used within such movies, often to apparently comic effect without portrayal of serious injury, nor of the personal and family consequences of property destruction. Examples include the movies ‘Wild Wild West’ ‘Secret Agent Cody Banks’ and ‘Kangaroo Jack.’ In these examples, the ‘perpetrator’ of the fire was most often male. There is scope for further sociological research to more fully understand determinants of the observed gender disparity in fire-related injury rates, particularly among children and young adults.

One of the most striking observations in this study was the high proportion of childhood fire deaths caused by play with matches or lighters. Similar findings were reported in an account of child fatalities in Scotland, where 30 per cent of house fires
in which children died were started by children playing with matches or lighters or other heat sources (Squires & Busuttil, 1995). A mandatory product safety standard for cigarette lighters (requiring them to be child resistant) was introduced in New Zealand in 1998 (Ministry of Consumer Affairs, 1998). In the 1999-2000 corporate year FIRS data recorded two fatal incidents resulting from the use of matches and none from the use of lighters (personal communication, Roger Chang, New Zealand Fire Service, March 2001). Further monitoring of the impact of cigarette lighter legislation on childhood deaths from fire and flame will provide valuable injury prevention data. However a significant proportion of incidents in the current series resulted from play with matches rather than lighters. The observation that children are capable of using matches at a very young age raises the possibility of requiring matches to be packaged in a child resistant manner, as recommended in Scotland:

If it is inevitable that the behaviour of a child cannot be observed and regulated on a continual basis, it follows that the environment in which a child is free to act should be rendered as objectively safe as possible...The most frequently observed example of an unsafe environment was access to matches...It is interesting to note that whereas prescribed medicines are available in childproof containers, parents usually keep matches in flimsy cardboard boxes.

Squires and Busittil (1995)

The phenomenon of fire incidents resulting from children playing in stationary motor vehicles has been reported in Australia (Byard, Lipsett, & Gilbert, 2000) but has not been reported in literature from other countries. The proportion of fatal childhood fire incidents in parked cars in the present study (15 per cent) is similar to the finding that three of the 23 deaths (13 per cent) of children aged 0-16 years in South Australia from 1989 to 1998 occurred when children were playing in stationary motor vehicles (Byard et al., 2000). Removal of all smoking materials from motor vehicles, and restricting access of children to parked vehicles, would reduce the risk of fatal fire
incidents resulting from ignition of motor vehicle interiors while playing with matches or lighters. There is also scope for further enquiry into patterns of vehicle use in relation to children. Are antipodean children more likely to be left in motor vehicles, or to have access to unlocked vehicles in which to play, than children in other countries? New Zealand housing remains predominantly detached dwellings with surrounding sections on which to park vehicles, which may mean children have more access to stationary vehicles than in apartment style dwellings with enclosed garaging. Patterns of transport with high use of private cars and inadequate provision of recreational space for children so that stationary vehicles are used as ‘play space’ may also contribute to the more frequent occurrence of injury from fires in stationary cars in Australia and New Zealand.

5.3.2. Alcohol, tobacco and other drugs

The observation that there was evidence of alcohol misuse in 69 per cent of fatal domestic fire-related incidents affecting young people and adults aged 15-64 years is consistent with other studies. In Australia, Ridolfo & Stevenson (2001) have identified fire injuries as both alcohol-related and tobacco-related causes of death and principal diagnoses on hospital admission. They cite a previous study by English et al, in which five blood alcohol case series were used to estimate an aetiological fraction of 0.44 for alcohol use. An aetiological fraction indicates the degree to which an identified factor contributes to a specified outcome within a population. In this case it means that alcohol use was estimated to contribute to 44 per cent of fire injuries.
English attributed partial aetiological fractions of between 0.31 and 0.5 to harmful and hazardous alcohol use; compared with moderate use of alcohol. English et al also used six case series of fire injuries to estimate an aetiological fraction of 0.23 for tobacco. These estimates are consistent with the observation, in the current study, that alcohol misuse was known to have been involved in 30 per cent of fatal unintentional fire deaths (with presence or absence of alcohol unknown in a further 35% of such incidents) and that tobacco was known to have been directly involved in 21 per cent of fatal incidents.

Alcohol, of course, is associated with many causes of injury. In a climate of limited research resources, it is even more imperative to identify strategies which could reduce the injury toll associated with alcohol. In contrast with chronic medical conditions, the risk of injury is principally associated with patterns of alcohol consumption, rather than long-term daily intake (McLeod, Stockwell, Stevens & Phillips, 1999). The case-crossover study design is particularly useful in investigating the role of acute effects of alcohol on injury occurrence (Humphrey, Casswell & Han, 2003; Vinson et al, 2003). These studies conclude that prevention efforts will need to focus not only on overall alcohol use, but also on amount consumed at each drinking session. Dawson (2001) used a prospective cohort study design to find that, over a seven and a half year period, risk of death from external causes was greatest for those who, at baseline, reported drinking less than once a month but drank over three drinks on each occasion, and those who drank two drinks or more at least twice a week. The role of alcohol use by caregivers is a key area requiring more information, as is the role of alcohol in deaths of young people (Rivara, 1998). The injury prevention response in relation to children and young people suggested by Rivara (1998) is also relevant to older age groups:
• Surveillance to determine the involvement of alcohol by testing all injury patients, whatever their age

• Routine use of screening instruments to identify adults and young people at risk of alcohol abuse and dependency

• Wider use of brief interventions for problem drinkers. These have been associated with halving the occurrence of repeat trauma inducing events, in a randomised controlled trial.

• Implementation of effective legislation to reduce drunk driving.

There is both genetic (Bierut, Schuckit, Hesselbrock & Reich, 2000) and behavioural (Little, 2000) evidence of a strong link between alcohol and tobacco use. It is not clear, from the description given by Ridolfo & Stevenson (2001), how the interaction between alcohol and smoking was addressed.

As noted in Chapter 2, an investigation by Ballard et al (1992) concluded that cigarette smoking was the underlying risk factor in such incidents. Clearly hazardous consumption of alcohol alone cannot cause a fatal fire. There must be a concurrent heat source. In addition to discarded cigarettes, abandoned cooking was also a significant heat source, in the current series, for fatal unintentional domestic fire incidents associated with alcohol misuse. Further investigation of the relationship between alcohol and smoking and fire-related fatalities is necessary to determine precisely the relative contribution of each. This question is not just of academic interest, but will provide important baseline data against which to assess the effects of intervention strategies and thus contribute to the pragmatic goal of reducing the fire-related injury toll.
It is probable that these factors contribute both individually and influence each other. For example lifestyle factors such as smoking and drinking alcohol tend to go together, and a smoker is more likely to fall asleep after drinking alcohol than when sober. Similarly an appetite for fried food is often stimulated by consumption of alcohol, leading to more risky cooking behaviour.

Within the current series the category ‘cigarettes or smoking materials’ was the most common ignition source. International studies listed in Table 5-1, although based on different population groups and using different definitions of injury, consistently show that a significant proportion of fire-related injuries are associated with cigarette use. Households which experience a fatal fire are more likely to include smokers than households which do not experience a fatal fire (Ballard, Koepsell, & Rivara, 1992). Fires started by discarded cigarettes disproportionately result in fatalities; a fatal fire is approximately 7.7 times more likely than a non-fatal fire to have been started by smoking materials (Runyan et al., 1992). Interest in a fire-safe cigarette goes back to the 1920s in the US Congress, and emerged again in the 1970s (Botkin, 1988). Reducing ignition potential of abandoned cigarettes is likely to be a cost effective fire safety strategy. A US study estimated the unit cost to be $US0.0001 per pack of cigarettes, and the total benefits per pack to be $US0.05 – a benefit-cost ratio of 505. This was the highest benefit-cost ratio of 84 injury prevention measures reviewed by Miller & Levy (2000). Appendix 2 reports collaborative work carried out by the candidate and colleagues, suggesting that roll-your-own cigarettes provide a naturally occurring standard for the ignition potential of cigarettes. Such products pose a demonstrably lower ignition risk than manufactured cigarettes, and comprise 25% of the tobacco consumed by New Zealand smokers. Remarkably, rerolling the tobacco from manufactured cigarettes into roll-your-own papers reduced the ignition
propensity to that similar to the hand-rolled product. Thus it ought to be very easy for tobacco companies to modify the design of their products to minimise the fire risk. Regulations to this effect have been introduced in New York State, Canada and Ireland. A key advantage of regulating cigarettes is their short life span since they are manufactured to be consumed and replaced constantly (Halbert, 1999). Thus any impact of reducing ignition potential would be reflected in fire incidence within a relatively short time frame.
### Table 5-1. Studies reported in international literature showing proportion of fires started by cigarettes

<table>
<thead>
<tr>
<th>Years</th>
<th>Location</th>
<th>Injuries attributable to cigarettes or smoking materials</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973-1974</td>
<td>USA, Baltimore</td>
<td>40 per cent of fires with casualties, and 65 per cent of fatal fires, were due to ‘careless smoking’ as determined by the fire investigator’s office.</td>
<td>(Levine &amp; Radford, 1977)</td>
</tr>
<tr>
<td>1976-1978</td>
<td>USA, Baltimore</td>
<td>55 per cent of fatal fires attributed to cigarettes</td>
<td>(Mierley &amp; Baker, 1983)</td>
</tr>
<tr>
<td>1978-1987</td>
<td>New Zealand, National</td>
<td>37.3 per cent of adult fatalities in residential fires resulted from ‘smoking materials’</td>
<td>(Waller, Marshall, &amp; Langley, 1998)</td>
</tr>
<tr>
<td>1978-1987</td>
<td>Germany, Hanover</td>
<td>37 per cent of accidental burn or fire deaths were from smoking</td>
<td>(Leistikow, Martin, &amp; Milano, 2000)</td>
</tr>
<tr>
<td>1980-1990</td>
<td>Scotland, National</td>
<td>Smoking materials accounted for 52 per cent of fatal fires with victims under 75 years and 34 per cent of fatal fires with victims over 75 years.</td>
<td>(Elder, Squires, &amp; Busuttil, 1996)</td>
</tr>
<tr>
<td>1985-1991</td>
<td>USA, New Jersey</td>
<td>Smoking or smoking materials accounted for 41 per cent of fatal fires.</td>
<td>(Barillo &amp; Goode, 1996)</td>
</tr>
<tr>
<td>Year(s)</td>
<td>Location</td>
<td>Incident Description</td>
<td>Reference</td>
</tr>
<tr>
<td>---------</td>
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<td>---------------------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>1986-1987</td>
<td>USA, King County, Washington</td>
<td>Households with a smoker present were between 3 and 8 times more likely to experience a fatal or non-fatal residential fire injury compared with households with no smokers present.</td>
<td>Ballard et al., 1992</td>
</tr>
<tr>
<td>1988-1989</td>
<td>USA, North Carolina</td>
<td>Smoking was the cause of 31 per cent of fatal fires and 6 per cent of non-fatal fires.</td>
<td>Runyan et al., 1992</td>
</tr>
<tr>
<td>1988-1993</td>
<td>Denmark</td>
<td>Smoking was the ignition source for 51 per cent of home fire fatalities</td>
<td>Leistikow et al., 2000</td>
</tr>
<tr>
<td>1989</td>
<td>Austria</td>
<td>Cigarettes and matches ignited 4.1 per cent of “significant fires”</td>
<td>Leistikow et al., 2000</td>
</tr>
<tr>
<td>1989</td>
<td>Holland</td>
<td>Smoking materials ignited 4.5 per cent of building fires, and were “the leading cause of fire deaths.”</td>
<td>Leistikow et al., 2000</td>
</tr>
<tr>
<td>1989</td>
<td>UK</td>
<td>Smoking materials and matches caused 37 per cent of home fire deaths and 26 per cent of all fire deaths</td>
<td>Leistikow et al., 2000</td>
</tr>
<tr>
<td>1990</td>
<td>Hungary</td>
<td>Smoking caused 14 per cent of “fires with losses” and 40 per cent of all fire deaths.</td>
<td>Leistikow et al., 2000</td>
</tr>
<tr>
<td>Year</td>
<td>Location</td>
<td>Details</td>
<td>Source</td>
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<tr>
<td>1990-1995</td>
<td>Australia, Victoria</td>
<td>42 per cent of non-intentional fatal fire incidents were caused by smoking, including the careless disposal of cigarettes. In the same series 46 per cent of the fatalities were attributable to smoking.</td>
<td>(Brennan, 1998)</td>
</tr>
<tr>
<td>1993</td>
<td>Australia</td>
<td>25 per cent of fire injuries caused by smoking materials</td>
<td>(Leistikow et al., 2000)</td>
</tr>
<tr>
<td>1994-1995</td>
<td>UK, Manchester and Midlands</td>
<td>Smoking materials were responsible for 41 per cent of fatal fires in a twelve-month period. In contrast 13 per cent of all fires not just fatal fires were started by smoking materials in 1993.</td>
<td>(Reynolds, 1997)</td>
</tr>
<tr>
<td>1995</td>
<td>Taiwan</td>
<td>17 per cent of fires from smoking</td>
<td>(Leistikow et al., 2000)</td>
</tr>
<tr>
<td>1996</td>
<td>Japan</td>
<td>Cigarettes caused 21 per cent of residential fire deaths</td>
<td>(Leistikow et al., 2000)</td>
</tr>
<tr>
<td>1996-1997</td>
<td>UK, London</td>
<td>18 per cent of fire related injuries occurring in occupied dwelling that resulted in emergency department visit, hospitalisation, or death were caused by cigarettes.</td>
<td>(DiGuiseppi et al., 2000)</td>
</tr>
<tr>
<td>Year</td>
<td>Country</td>
<td>Description</td>
<td>Source</td>
</tr>
<tr>
<td>------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td>For non-fatal casualties the injury rate was highest for fires caused by smokers’ materials and matches (367 casualties per 1000 fires).</td>
<td></td>
</tr>
</tbody>
</table>
5.3.3. Seniors

Those aged over 65 years are a vulnerable population group which is likely to increase in size with ageing of the population (Gulaid, Sacks, & Sattin, 1989). Seniors who die in fire incidents are less likely to be smokers, and more likely to be in a fire caused by faulty or misused electrical items such as electric blankets or heaters (Elder, Squires, & Busuttil, 1996; Reynolds, 1997). Living alone increases fire-related mortality risk for older people, particularly individuals with physical or cognitive impairment. The presence of a functioning smoke detector lowers risk of death for both impaired and non-impaired individuals by about 70% (Marshall et al., 1998).

The finding that 47 per cent of fire-related fatalities among seniors in New Zealand had heating appliances as the heat source differs from overseas studies where heating appliances account for a lower proportion of fatal fires. In the USA for example, 18 per cent of fatal fires among citizens 65 years and over in 1998 were attributed to heating (U.S. Fire Administration, 2001a). In the USA heating fires are more frequent in rural areas, where central heating systems are less prevalent (U.S. Fire Administration, 2001a, 2001b). Use of portable heaters, rather than central heating systems, is part of the New Zealand ‘way of life’ which needs special consideration in fire safety strategic planning, particularly for the older age groups. A further issue to address is the use of heaters to air or dry laundry. This practice is not uncommon, and contributed to a ‘near miss’ incident in the Bay of Plenty (Butzbach, 1997) as well as to incidents in the current series. Consumer education and provision of alternative effective means of drying laundry items need to be considered.
5.3.4. Ethnic disparities

The ethnic disparity calculated using the collated data sets is considerably larger than that previously calculated from health data alone (Duncanson, Ormsby, Reid, Langley, & Woodward, 2001), principally because of a significant undercount of Māori in the 1991-1994 mortality data. The increased magnitude of the disparities between Māori and nonMāori observed in the analysis of 1996-1997 data suggests that changes to the death registration requirements, together with education of funeral directors, has considerably reduced the undercount of Māori in more recent years and improved the accuracy of ethnicity data in the national minimum data set since 1996. Before changes to the Births, Deaths and Marriages Act came into effect in September 1995, Māori ethnicity in death certification was consistently underestimated (Graham, Jackson, Beaglehole, & de Boer, 1989; Tipene-Leach, Stewart, & Beaglehole, 1991).

For Māori in 1994 the category ‘fire and burns’ was the third leading cause of injury death in the 1-14 and over 64 age groups (Langley & Broughton, 1999). Because Māori are over represented in the proportion of the population living in relative social and material deprivation (Ministry of Health, 1999), increased fire-related mortality rates might reflect, at least partly, underlying social and economic determinants of injury (Ballard et al., 1992; Mallonee et al., 1996; Mierley & Baker, 1983; Townsend et al., 1992). However the relationships between ethnicity, socio-economic status and mortality are complex and cannot be reduced to socio-economic factors alone (Davey Smith & Bartley, 2000; Smith, 1984).
5.3.5. Socio-economic disparities

The finding of a socio-economic gradient for structural fire incidents and for fire-and-flame-related injury mortality in this project is consistent with the observations reported on pages 19-20 and 27-29 (Mallonee et al, 1996; Ballard et al, 1992; Istre, 2001). Rivara (1999), Roberts (1997) and Townsend, Davidson and Whitehead (1992) all highlighted the particular vulnerability of children living in restricted socio-economic circumstances to fatal injury from fire and flame. These findings occur in the context of a now substantial international literature describing in detail the association between socioeconomic circumstances and health status.

Households and societies require a basic level of material goods to survive. The Universal Declaration of Human Rights articulates the right of every person to “the economic, social and cultural rights indispensable for his dignity and the free development of his personality” (Article 22) (United Nations Office of the High Commissioner for Human Rights not dated). Signatories to the United Nations Convention on the Rights of the Child (the Convention), including New Zealand and almost every other country in the world, recognise that every child “has the inherent right to life” and agree to “ensure to the maximum extent possible the survival and development of the child” (Article 6). The signatories to the Convention further “recognise the right of every child to a standard of living adequate for the child's physical, mental, spiritual, moral and social development” and undertake to “take appropriate measures to assist parents and others responsible for the child to implement this right and shall in case of need provide material assistance and support programmes, particularly with regard to nutrition, clothing and housing” (Article 27) (United Nations Office of the High Commissioner for Human Rights Committee on
the Rights of the Child not dated). The Millennium Development Goals (MDGs) were developed by the United Nations Development Programme (UNDP) and adopted by world leaders in 2000 in a commitment to “work together to build a safer, more prosperous and equitable world” (UNDP, 2010). The first MDG is to eradicate extreme poverty and hunger, issues which are described as “an affront to our common humanity” and which exacerbate many other problems (Annan, 2000 p 19). The UNDP claims that tens of millions of lives will be saved if these goals are achieved (UNDP, 2010).

In this international perspective the emphasis is on absolute poverty, and its significant negative health effects. However an association is also observed between relative poverty and health in developed economies. Cohort studies of British public servants, all employed in stable jobs, showed that death rates from coronary heart disease (CHD) and from all causes were highest among clerical staff (the lowest grade) and lowest among employees in the senior administrative grades:

*The relative risk of death owing to CHD was 2.2 in clerical compared with senior administrative staff, and 1.6 for those in the intermediate professional and executive grade ...When conventional risk factors were controlled for, two-thirds of the mortality risk differential between the clerical and administrative grades remained unexplained*

Marmot & Brunner (2005) p 251

In 1980 the Government of the United Kingdom released ‘Inequalities in Health’, an independent enquiry under the Chairmanship of Sir Douglas Black, the then Chief Health Officer and President of the Royal College of Physicians. The message and recommendations of “the Black Report”, as it came to be known, were unpalatable to the government at the time, yet the report “put fire into the bellies of many within the public health community of the day, in many cases resulting in [long-term] energetic local action” (Sim & Mackie, 2006, p 185). One of the specific observations in the
report was that children living in socio-economically deprived circumstances were at higher risk of injury than other children (Carter, 2001). Almost two decades after the original ‘Black report’ Sir Donald Acheson, former Chief Medical Officer, found that “health inequalities had worsened, so that the so-called ‘gap’ had widened further” (Sim & Mackie, 2006, p 186). This was despite the agreement in 1984, by European member states of the World Health Organization, to specific targets including the reduction of at least 25% in the “actual differences in health status between countries and between groups within countries” by the year 2000, through improvement in the health status of disadvantaged nations and groups (Whitehead, 1991). The association between relative poverty and ill-health was continually demonstrated through the 1990s in many different contexts. In New Zealand the principal findings of a report of the National Health Committee in New Zealand were that:

- **Social, cultural and economic factors are the main determinants of health**
- **There are persisting health inequalities as a result of socioeconomic factors in New Zealand and some evidence that these may be worsening**
- **Current trends in many socioeconomic factors in New Zealand are likely to widen health inequalities further**
- **There are good reasons for intervening to reduce socioeconomic inequalities in health**
- **There are evidence-based interventions for reducing these inequalities**


The committee made a number of recommendations for action within and beyond the health sector to redress the observed inequities in health status. The New Zealand Ministry of Health (MoH) recognises that “Effective action to address inequalities in health must take a balanced approach. It must both tackle the social and economic inequalities that are the root causes of health inequality, and improve access to and effectiveness of health and disability services for all” (Ministry of Health, 2002 p. 4). The framework developed by the MoH to address inequalities in health includes
intervention at local, regional and national level with comprehensive strategies at four levels:

- **Structural** – tackling the root causes of health inequalities, that is, the social, economic, cultural and historical factors that fundamentally determine health.
- **Intermediary pathways** – targeting material, psychosocial and behavioural factors that mediate the impact of structural factors on health.
- **Health and disability services** – undertaking specific actions within health and disability services.
- **Impact** – minimising the impact of disability and illness on socioeconomic position.

The Ministry recognise that effective action will be cross-sectoral and involve agencies and organisations outside the health sector.

Addressing the socioeconomic gradient associated with fire-related injury requires a similar cross-sectoral approach. Within the health sector, recognition of injury as a health problem is an important step. The Auahi Whakatūpato programme reported in Appendix 1 was initiated by a regional health service, in response to clinical events which were assessed as preventable. The programme itself recognised socioeconomic factors in prioritising the distribution of domestic smoke alarms among participating communities. It has been followed by intersectoral community interventions that distribute domestic smoke alarms and create a safer environment, and also develop sustainable employment opportunities and increase knowledge and skills at community and personal levels (personal communication, Mr Jim Dance, New Zealand Fire Service).

**5.3.6. Cooking fires**

Although numbers were small in the present series the excess mortality risk for Māori appears to be higher for cooking related fires than for household fires generally,
suggesting that cooking related fires are a particular issue for Māori. A survey in the Bay-Waikato fire region (Thomas et al., 2000) indicated that Māori were less likely than the general population to appreciate the likelihood of fires starting in the kitchen. Over one quarter (27 per cent) of the 300 Māori participants in the survey had experienced a kitchen fire, usually when frying food or having a “boil-up”. Thus fire safety campaigns for Māori need to include dangers associated with cooking, particularly in association with alcohol. Because a high proportion of the Māori deceased were aged under 25 years, a household rather than simply individual focus is appropriate.

5.3.7. Smoking materials

Ignition of clothing, bedding, lounge furnishings or contents of rubbish bins by discarded cigarettes can result in slow smouldering fires that are not noticed for many hours (Baker, 1992). Manufacture of self-extinguishing or non-flammable cigarettes is possible (Barillo, Brigham et al. 2000), although there has been sustained opposition from cigarette manufacturers (McGuire, 1999; Halbert, 1999). As mentioned earlier, development of ‘fire-safe’ cigarettes is assessed to have a high benefit-cost ratio in preventing injury (Miller & Levy, 2000). Legislation to reduce risk of fire events from discarded cigarettes will be of direct benefit to all people who have become addicted to nicotine, and have been unable to quit. Such measures are particularly relevant to those who live with significant disability and may be more likely to smoke in bed or less able to move in the case of clothing or lounge furniture ignition.
Prior to this study, Brereton and Laing (1992) reviewed burn related deaths (1977-86) and hospitalisations (1986) to estimate the role of upholstered furniture in fire-related injury. Information regarding heat source and items ignited had not been collected systematically in the datasets analysed in the Brereton and Laing study, and they therefore caution that their results are likely to underestimate deaths and injury from fire involving upholstered furniture. Upholstered furniture and bedding were implicated in 28 per cent of all burn related deaths in New Zealand from 1977 to 1986. Bedding was a particular hazard, with bedding and mattresses the first item ignited in 25 per cent of all fatal bedroom fires. Alcohol was involved in 14 per cent of the fatalities involving upholstered furniture.

Wong (2001) reviewed FIRS data and coroners’ reports for fatal residential fire incidents and found that upholstered furniture was involved in 45 fatalities or 35 per cent of the 127 residential fire-related fatalities, and was likely to have been involved in a further 19 per cent of such incidents between 1 July 1995 and 30 June 2000. The item of upholstered furniture was the first item ignited in only 16 per cent of the incidents studied by Wong (2001). In most (84 per cent) of the fatal residential fires involving upholstered furniture flame spread to the furniture item by small or large flame ignition, after primary ignition of other combustibles. Where upholstered furniture was the first item ignited, the most common heat source was smoking materials.

These New Zealand findings are consistent with observations overseas. Ignition of furnishings (including bedclothes, mattresses and lounge furniture) featured in the top three fire death scenarios in the USA in the early 1970s (Clarke III & Ottoson, 1983),
which accounted for 36 per cent of all fire fatalities. The three most significant scenarios occurred in a residential location and involved ignition of furnishings by smoking materials (27 per cent of US fire deaths), open flame (5 per cent of US fire deaths) or cooking and heating equipment (4 per cent of US fire deaths).

The experience in the United Kingdom has been rather different. This finding is usually attributed to regulation of furniture flammability, introduced in 1988. A review of the effectiveness of the regulations concluded that the regulations were extremely cost-efficient, and had resulted in the saving of 710-860 lives over 10 years (Department of Trade and Industry, 2000). Appendix 1 comprises the executive summary of New Zealand research, which could not confirm that similar regulation in New Zealand would be cost effective. The key areas of difference were the differing values of statistical life in the two studies (£3.4 million in the UK study, compared with NZ$2.6 million), the attribution of all the reduction in fire related injury in the UK to the furniture regulation of furniture flammability without allowing for any effect of increased prevalence of domestic smoke alarms, increased replacement of stand alone heaters by central heating systems, and decreasing tobacco consumption. Estimates provided by New Zealand manufacturers, based on the current differences in cost between fire retardant and standard foam used in mattresses and upholstered furniture, were also considerably higher than the reported costs of producing items that comply with the UK regulations.

5.3.9. Safe heating and lighting

Maintaining a warm home environment is important for physical health, particularly of children and of seniors (Isaacs & Donn, 1993). However the means of achieving
this must not increase risk of physical injury. Use of free-standing heaters is a characteristic of New Zealand homes, where central heating is still unusual. The use of electric bar heaters, kerosene or gas heaters exposes all household members to increased fire risk. It is of particular concern that safety standards do not apply to heaters purchased from second hand outlets. In one coronial verdict the coroner highlighted risks associated with gas heaters, however the issue seems to apply to any type of heating, particularly heating of children’s bedrooms. The involvement of portable heaters in three of the four fatal incidents in caravans highlights the particular importance of safe heating in temporary accommodation. Wall mounted heaters are likely to be safer in these circumstances. The development and distribution of appropriate smoke alarms for caravans (or one roomed dwellings) would also assist in allowing occupants to have early warning and exit safely in the event of an unintentional fire incident.

Use of candles was also associated with fatal fire incidents, particularly those involving children under 15 years in the current series. Since the time frame of the current study media reports have linked at least three fires involving New Zealand children to lack of electricity (Jackson & Gee, 2001; Jackson & Larkin, 2001; NZPA, 2000). It is uncertain how many homes in New Zealand are without electricity, but it seems recent changes in the electricity market may have exacerbated the situation. The New Zealand Herald reported in June that 100 houses in Northland have the electricity supply disconnected each week (Northern Advocate, 2001). Safe and affordable means of heating and lighting should be key components of housing policy for all New Zealanders. There could be a case for arguing that electricity supply be regarded as a public good in much the same way as all dwellings must have an adequate water supply. Some households choose alternative means of providing
power to reflect lifestyle priorities. In all situations where alternative means of heating and lighting are used, householders have a right to access realistic advice about safe options.

5.3.10. **Clothing combustibility**

There was only one child death involving clothing ignition among children in the present series, and in this case the item first ignited was petrol, which was being used to revive an open fire. Measures to regulate for children’s nightwear to be styled to reduce fire risk (i.e. fitting rather than loose), and manufactured from less flammable material, appear to have been effective, particularly as use of home sewn night attire is possibly decreasing (McLoughlin et al., 1986).

Most (12 out of 15) deaths as a result of clothing ignition occurred among seniors aged over 64 years. Clothing ignitions accounted for one sixth of the fatalities among adults aged over 64 years. Gulaid (1989) recommended use of fitting (rather than loose) garments and use of flame resistant fabrics for nightwear in seniors. Such measures have proven effective in reducing injury as a result of clothing ignition in children. As it is unlikely that older New Zealanders would replace garments frequently, the effects of such standards would be delayed and have a long term rather than short term effect. As an immediate strategy advice about clothing design could be included in fire safety education programmes directed to older New Zealanders.

Over one third of the fatal fire incidents in this series resulted from ignition of bedding or other combustible materials in a bedroom. Some of these incidents would have been prevented by ensuring safer heating appliances in bedrooms, and by effective strategies to reduce children’s access to matches and lighters. However it
may also be timely to consider flammability standards for bed linen. In relation to deaths of children in fires started in motor vehicles Byard, Lipsett & Gilbert (2000) also recommend that car manufacturers should develop less flammable interiors in motor vehicles.

5.3.11. Disruption and isolation

It is important that fire safety campaigns include issues such as taking responsibility for guests and visitors in one’s home, and being safe “wherever you are”. Particular issues associated with geographical isolation may require further investigation to develop appropriate fire safety strategies. Installation of smoke alarms is clearly of particular importance in such circumstances, perhaps in association with enhanced capacity to begin fire-fighting action before the arrival of emergency services.

5.4. For further consideration

An early finding of the research included in this thesis was the undercounting of fire related fatalities within the New Zealand Fire Service electronic database (FIRS). Accurate data collection is essential to underpin research of this type. Changes to the Fire Incident Reporting System and to the indexing of coronial files since data were obtained for this study will make future research more efficient and precise. Fire Incident Reporting and Management System (FIRMS) data are now collected electronically from the attending service. This allows for much faster transfer of data, compared to the previous hard copy system. The use of on-screen drop down boxes for variables within each field is also believed by the Fire Service to be increasing the accuracy of the data. FIRMS data would be further improved by mandatory
completion of the fields concerning domestic smoke alarms and encouraging use of the free text field to briefly describe the incident.

Current fire safety campaigns are appropriately focusing on installation and maintenance of domestic smoke alarms, safety with matches and lighters, safe cooking and heating practices, and avoiding cooking after consuming alcohol. Safe use of candles is a useful short term mitigation strategy which would be superseded by securing adequate and affordable electricity supplies to all households.

Campaigns to further reduce the incidence and impact of domestic fire incidents should include attention to fire safety away from home, fire safety planning for private social gatherings involving alcohol, promoting use of oven or microwave cooked food, safe use of flammable substances in the home environment, and safe disposal of smoking materials.

Intersectoral programmes to promote regional development and improve employment, education, housing and social services need to underpin fire safety interventions. Effective population approaches to reduce smoking and alcohol use will also have some positive impact on fire safety. The New Zealand Fire Service is an appropriate and important stakeholder in such programmes.

A tenet of injury prevention is that passive strategies (which work automatically) are most likely to result in a sustained decrease in injuries (Rivara, Grossman, & Peter, 1997a). Rivara et al (1997) define active strategies as those which require people to change their behaviour, and to remember to repeat this new behaviour every time they are exposed to risk. In relation to fire safety, active prevention strategies are less likely to be used in circumstances of household disruption or alcohol consumption. For example, a non-smoking parent may not notice that a guest in the home has left
smoking materials in easy reach of children; an escape route planned for a household of one or two people may not be effective when guests in an infrequently used room also need evacuation; the usually careful smoker may fall asleep while smoking after consuming alcohol.

Environmental interventions to further reduce the incidence and impact of domestic fire incidents include the installation of domestic sprinkler systems, regulation of ignition potential of manufactured cigarettes, and regulation of flammability of bedding and upholstered furniture. Untested but suggested interventions include childproof packaging of matches, and automatic ‘cut-off’ devices for stove tops.

A further striking observation from the review of unintentional domestic fire-related fatality data, is that although almost two-thirds of the fatalities occurred in unintentional domestic incidents, a significant minority occurred in other circumstances. A report concerning workplace fire-related injury has been completed (Kool, 2001). Incidents involving children that occur in non-domestic locations (e.g. on a farm or in a public place) are not included in the definitions of either workplace or domestic fatalities. There were two such incidents in the 1996-1997 series. It is also notable that 27 (9 per cent) of the 246 fire-related deaths were intentional or occurred in deliberately lit fires. Given that nationally there were 3542 deaths by suicide and 445 deaths by homicide in the study period (IPRU website, injury statistics), fire and flame would seem to be a relatively uncommon cause of self-harm or assault, accounting for fewer than one per cent of intentional injuries. Nevertheless there may be value in identifying factors associated with intentional injury from fire and flame as they form a small but not insignificant proportion of fire-related deaths. A particular factor to investigate would be the contribution of access to flammable gases or liquids to deaths in intentional fire incidents.
6. Conclusion

The key thesis examined in this work was that collation and analysis of existing data sources could identify factors associated with unintentional injury from fire and flame in the domestic location, and that such identification could inform the development of further strategies to reduce the incidence and impact of such injury. The data sources used for this collation and analysis were electronic data from the New Zealand Fire Service (NZFS) and New Zealand Health Information Service, together with hard copy information from the Coroners’ Courts and NZFS Fire Investigation Reports. The inclusion of post-mortem data, particularly the inclusion of blood alcohol measurements, and the availability of narrative data contributed significantly to achieving this outcome. Use of New Zealand data sources enabled the identification of trends similar to those observed elsewhere, and also the identification of issues specifically relevant to the national context.

The factors identified through the research process indicate that fire safety intervention programmes must operate at several levels. In this concluding chapter, the information presented earlier is discussed with reference to individual, household, community and national factors relevant to prevention of unintentional, domestic fire-related injury.

At an individual level age, gender and ethnicity are associated with risk of dying in an unintentional house fire. While these factors are not modifiable in themselves, when considering the issue of fire-related injury the risk associated with these factors may be modified. Household level factors such as the presence of an able-bodied rescuer, or an adult caregiver unimpaired by alcohol, may reduce the fire fatality risk
associated with youth, advanced age and disability. Dwelling design, particularly the existence of multiple, accessible exit points, can also mitigate limitations of age and disability. As discussed on page 113, there may be wider cultural and societal influences on the gender disparities in risk. The observed ethnic disparity in risk of fire-related fatality and injury requiring admission to hospital is determined by factors operating beyond the individual. In the New Zealand context there are no known indigenous cultural practices that place Māori at increased risk. However since the beginning of colonisation systematic policies and practices have resulted in Māori being significantly underrepresented in the less socio-economically deprived (and therefore safer) small areas, in higher smoking rates among Māori, and in more risky patterns of alcohol consumption. It is also probable that fire safety messages have been delivered in such a way that they were preferentially taken up by nonMāori compared with Māori. Thus, even individual level factors associated with injury from fire and flame can be mitigated by household and community level support, and by strategic use of knowledge about community values and preferences to ensure that appropriate fire safety measures are adopted across demographic groups in the community.

At a household level there are physical and social factors which are associated with risk of fire related injury. Such factors include presence of a functioning domestic smoke alarm, clear and practised escape routes, safe heating and lighting, style and type of furniture, safe practices around smoking and cooking, and issues associated with hospitality and entertaining. There remains uncertainty about the best ways to increase installation and maintenance of domestic smoke alarms. However, the results of the Auahi Whakatūpato project reported in Appendix 1 suggest that community based programmes, which include installation of alarms and an integrated
fire safety education presentation, can have a significant impact at household level. Use of candles for lighting and use of free-standing radiant bar heaters are associated with socio-economic deprivation and, in the case of heaters, with old age. In the short term strategies such as distribution of stable candle holders may mitigate such risk. However there is also a need for action at societal and political levels to address these concerns. Assessment of home safety for seniors should include wall mounting of heaters, or replacement of old appliances with models that meet current safety standards. Tobacco control strategies in New Zealand have emphasised that smokers can be part of the solution by not smoking within private dwellings and thus protecting those with whom they live from the harmful effects of second-hand smoke.

In the Auahi Whakatūpato evaluation (Appendix 1) one interviewer annotated several response forms from households including one or more smokers to indicate that the household was smokefree. This observation suggests that many smokers have heeded the message to smoke outside. Such actions will also have a positive impact on fire safety.

Fire safety campaigns also need to recognise that households are not static entities. Regard must be taken of the need to check fire safety issues when away from home, and when having a party or guests in the home. The narrative data in the descriptive study highlighted particular concern where makeshift accommodation is arranged in sheds or stationary vehicles.

Further factors at a community level that are amenable to change and to improve fire safety include the connectedness between households and the sense of belonging. Community level attitudes to alcohol use, including the acceptance of the value of a sober driver, have altered over recent years with a significant improvement in the number of road traffic deaths. A similar attitudinal change is needed in relation to
other types of injury associated with alcohol use. In the case of fire safety, the work described in this thesis clearly demonstrates that a “sober cook” would be an advantage in party situations. Provision of savoury food before patrons depart from licensed premises could reduce the urge for a “fry-up” when people return home after drinking alcohol. At a household level, supplies of suitable food ready to heat in a microwave oven would similarly reduce fire risk.

At a political level, decisions about economic and social policy also impact on fire safety. Restructuring of the electricity market has, anecdotally, led to increased numbers of households having supplies disconnected as a result of non payment of bills. Reduced availability of state housing, or increased rental costs of the same, lead to overcrowding and unsafe dwellings. Strategies to reduce tobacco consumption and alcohol misuse will impact mainly on more prevalent health conditions. However there will also be a probable beneficial effect on fire safety. Wider international trade agreements also have injury prevention implications, as appropriate restrictions used to protect citizens are perceived as barriers to free trade.

Many of the observations of this research programme were consistent with those in other countries. However the value of research in the local context was the ability to verify that overseas studies are relevant in New Zealand. This was particularly true for the observations about the relationships between socio-economic deprivation and risk of a fatal fire. Despite a large body of anecdotal information from fire-fighters, and the overseas studies, there was a reported reluctance to accept that factors other than lack of personal responsibility contributed to fire risk in certain communities. This research, together with other projects commissioned by the New Zealand Fire Service, has contributed to a growing commitment to address underlying determinants of fire risk. The operational nature of much of the intersectoral work in this area
means that it is not often described in the academic literature. This remains a challenge, as the work undertaken in New Zealand could valuably inform international fire safety programmes.

The work described in this thesis has also led to interdisciplinary applied research projects investigating possible environmental strategies to reduce fire risk (see appendices). Modifying furniture flammability has been a mainstay of fire engineering research over many years. The finding that, on current figures, such a move is unlikely to be cost-effective calls into question the merits of pursuing one engineering path to the exclusion of other possibilities. There might be more value in development of new types of padding that cost less but do not fuel and accelerate fires to the same extent as polyurethane foam. Modifying manufactured cigarettes, so that they are less likely to start fires, is likely to be cost effective, and would prevent a high proportion of fires where upholstered furniture is the item first ignited. In New Zealand the use of hand-rolled cigarettes is associated with lower risk of fires occurring. These products provide a natural standard against which the ignition potential of manufactured cigarettes can be assessed.

The New Zealand Fire Service has a statutory role in reducing fire-related deaths in New Zealand. Effective implementation of strategies to achieve this goal will require active collaboration with other agencies and across government sectors. Development of a bicultural understanding at all levels of the Service, and development and evaluation of specific interventions for Māori will be essential to address ethnic disparities in fire fatality rates. It is probable that similar processes will be required for Pasifika and new migrant communities. Details of effective interventions are likely to be of interest and benefit beyond New Zealand, as international injury
prevention and fire safety organisations seek to reduce the incidence and impact of unintentional domestic fire incidents.
References


Northern Advocate. (2001, 05.06.2001). Up to 100 Far North homes lose power every week. *New Zealand Herald*.


Appendix 1

Auahi Whakatūpato programme

The focus of this appendix is an evaluation of a fire safety intervention programme in eastern Bay of Plenty. This intervention was uncontrolled and therefore the results are open to criticism. Nevertheless this New Zealand project differs in significant aspects from smoke alarm distribution programmes described in the international literature, and makes a useful contribution to the continuing search for effective ways to improve fire safety and redress disparities in risk within and among populations.

The writer undertook the evaluation after completion of the Auahi Whakatūpato programme. She had no involvement in the planning or implementation of the programme. The writer conducted the evaluation, which comprised aspects that were both formative (review of documents to understand how the project was planned and implemented) and summative (follow-up survey to determine prevalence of alarm installation some months after the programme). Outcomes were also assessed using existing surveillance data about residential structure fires and fire-related injury and deaths.

The aim of the evaluation was to understand the impact of a community-based fire safety programme on fire safety practices. Specific objectives of the evaluation were:

- To provide a record and process evaluation of a smoke alarm distribution programme undertaken in the Eastern Bay of Plenty among residents of eight communities;
To assess the medium term effectiveness of a smoke alarm distribution programme undertaken among residents of eight communities in the Eastern Bay of Plenty; and

To make recommendations regarding implementation of a similar programme in the future.

The methods used to achieve the evaluation objectives were a review of programme documents and data, key informant interviews, door to door survey of randomly selected households, and review of fire information report data for the region.

The key outcome measures were the extent to which the programme met its objectives and the number of structural fires and fire related injuries and deaths in the region, before and after the programme.

**Background**

The Auahi Whakatūpato programme was an intersectoral approach to reducing the impact of fire related injury in an at risk population. In the two years prior to the programme there had been seven fire-related deaths in the study region, the Eastern Bay of Plenty. The local Health and Hospital Service, Eastbay Health, the Bay Waikato Fire Service, Te Puni Kokiri (the Ministry of Māori Development), and local communities worked together to install smoke alarms in dwellings in eight communities in the region.
Data sources

The principal investigator visited the region and completed face-to-face interviews with key informants from the New Zealand Fire Service, Eastbay Health, and Te Puni Kokiri. A semi-structured interview format was used, with manual note-taking.

Documents related to the Auahi Whakatūpato smoke alarm installation programme were obtained from key informants in the region. These included minutes of planning meetings, contractual documents and media reports.

The Fire Service provided electronic records of installation data. These data had been recorded manually by installation teams, and entered into an ACCESS database. The data included the addresses visited by the teams in each town, the pre-intervention alarm status of the dwelling, and the number of alarms installed.

Face-to-face house visits, and completion of a brief questionnaire, were conducted in a random selection of households who had participated in the Auahi Whakatūpato intervention programme. The interviewers were volunteer fire-fighters, who met with the principal investigator for interviewer training.

National Fire Incident Reporting System data were provided from the National headquarters of the New Zealand Fire Service.
Findings of formative evaluation

Role of key stakeholders

Eastbay Health funded the programme and contracted the Fire Service to purchase and distribute domestic smoke alarms within the Eastern Bay of Plenty district, provide educational material about use of domestic smoke alarms, and to work jointly with Eastbay Health Staff on fire prevention issues during the national Kidsafe week in 1997. Eastbay Health public health staff played key roles in the planning and implementation of the Auahi Whakatūpato programme including participation in community hui and linking with other child health and injury prevention services.

The New Zealand Fire Service (Bay-Waikato region) was principal contractors to Eastbay Health. The Fire Service emphasised the importance of a community based approach with careful consultation and attention to cultural sensitivity. The Fire Service purchased the alarms, and also provided administrative and clerical assistance, which was identified as a critical need early in the planning process. The issue of indemnity for fire-fighters was raised and referred to the New Zealand Fire Service lawyers.

The involvement of Te Puni Kokiri (Ministry of Māori Development) was seen to be crucial to the implementation of the programme. Te Puni Kokiri played an essential role in identifying community stakeholders and facilitating community meetings, usually on marae, and advising participants on marae protocol.

Local police also participated in the planning meetings and assisted with taking the fire safety message to schools.
**Documented programme planning**

The Auahi Whakatūpato programme was the first known example, in New Zealand, of a collaborative programme undertaken by the Fire Service and a health service provider.

Records showed that the aim of the programme was “to distribute and install domestic smoke alarms throughout the Eastern Bay of Plenty.” Prioritisation of distribution of domestic smoke alarms was to be undertaken with regard to:

- Socio-economic situation of householders;
- Vulnerability of households; and
- Distance from nearest fire station.

At the first recorded meeting (21 July 1997) six branches for the programme were identified, and responsibilities allocated:

- Identification of priority areas;
- Training of installation “team”;
- Community awareness and acceptance raising;
- Supporting community stakeholders (e.g. Landlords, insurance companies, manufacturers;
- Development of educational material; and
- Planning for evaluation.

The contract with Eastbay Health stated that prioritisation of distribution of domestic smoke alarms was to be undertaken with regard to:
• Socio-economic situation of householders;

• Vulnerability of households; and

• Distance from nearest fire station.

The project team had identified priority areas using a General Linear Regression model based on census derived demographic and social factors known to be relevant to fire incidence, as shown in Table 1. Areas were also ranked according to the average number of residential fires in the previous three years, per head of population. It does not appear that distance from the nearest fire station was included in the model. However the majority of the communities had a volunteer Fire Service Brigade and these communities were thus relatively distant from a professional fire-fighting service. The community of Te Teko, which rated second on the GLR scale, and first on the annual average fire scale, was selected as a pilot community for the programme.
Table 1  Census derived variables included in General Linear Regression model to prioritise communities for participation in Auahi Whakatūpato fire safety intervention in Eastern Bay of Plenty

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<th>Demographic variables</th>
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<tbody>
<tr>
<td>• Total population</td>
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<tr>
<td>• Number of dwellings</td>
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<tr>
<td>• Land area</td>
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<tr>
<td>• Population density (population divided by area)</td>
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<tr>
<td>• Occupancy of dwellings (population divided by number of dwellings)</td>
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<th>Social variables</th>
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<tr>
<td>• Percentage of population aged under 10 years</td>
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<td>• Percentage of population aged over 69 years</td>
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<td>• Household equivalised income (averaged)</td>
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<td>• Median household income</td>
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<tr>
<td>• Percentage of population aged 18-59 who are unemployed</td>
</tr>
<tr>
<td>• Percentage of population aged 18-59 who are receiving a government benefit</td>
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<td>• Percentage of population aged 18-59 who have no school qualification</td>
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<tr>
<td>• Percentage of households who own their own dwelling</td>
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<th>Ethnicity variables</th>
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<tr>
<td>• Percentage of the population who described themselves as Māori;</td>
</tr>
<tr>
<td>• Percentage of the population who described themselves as Pacific Island People.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Meteorological variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Average monthly temperatures</td>
</tr>
<tr>
<td>• Average monthly rainfall</td>
</tr>
</tbody>
</table>
Programme implementation

Training

Meetings were held with members of each Fire Service Brigade in the region to provide information about the programme. Instruction about installation was hindered initially by the lack of a New Zealand standard for installation. Trained fire-fighters (professional and volunteer) participated in installation teams.

Community promotion and acceptance and support

A media release was circulated following the first recorded meeting in July 1997. Cuttings, including those in the Fire Service account of the installation programme (Bay-Waikato Fire Region, 1998), indicate a strong print media campaign describing the progress and purpose of the programme. Programme records also note the use of radio advertising, flyers (including one sent with electricity accounts), local panui, and billboards.

The use of a more visual, culturally sensitive approach was raised in the meeting of 19 August and led to the development of a logo using Māori imagery (Figure 1).
The designer, Tim Worrall, used the shape of a whare, or dwelling, in which a fire can be seen setting off a smoke alarm. A mother and child motif symbolises the protection of life. The logo was used widely on all flyers, billboards, advertisements and home safety information packs (Bay-Waikato Fire Region, 1998).

At the same meeting the importance of a “uniform friendly installation team” was also raised. It was considered that because the dress uniform of fire-fighters resembles that of Police and Traffic Wardens, this may “hinder a positive outcome in many instances.” A casual ‘uniform, with a printed T-shirt identifying the wearer as a member of the installation team was suggested. Hui were held in each community prior to installation day. Community members were invited in a personalised letter. At these events fire safety messages were presented. No written accounts of the hui
have been located. However reports by stakeholders who attended indicated that there was a lot of discussion about the issues raised. In particular people were aware of the dangers of falling asleep while smoking, and of cooking while under the influence of alcohol.

**Educational material**

Presentations prepared for the community meetings and hui included a video presentation about the effects of fire, fire safety displays and verbal information. Information about the programme, with relevant pamphlets, was also distributed through schools and Kohanga Reo in the region.

Each household visited in the installation programme received fire safety instruction from the installation team, and a Home Safety Information Pack which included:

- A letter about the importance of smoke alarms in English and Te Reo Māori;
- A pamphlet about maintaining smoke alarms, including advice about replacing batteries;
- Home Safe Home “Protect what you value” pamphlets in English and Te Reo Māori;
- Tips for a fire-safe home pamphlet (English only);
- Plan to get out alive pamphlet (English only);
- Fridge magnet with smoke alarm maintenance advice; and
- Stickers for children about smoke alarms.
Data collection

Fire service staff and volunteers, and community volunteers, completed individual data sheets at each dwelling that provided baseline data; data about the number of alarms installed; and information about the household (Appendix 1). These data were entered onto an electronic database to provide information about the installation programme. The data were also accessed to select a random sample of homes for the follow-up survey.

Quality of these data were variable, with missing and sometimes conflicting information. Some fire-fighters commented that they did not like doing the paper work. There remains an ongoing challenge to provide feedback to firefighters that show how important the information recorded in the “paperwork” is essential to understand fire safety issues in an area.

Te Teko Pilot

The programme began in Te Teko in November 1997. The value of using community networks to publicise the programme was evident in the evaluation of the pilot. Written feedback from members of installation teams was positive, and supportive of the inclusion of trained firefighters as well as community volunteers in the teams.

Most people knew we were coming and were happy to see us.

The combination of Fireman and other person being female and Māori-speaking worked well in the door to door approach.

The evaluation identified several practical issues for consideration in later installation programmes. Some alarms were faulty, or had flat batteries. It was recommended that all alarms should be unpacked and tested prior to installation. Installation teams were also advised to carry spare batteries with them. Members of the installation
teams were enthusiastic about the programme and most were prepared to participate in subsequent programmes. Written feedback from another member of an installation team stated:

Received with joy in all the homes installed. Excited about participating in the project.

A letter from the Te Teko Rugby and Sports Club Inc expressed appreciation of the project:

This club has experienced bad times in relation to club members perishing in recent fatal fires and [is grateful for] those efforts to avoid further tragedies.

**Installation days**

An account of installation days to 31 July 1998 has been prepared by the Bay-Waikato region (Bay-Waikato Fire Region, 1998). The date and time of installation in each community was decided by the local Fire Service Brigade. In each community installation day was preceded by community meetings to raise awareness of the programme. There was also a strong media campaign through local newspapers and radio stations. On installation days a Fire Service marquee, complete with fire safety displays provided a base for all volunteer personnel. A Fire Safety Bouncy Castle for children contributed to the community involvement in the project. A colouring competition for children was held in each community, and judged on installation day. Each entrant received a small prize, with major prizes provided by local businesses.

Dwellings where residents were not at home on installation day were visited by the local Fire Service brigades over the following weeks. In most communities installation was completed within four weeks. Because Kawerau was a much larger town the installation was planned in a staged manner and completed over an eighteen
month period. Similarly Edgcumbe dwellings received alarms over a three month period. It appears that all alarms were installed on one visit in the small rural communities of Ruatoki and Waimana. In Te Teko most alarms were installed within two weeks of installation day, however alarms were installed in a further eleven dwellings throughout 1998 and 1999.

**Baseline data**

Prior to the programme 1800 of the 4453 dwellings visited in the study region had one or more existing alarms (40 per cent). There was considerable variation in the proportion of dwellings in each community with existing smoke alarms from under 10 per cent in Ruatoki North to over 65 per cent in Edgcumbe (see Table 2). In general, the prioritisation method described on page 155 identified communities where a very small proportion of dwellings had existing smoke alarms. The exception was Edgcumbe, where over 65 per cent of dwellings had smoke alarms. Edgcumbe scored third highest on the social and demographic risk scale, but seventh on the average number of residential structure fires.

Homes with existing smoke alarms contained 2850 alarms, of which 2353 (83 per cent) were operational at the time of the visit. Of the 1800 homes with existing smoke alarms, 1500 (83 per cent) had at least one operational smoke alarm. In homes with more than one alarm, the alarms were even more likely to be functional. In almost all cases where dwellings had more than two alarms, all of the alarms were operational. This may reflect a greater degree of fire safety awareness in those homes where more than one alarm had been installed (see Table 2).
Table 2. Existing smoke alarms, and number of existing alarms that were functional, in dwellings visited by installation teams in the Auahi Whakatūpato smoke alarm installation programme, Eastern Bay of Plenty, November 1997 to August 1999.

Data source: New Zealand Fire Service.

<table>
<thead>
<tr>
<th>Existing smoke alarms</th>
<th>Dwellings</th>
<th>Dwellings with at least one operational alarm (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1082</td>
<td>856 (79)</td>
</tr>
<tr>
<td>2</td>
<td>517</td>
<td>467 (90)</td>
</tr>
<tr>
<td>3</td>
<td>128</td>
<td>111 (87)</td>
</tr>
<tr>
<td>&gt;3</td>
<td>73</td>
<td>66 (90)</td>
</tr>
<tr>
<td><strong>Total/Overall</strong></td>
<td><strong>1800</strong></td>
<td><strong>1500 (83)</strong></td>
</tr>
</tbody>
</table>

The refusal rate was between 1 and 2 per cent of dwellings visited (45 direct refusals; 34 dwellings with no reason given for non-installation). Alarms were not installed in a further 142 dwellings which had adequate alarms, and 55 unoccupied dwellings (see Table 3). This low refusal rate, and written comments by installation teams suggest that the programme was acceptable to the communities concerned.
Table 3. Reasons for non-installation of smoke alarms in dwellings visited during Auahi Whakatūpato smoke alarm installation programme in Eastern Bay of Plenty November 1997-September 1999.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of dwellings</th>
<th>Percentage of total dwellings (n = 4453)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have adequate alarm(s)</td>
<td>142</td>
<td>3.2</td>
</tr>
<tr>
<td>Unoccupied (including 1 burnt out)</td>
<td>55</td>
<td>1.0</td>
</tr>
<tr>
<td>Refused</td>
<td>46</td>
<td>1.2</td>
</tr>
<tr>
<td>Unknown</td>
<td>34</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>277</strong></td>
<td><strong>6.2</strong></td>
</tr>
</tbody>
</table>

The Auahi Whakatūpato programme resulted in the installation of 5273 alarms in 4223 dwellings in Te Teko, Matata, Kawerau, Taneatua, Edgecumbe, Ruatoki, and Waimana, and Murupara. Use of census data in the evaluation showed the differences between local knowledge and understanding, compared with statistical boundaries. This was most marked in Te Teko, where installation teams clearly believed the boundaries to extend beyond the area used in the census, and thus the number of homes where alarms were installed was greater than the census count of dwellings (see Table 4). The final smoke alarm installations in Murupara were completed in September 1999. The Auahi Whakatūpato programme increased the proportion of dwellings visited in the study area with at least one smoke alarm from 40 per cent before the project to 97 per cent after the project. An additional 47 alarms were installed in selected dwellings in Whakatane and Opotiki. Installation rates cannot be calculated for these two localities, as this was not a community wide installation programme, and there is therefore no available denominator figure.
Table 4. Smoke alarm coverage at baseline of Auahi Whakatūpato programme in Eastern Bay of Plenty. Data sources: New Zealand Fire Service Bay-Waikato region; Statistics New Zealand.

<table>
<thead>
<tr>
<th>Community</th>
<th>Dwellings visited</th>
<th>Percentage with existing alarms (n)</th>
<th>Households in 1996</th>
<th>Percentage of census households visited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edgecumbe</td>
<td>560</td>
<td>66 (367)</td>
<td>591</td>
<td>95</td>
</tr>
<tr>
<td>Kawerau</td>
<td>2288</td>
<td>45 (1032)</td>
<td>2430</td>
<td>94</td>
</tr>
<tr>
<td>Matata</td>
<td>235</td>
<td>44 (103)</td>
<td>225</td>
<td>104</td>
</tr>
<tr>
<td>Murupara</td>
<td>539</td>
<td>27 (144)</td>
<td>642</td>
<td>84</td>
</tr>
<tr>
<td>Ruatoki North</td>
<td>172</td>
<td>9 (15)</td>
<td>216</td>
<td>80</td>
</tr>
<tr>
<td>Taneatua</td>
<td>220</td>
<td>28 (62)</td>
<td>228</td>
<td>97</td>
</tr>
<tr>
<td>Te Teko</td>
<td>292</td>
<td>13 (37)</td>
<td>165</td>
<td>177</td>
</tr>
<tr>
<td>Waimana</td>
<td>147</td>
<td>27 (40)</td>
<td>180</td>
<td>81</td>
</tr>
<tr>
<td><strong>Total/Overall</strong></td>
<td><strong>4453</strong></td>
<td><strong>40(1800)</strong></td>
<td><strong>4677</strong></td>
<td><strong>91</strong></td>
</tr>
</tbody>
</table>
Follow-up survey

Aim

The follow-up survey was undertaken by the Ph.D. candidate to determine the proportion of installed alarms functioning up to 30 months after installation, and to determine whether there is a difference in the proportion of functioning alarms among households where installation occurred more than eighteen months previously compared with households where installation occurred less than eighteen months previously. The time frame of eighteen months was chosen to ensure that alarms in both groups had been installed more than one year previously, and that it could be expected that the occupants should have checked the alarm regularly and replaced the battery at least once (advice is to replace annually).

Method

Examination of the installation database indicated that over 1000 dwellings had no telephone number recorded. A door to door survey was therefore selected as the method of choice for the survey because it enabled wider participation, and had the added benefit of direct inspection of the smoke alarms. A questionnaire was developed using the findings from a previous survey that had been conducted in the region by the Kawerau Fire Brigade. Eight Fire Service volunteers were recruited locally and attended a training session in Edgecumbe.
in April 2000. The survey was conducted over the following four weeks, from 7 April to 2 May 2000.

**Sampling frame**

The sampling frame was defined using the following parameters:

- Dwelling in which programme records recorded that at least one smoke alarm was installed during the Auahi Whakatūpato programme;
- Dwelling located in Edgecumbe, Kawerau, Matata, Murupara, Ruatoki, Taneatua, Te Teko or Waimana;
- Occupants did not refuse permission for follow-up evaluation of programme effectiveness.

**Sampling procedure**

Sample size calculations using EpiInfo indicated that a sample of 400 dwellings would be required to assess the proportion of alarms functioning with a margin of error of ± 5 per cent. Assuming a response rate of 80 per cent, a random sample of 500 dwellings was generated from the sample frame using the EpiInfo computer statistics package.

**Results**

**Participation**

Door to door interviews were completed with 437 (87 per cent) of the 500 randomly selected households. Reasons for non response are shown in Table 5.
Each dwelling was visited at least three times, at different times of the day and on different days of the week, before the occupants could be recorded as not at home. Properties without safe road access or with unrestrained dogs were not visited (high-risk entry). Sample selection was made from the original installation database and in two cases the information given was not adequate to locate the dwelling. Four returned forms were invalid because the detector was not sighted or information was inconsistent. Six survey forms were not returned.

Almost two thirds (65 per cent) of the 437 interviews were completed at the first visit, a further 24 per cent after two visits, and the remaining 11 per cent required three or four visits to complete the interview.

Table 5. Responses of randomly selected households in Auahi Whakatūpato follow-up survey April - May 2000.

<table>
<thead>
<tr>
<th>Reason</th>
<th>Number of dwellings</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response received</td>
<td>437</td>
<td>87</td>
</tr>
<tr>
<td>Not at home ~3 visits</td>
<td>30</td>
<td>6</td>
</tr>
<tr>
<td>Dwelling unoccupied</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Survey form not returned</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>High risk entry</td>
<td>3</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Invalid form</td>
<td>4</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Refused entry</td>
<td>4</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Unable to locate</td>
<td>2</td>
<td>&lt;1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>500</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Occupancy

The original occupants continued to live in 79 per cent of the 437 dwellings. As might be expected the proportion of original occupants was lower in the dwellings where installation occurred more than 18 months before the survey (219/289; 76 per cent) compared with those where alarms were installed more recently (127/148; 86 per cent) (see Table 6).

Table 6. Number and percentage of dwellings participating in Auahi Whakatūpato follow-up survey April - May 2000, by occupancy status and time since installation.

<table>
<thead>
<tr>
<th>Time since installation</th>
<th>Less than 18 months n (%)</th>
<th>More than 18 months n (%)</th>
<th>Overall n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original occupant</td>
<td>127 (86)</td>
<td>219 (76)</td>
<td>346 (79)</td>
</tr>
<tr>
<td>New occupant</td>
<td>21 (14)</td>
<td>70 (24)</td>
<td>91 (21)</td>
</tr>
<tr>
<td>Total</td>
<td>148 (100)</td>
<td>289 (100)</td>
<td>437 (100)</td>
</tr>
</tbody>
</table>
Proportion of households with functioning alarms

Among participating households, 72 per cent had at least one functioning smoke alarm. The proportion of households with at least one functioning alarm was higher in households where the installation occurred less than 18 months before the follow-up survey (80 per cent), compared with installation more than 18 months before the follow-up survey (68 per cent). Households with more recent installation (less than eighteen months before survey) were 23 per cent more likely to have a functioning detector compared with households with earlier installation (RR 1.23 95%; CI 1.07 – 1.4; p = 0.005).

The proportion of households with functioning detectors was also higher in owner occupied compared with rental dwellings and in households with occupant(s) over 65 years of age compared with households with no seniors. Of concern is the observation that households including children under five years were less likely than households without pre-schoolers to have a functioning alarm. Similarly a lower proportion of households including one or more smoker had a functioning alarm compared to households without smokers Table 7.
Table 7. Number and percentage of households with at least one functioning smoke alarm in Auahi Whakatūpato follow-up survey April - May 2000 by time since installation, tenure of dwelling, presence of smokers, children aged under 5 years and adults aged over 65 years.

<table>
<thead>
<tr>
<th></th>
<th>Number of households (n)</th>
<th>households with at least one functioning alarm (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time since installation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 18 months</td>
<td>148 (34)</td>
<td>119 (80)</td>
</tr>
<tr>
<td>More than 18 months</td>
<td>289 (66)</td>
<td>196 (68)</td>
</tr>
<tr>
<td><strong>Tenure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owner occupied</td>
<td>339 (78)</td>
<td>259 (76)</td>
</tr>
<tr>
<td>Rental</td>
<td>93 (21)</td>
<td>53 (57)</td>
</tr>
<tr>
<td><strong>Smokers in household</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>172 (39)</td>
<td>143 (83)</td>
</tr>
<tr>
<td>One or more</td>
<td>265 (61)</td>
<td>172 (65)</td>
</tr>
<tr>
<td><strong>Children under 5 years of age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>302 (69)</td>
<td>230 (76)</td>
</tr>
<tr>
<td>One or more</td>
<td>135 (31)</td>
<td>85 (63)</td>
</tr>
<tr>
<td><strong>Adults over 65 years of age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>357 (82)</td>
<td>249 (70)</td>
</tr>
<tr>
<td>One or more</td>
<td>80 (18)</td>
<td>66 (83)</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>437 (100)</td>
<td>315 (72)</td>
</tr>
</tbody>
</table>
Problems with alarm

Problems with the installed alarms were reported by 165 households (38 per cent). The most common cause of problems was the occurrence of nuisance alarms, i.e. alarm being set off by usual household activities such as cooking or showering. A further 36 households reported nuisance alarms but did not consider this to be a problem. All reports of nuisance alarms, in the total of 201 households, were grouped together for analysis since optimal siting of a smoke alarm may reduce the occurrence of nuisance alarms. As shown in Table 8 the most common causes of nuisance alarms were alarms set off by cooking (78 per cent) and steam (30 per cent). The total is higher than 100 per cent because a high proportion of households reported more than one cause of nuisance alarms. None of the households reporting nuisance alarms or other problems had informed the Fire Service of their concerns.
Table 8. Problems with smoke alarms reported by households in Auahi Whakatūpato follow-up survey April - May 2000.

<table>
<thead>
<tr>
<th>Description of problem</th>
<th>Number of reports</th>
<th>Percentage of all households (n=437)</th>
<th>Percentage of households reporting problems (n=201)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set off by cooking</td>
<td>157</td>
<td>36</td>
<td>78</td>
</tr>
<tr>
<td>Set off by steam</td>
<td>61</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>Faulty alarm</td>
<td>31</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Set off by cigarettes</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Set off by means of heating</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>261</strong></td>
<td><strong>60</strong></td>
<td><strong>130</strong></td>
</tr>
</tbody>
</table>

*Total exceeds 100% due to households reporting more than one cause of alarms.

**Alarm maintenance**

Over half the households had changed one or more battery since installation day (243 households, 53 per cent). The most common reason for changing the battery was a ‘beeping’ alarm (152 households, 63 per cent of battery changers). Thirty four households (14 per cent) changed the battery on a
nominated day (Table 9). Fourteen of these households had changed the battery in March 2000, which was the month in which daylight saving finished suggesting that they took heed of the slogan “change your clock, change your battery”. Other nominated days were in October, December, and April (four households each), February (3 households), November and January (2 households each).


<table>
<thead>
<tr>
<th>Reason for changing battery</th>
<th>Number of households</th>
<th>Proportion of households who had changed batteries (n=243)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beeping alarm</td>
<td>152</td>
<td>63</td>
</tr>
<tr>
<td>Nominated day</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>Official reminder</td>
<td>22</td>
<td>9</td>
</tr>
<tr>
<td>Flat battery</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Not stated</td>
<td>18</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>243</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Fire warnings

Thirty-two households reported that an alarm in their dwelling had warned of fire, as shown in Table 10. The majority of these warnings were for cooking fires, including pots left on the stove, ovens left on, and other cooking including burnt toast.
At least seven incidents were potentially serious because the occupant was asleep at the time, or temporarily absent from the dwelling. The details of these potentially serious incidents, listed in Table 11, show that in two cases a neighbour who heard the alarm called emergency services. Without this intervention the fire may have become established and caused structural damage and possibly injury.

*Table 10. Cause of potential fire incidents averted because of warning from smoke alarm installed during the Auahi Whakatūpato programme in Eastern Bay of Plenty November 1997–September 1999, as reported in follow-up survey April–May 2000.*

<table>
<thead>
<tr>
<th>Cause of fire</th>
<th>Number of incidents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pot left on stove</td>
<td>16 (50)</td>
</tr>
<tr>
<td>Other cooking</td>
<td>7 (22)</td>
</tr>
<tr>
<td>Oven left on</td>
<td>3 (9)</td>
</tr>
<tr>
<td>Car fire (adjacent to dwelling)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Cigarette</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Electrical</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Plastic container smouldering</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Not specified</td>
<td>2 (6)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32 (100)</strong></td>
</tr>
</tbody>
</table>
Table 11. Details of potentially serious fire incidents averted because of warning from smoke alarm installed during the Auahi Whakatūpato programme in Eastern Bay of Plenty November 1997–September 1999, as reported in follow-up survey April-May 2000.

<table>
<thead>
<tr>
<th>Details of incident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Went to sleep and left oven on. Alarm woke occupant</td>
</tr>
<tr>
<td>Smoker fell asleep while smoking. Cigarette fell onto mattress and mattress began smouldering. Occupant woken by alarm.</td>
</tr>
<tr>
<td>Member of household put pot on stove and went out</td>
</tr>
<tr>
<td>Pot left on stove. Alarm alerted neighbours, who alerted fire brigade</td>
</tr>
<tr>
<td>Left pot on stove. Went to sleep. Slept through alarm. Fire in kitchen. 111 call from neighbour.</td>
</tr>
<tr>
<td>Left pot on stove with dripping in it, was on the phone when heard alarm. Just caught it in time before fire spread to walls. Never rang the fire brigade.</td>
</tr>
<tr>
<td>Car fire. Vehicle parked next to verandah inches away from house.</td>
</tr>
</tbody>
</table>

Proportion of alarms functioning

In total 779 detectors had been installed in the surveyed houses. There were 256 non-functioning or missing alarms (33 per cent of the total). Over half of the non-functioning alarms had no batteries (48 per cent) or flat batteries (10 per cent). One fifth of the non-functioning alarms (20 per cent) had batteries that were not fully connected. One alarm was never installed, nine had been
removed by the occupant (4 per cent), and 19 (7 per cent) had been damaged (see Table 12).

Table 12. Reason smoke alarm was not functioning when inspected during Auahi Whakatūpato follow-up survey April -May 2000

<table>
<thead>
<tr>
<th>Reason alarm not functioning</th>
<th>Number of non-functioning alarms</th>
<th>Proportion of non-functioning alarms (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No batteries</td>
<td>123</td>
<td>48</td>
</tr>
<tr>
<td>Batteries not fully connected</td>
<td>52</td>
<td>20</td>
</tr>
<tr>
<td>Flat batteries</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Faulty detector</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>Detector damaged</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>Detector removed</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>No reason given</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Detector never fitted</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>256</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Outcome evaluation

Structural fires

There has been an apparent reduction in the number of structural fires in the region in 1998 and 1999, compared with the number in previous years (see Figure 2). However the numbers are not sufficiently large for the results to be statistically significant, and it should be noted that there was also a reduction in the number of residential structure fires in Aotearoa New Zealand from 4011 in the 1997-1998 year to 3752 such fires in 1998-1999 (New Zealand Fire Service Commission, 1999).

Figure 2. Number of residential structural fires 1990 – 1999 in communities participating in Auahi Whakatūpato fire safety programme in the Eastern Bay of Plenty. Data Source: Fire Incident Reporting System national database. Figure source: Bay Waikato Fire region.
Fire-related injury

Table 13 summarises FIRS data from the study region for the years 1990-2000. These data show that there were no unintentional fatal fire incidents in the relevant communities after implementation of the Auahi Whakatūpato programme, to May 2000. (The two fatalities in 1997 occurred prior to the Auahi Whakatūpato programme. In 1998 there were two deaths but these were the result of homicide.) The total number of fatal injuries in the 1995/1997 period is lower than the previously quoted seven deaths. This is because not all the 1995/1996 deaths occurred in communities where the Auahi Whakatūpato programme was implemented, but occurred in other parts of the Eastern Bay of Plenty.

Numbers of non-fatal injuries have been similarly low throughout the time frame. The number of fatal and non-fatal incidents is too small for the differences observed to be statistically significant. A major review of interventions to promote smoke alarms has recently concluded that the evidence for these campaigns to reduce injury is limited (DiGuiseppi & Higgins, 2000). The major limitations appear to be the rapid decline in the proportion of homes with operational smoke alarms, due to willful damage or removal, or failure to replace flat batteries. In the Bay of Plenty willful damage and removal of alarms was very uncommon. Regular battery replacement campaigns, preferably with a door-to-door component, would be likely to restore function to most non-operational alarms.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fire-related fatal injury</th>
<th>Fire-related non-fatal injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1991</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1992</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1993</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1994</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1996</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1997</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>5</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>13</strong></td>
</tr>
</tbody>
</table>
“Near misses”

Fire service brigades reported two incidents where the presence of a smoke alarm in a dwelling alerted the occupants to a fire, and allowed them time to take action to prevent more severe damage. The documents provided by Eastbay Health also report an incident where a newly installed smoke alarm alerted neighbours of a fire incident, and allowed the rescue of the two occupants who had fallen asleep after putting a frying pan on the stove.

6.1. Discussion

Principal findings

The Auahi Whakatūpato fire safety programme in the Eastern Bay of Plenty achieved the aim of installing domestic smoke alarms in high-risk dwellings in the area. At completion of the programme there was an estimated coverage of 97 per cent of dwellings in the study area with at least one functioning domestic smoke alarm. Door-to-door distribution and installation of smoke alarms appeared to be acceptable to the target population.

Strengths of the programme were the intersectoral approach, a high level of community participation and involvement, the intentional use of culturally appropriate motifs, and the inclusion of trained fire-fighters in installation teams.

At follow-up very few alarms had been removed and relatively few had been damaged. There were no unintentional fire-related deaths in the study region in
30 months following the Auahi Whakatūpato programme. Numbers of structural residential incidents and fire-related injuries also appear to have declined, but the numbers involved are too small to show a statistically significant change since implementation of the project, and similar secular trends were noted nationally.

Thirty households in the follow-up survey (7 per cent of respondents) reported that an alarm in their dwelling had warned of fire, including at least seven potentially serious incidents. In two of the potentially serious incidents a neighbour who heard the alarm called emergency services. Without this intervention the fire may have become established and caused structural damage and possibly injury or death. If the households who participated in the follow-up survey are representative of the region as a whole, then it is possible the smoke alarms installed in the Auahi Whakatūpato programme have warned of around 300 potential or actual fire incidents. It must be noted that the number of such ‘near miss’ incidents exceeds the number of fatal fire incidents occurring in previous years, and it is therefore probable that many of these potential ‘victims’ would have somehow escaped injury even without the alarms.

**Strengths and weaknesses of the evaluation study**

The evaluation was conducted in partnership with the community organisations involved in the project. Their co-operation enabled retrieval and review of a comprehensive collection of programme documents. Interviewers were
recruited from local communities and were accepted into the homes of participants, which may have contributed to the acceptable response rate.

A key weakness of the evaluation is that it was uncontrolled. As noted by DiGuiseppi et al (DiGuiseppi & Higgins, 2000), it is difficult for studies of this kind to unravel cause and effect. Nevertheless it is difficult to conceive of other factors increasing prevalence of installed smoke alarms to the extent achieved in the Auahi Whakatūpato programme. Although the Auahi Whakatūpato programme was ambitious, and seemed a large project for those involved, the numbers were not large enough to demonstrate any statistically significant effect on injury in the region. In this instance an output measure, namely installed smoke alarms on completion of the programme, was the proxy measure for injury prevention benefits. This is not unreasonable, given the strong relationship between lack of a smoke alarm and risk of fire-related fatalities (Marshall et al., 1998; Roberts, 1996; Runyan et al., 1992).

There was no specific evaluation of the effectiveness of the educational material used in the campaign. Overseas studies have shown that education alone has little effect on smoke alarm ownership, however combined with free or discounted smoke alarms there is a positive benefit (DiGuiseppi & Higgins, 2000; Mallonee et al., 1996). Further research to explore these issues would be helpful to inform future fire safety projects.

**Relationship to other studies**

The finding that 72 per cent of dwellings have at least one functioning smoke alarm up to 28 months after installation is comparable with reviews in three US
areas which showed between 58 and 73 per cent of alarms continuing to function up to four years after installation (Shults et al., 1998).

Door to door installation has been shown to be the most efficient and cost effective method of distributing smoke alarms in high risk communities (Douglas et al., 1998). This method may also prove useful in ensuring that alarms remain functional. Door to door visiting has the advantage of identifying remediable problems with installed alarms, including the relatively high proportion of replaced batteries that are not properly connected to the alarm. The latter problem can be rectified immediately, and other problems can be dealt with at the scene. Follow up of distributed detectors in the USA found that in 83 per cent of non-functioning detectors, function could be restored by replacing the battery (Shults et al., 1998). Personal contact may also be able to counteract the tendency of householders to disable, or less commonly remove, faulty or poorly sited alarms rather than seeking assistance from the Fire Service directly.

A key issue in fire safety research is identification of the best processes to increase prevalence of installed and functioning domestic smoke alarms. A well-conducted randomised trial of free smoke alarm distribution in inner London found no difference, at follow-up, between intervention and control groups, in terms of smoke alarm installation, residential fire occurrence, or fire-related injury. A key observation in this study was that very few of the alarms provided had been installed, although recipients were provided with contact details to arrange free installation (DiGuiseppi et al., 2002). In contrast, installation was an integral component of the Auahi Whakatūpato programme.
Inclusion of trained fire-fighters in the installation teams provided opportunity to maximise the impact of the concurrent fire safety messages, delivered within homes.

**Implications of study**

The key challenge raised by the findings of this survey is the need to develop strategies to ensure alarms are maintained in order to counteract the decline over time in the proportion of households with at least one functioning smoke alarm. Door to door visiting has the advantage of identifying remediable problems with installed alarms, including the relatively high proportion of replaced batteries that are not properly connected to the alarm. The ongoing challenge with the Auahi Whakatūpato programme, as with all smoke alarm distribution programmes, is to ensure that the installed domestic smoke alarms remain operational through a systematic follow-up programme.

Nuisance alarms, when the smoke alarm is set off by usual household activity, are a commonly raised issue with a negative effect on household compliance with smoke alarm installation. Correct siting of the alarm, away from the kitchen or bathroom, may minimise such alarms. Not all households who experienced ‘nuisance’ alarms considered them to be a problem. In fact, as described in Table 10, some of the fire warnings reported were of burning toast and other general cooking activities. One household changed the battery when they noticed that the alarm was no longer “going off to cooking”. It is also of note that unattended cooking fires were the most common incidents where a smoke alarm alerted household members or neighbours and potential damage...
was avoided. Advising occupants to contact the fire service with any problems does not seem to be effective, as none of the households in this survey had done so. A smoke alarm distribution programme in Minnesota used more formal follow-up until the relationship with the Fire Service was strengthened and participants were confident to contact fire service staff about any problems (Shults & Harvey, 1996).

The recommended advice about changing smoke detectors regularly, on nominated day(s) each year, was followed by a minority of respondents. Most commonly, among those who did change the batteries, the low battery capacity ‘beeping’ of an alarm was the prompt to replace the battery. Beeping alarms also prompted householders to remove batteries, which were often not replaced. Further qualitative research could help to understand factors influencing alarm maintenance and lead to the development of appropriate ‘battery change’ campaigns. Alternatively use of hard wired alarms or long life (10 year) batteries could be considered.

Although not reported fully, the fire warning anecdotes capture some of the possible benefits of the Auahi Whakatūpato programme. The original allocation of funding was made with a comment that preventing one serious burn injury would more than cover the cost of the programme. The incident where the occupant slept through an alarm sounding, and was rescued by a neighbour, shares many of the characteristics of fire incidents that result in serious injury or death and may have, in itself, provided that empirical economic justification of the Auahi Whakatūpato programme.
**For further consideration**

One of the most intriguing findings of this study was the anomaly of Edgecumbe, the community with the third highest level of socio-economic disadvantage as measured by the model used for the project, the third lowest rate of residential fires per capita, and the highest prevalence of installed and functioning domestic smoke alarms prior to the Auahi Whakatūpato programme. This suggests that fire occurrence statistics should be given greater weight in future prioritisation strategies. It would also be of interest to find out why so many households in Edgecumbe had installed alarms. In Kawerau a major employer had previously distributed smoke alarms to staff, and it is possible a similar programme had been undertaken in Edgecumbe. In future the Fire Service may also wish to consider use of the New Zealand indices of deprivation in assessing the social and economic circumstances of a community. These indices have shown a strong correlation with the occurrence of fatal residential fires, with the most deprived decile showing a rate of fatal fires 4.5 times that of the least deprived decile. (Duncanson, Woodward, & Reid, 1999). As the indices are developed using small areas, (census meshblocks) it may be possible to identify small areas within larger communities where fire risk is potentially greater.
Appendix 2

Costs and Benefits of Regulating Fire Safety Performance of Upholstered Furniture in New Zealand

C.A. Wade, M. Duncanson, D. O’Dea, C.R. Duncan

Executive summary from Fire Service Research Report prepared by a cross-disciplinary research group comprising C.A. Wade and C.R. Duncan, Fire Engineers; D. O’Dea, Economist; and the Ph.D. candidate M. Duncanson.

The candidate was co-principal researcher, and responsible for the literature review, with contributions from C. Wade and C. Duncan in relation to the technical fire safety literature, for the collation and analysis of fire incident reporting system data, for working with D. O’Dea in the cost effectiveness analysis, and for writing the final report together with C. Wade.
Costs and Benefits of Regulating Fire Safety Performance of Upholstered Furniture in New Zealand

C.A. Wade*, M. Duncanson¹, D. O’Dea¹, C.R. Duncan*

Joint Report of BRANZ Ltd* and the University of Otago¹

BRANZ Report No. FCR 8

BRANZ Ltd, Private Bag 50908, Porirua City, New Zealand
This work was funded by the New Zealand Fire Service Commission contestable research fund. The use and copying of this report for non-profit purposes is welcomed and allowed.
Executive summary

Introduction

The aim of the research was to provide an independent assessment of the likely costs and benefits associated with introducing new regulations to improve the fire safety of upholstered furniture in New Zealand. The focus of this report was on upholstered sofas, chairs, mattresses and bed bases used in private residential dwellings. Within the report, unless otherwise specified, the term upholstered furniture refers to this entire group of items.

Costs and benefits of regulating the flammability of upholstered furniture for domestic use in New Zealand were assessed using a conventional economic model. Results have been expressed in terms of cost per life saved and compared to other recent studies concerned with domestic fire safety.

Literature review

The key New Zealand research projects with a specific focus on human injury and upholstered furniture were conducted by Brereton (1992) and Wong (2001). More general investigations of domestic fire hazard and of fire-related mortality that include information about heat sources and items ignited are those by Irwin (1997), and Duncanson, Ormsby, Reid, Langley and Woodward (2001a, 2001b, 2001c).

Brereton and Laing found that upholstered furniture and bedding were implicated in 28% of burn-related deaths in New Zealand from 1977 to 1986, with bedding a particular hazard. Mortality rates in fires involving upholstered furniture were highest for those aged over 55 years and those who lived alone. Alcohol was involved in 14% of the fatalities involving upholstered furniture. Eleven per cent of hospital admissions involving burns from fire were the result of fire which started in a lounge or bedroom, and so could have involved upholstered furniture (Brereton, 1990).

Wong (2001) reviewed FIRS data and coroners’ reports for fatal residential fire incidents between 1995 and 2000 in New Zealand. Upholstered furniture (including beds and mattresses) was involved in 45 fatalities or 35.4% of all residential fire deaths, and was likely to have been involved in a further 19% of fire related deaths.

In the United States, upholstered furniture, mattresses and bedding, curtains, blinds and drapes, and carpets and rugs were the first materials or items ignited in about 11% of all fires in single-family dwellings between 1982 and 1996. Those fires accounted for more than 35% of the fires deaths and 25% of fire injuries in those structures (Richardson, 2001).

Between 1979 and 1984 the Wool Research Organisation of New Zealand (WRONZ) highlighted the fire hazard of polyurethane foam upholstered furniture and bedding in
New Zealand and recommended regulatory action. Similar testing methods were used in research at the University of Canterbury. The main objective of research at the University of Canterbury has been to predict the combustion behaviour of upholstered furniture through use of small-scale tests. Conclusions from the research have shown that it is possible to make some predictions on the basis of small-scale tests but the behaviour is also influenced by geometry and configuration of the furniture. The effect of fabric covers on the combustion behaviour of the furniture is also important. It is the combination of fabric and foam which has the most significant influence on the ignitability of the furniture.

An outcome of the European study of the Combustion Behaviour of Upholstered Furniture (CBUF, 1995) has been progress towards being able to predict the behaviour of upholstered furniture using mathematical models based on the combustion behaviour of small-scale samples. Model I is a method to predict the heat release rate (HRR) of a burning furniture item; Model II predicts the HRR time history. Model III of CBUF investigates the combustion behaviour of mattresses. Part of the Canterbury University research has focussed on comparing the combustion behaviour of New Zealand furniture samples to the findings of the CBUF research using European-sourced furniture, and in particular the applicability of CBUF Models I and II to New Zealand.

**Regulations, codes and test standards**

**United Kingdom**

The Furniture and Furnishings (Fire) (Safety) Regulations 1988 in the United Kingdom (HMSO, 1988) specify that fillings and coverings of all furniture must pass stringent flammability tests according to BS 5852 Parts 1, 2 or BS 7177/BS 6807. The requirements are generally met by use of chemical flame retardants in the foam (combustion modified foams) and in the back-coating for covering fabrics. In general the regulations require testing of foam/fabric composites and allow the option of a bench-scale test whereby fabrics are tested over standard padding, and paddings are tested beneath a standard fabric. If different construction is used for different parts of the furniture, e.g.: seat, back, sides then separate tests are required.

A review of the impact of the Furniture and Furnishings (Fire) (Safety) Regulations 1988 in the United Kingdom commissioned by the Department of Trade and Industry (DTI) concluded:

*Significant life-saving and injury reduction benefits have resulted from the introduction of the Furniture and Furnishings (Fire) (Safety) Regulations in 1988 in the UK. Corresponding benefits relate to reductions in the number of serious dwelling fires and in cost savings arising from reduced property loss and lives saved.* (Department of Trade and Industry (DTI), 2000 p23).

The report was written with the benefit of almost 10 years of fire statistics since the introduction of the regulations in 1988, and was essentially an economic analysis of the costs and benefits resulting from those regulations.

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The cumulative benefits attributed by the report to the regulations in the 10 years from 1988 to 1997 included:

- 710 lives saved which would have been lost in fires first ignited in upholstered furniture from 1988 to 1997. Possible saving of a further 150 lives in fires which did not start in upholstered furniture but which may have spread to include upholstered furniture.

- Prevention of 5774 non-fatal injuries which would have occurred in fires in upholstered furniture. Possible prevention of a further 11,226 non-fatal injuries which did not start in upholstered furniture but which may have spread to include upholstered furniture.

- £53 million worth of property saved.

- Projected saving of at least 791 lives, prevention of 7250 non-fatal injuries and prevention of £112 million property damage from 1998 to 2031.

- The report concluded that the benefit to cost ratio of implementation of the regulations was 38:1 (that is £38 of benefit for every £1 spent) using cost savings estimates for property damage.

- The cost of the regulations to industry and to those who buy furniture was estimated to be between £15 and £20 per item.

**United States**

In the United States there are voluntary standards for cigarette ignition of upholstered furniture for both residential and institutional buildings. These standards were produced by the Upholstered Furniture Action Council (UFAC) and were agreed to by the US Consumer Products Safety Commission (CPSC) in 1981. For residential furniture they are basically cigarette ignition tests. UFAC procedures were published in NFPA 260 (1986) and ASTM E 1353 (1990).

California has its own regulations for cigarette and small-flame ignition resistance of fabrics and padding material. The relevant standards for residential furniture components are TB116 and TB117 (Bureau of Home Furnishings and Thermal Insulation (BHFTI), 1980, 2000a). These have been the minimum standards for any occupancy in California since 1975. TB116 is a voluntary standard requiring that either the furniture meet cigarette ignition criteria or be labelled if it does not. TB117 is a mandatory standard in California and requires flammability testing of the fabric and padding. TB117 does not require the use of fire-retardant covers or fabrics. There are also standards for institutional occupancies i.e. TB129 and TB133 (BHFTI, 1993; BHFTI, 1991).

Mattresses in the US are subject to mandatory federal flammability standards. Currently all mattresses manufactured in the United States are subject to CPSC Standard DOC
FF4-72, a flammability standard established by the CPSC in 1972 to address cigarette ignition resistance (CPSC, 1998) for mattresses in residential buildings. In October 2001, the CPSC announced it also intended to develop a small-flame ignition resistance test for mattresses (CPSC, 2001).

Between 1994 and 1997 the CPSC developed a small-flame ignition test for upholstered furniture. However, because the new flammability test was expected to result in increased use of fire retardants and the speculation that these fire retardants would pose toxic hazards of their own, the CPSC was required to commission research on the toxicity of fire retardants, delaying any further action regarding the small-flame ignition test. The CPSC developed the test because after extensive laboratory testing it believed the TB117 test did not give results that correlated with full-scale furniture behaviour. It was concluded that the BS 5852 approach, using composite mock-up specimens (British Standards Institution (BSI), 1990), was better able to achieve this, so it developed a new test similar to BS 5852.

**Regulatory actions and their effectiveness**

Key factors to be considered in conducting an economic evaluation of flammability standards of upholstered furniture relate to the potential savings through reduced property damage, together with fewer deaths and injuries, and the costs to the industry, consumers and society as a whole of developing and implementing standards. International precedents suggest three principal levels of standard development:

- Mandatory labelling of upholstered furniture and mattresses, warning of the fire risk associated with upholstered furniture and indicating compliance or not with an appropriate standard.

- Mandatory standards for flammability in mattresses with voluntary standards for lounge furniture with labelling as above.

- Mandatory standards for flammability of all upholstered furniture products and mattresses.

The cost-benefit study in this report is based on introducing mandatory standards for ignition resistance of upholstered furniture and mattresses, similar to those currently used in United Kingdom and proposed for use in the USA. In each of these cases the regulatory change has been argued to be cost-effective, and thus it is of interest to assess whether this is also the case for New Zealand.

**Cost-benefit analysis**

Cost-benefit analysis measures the costs and benefits and provides the decision-maker with the results of these calculations in an appropriate form. If there is risk and uncertainty associated with the estimated costs and benefits, as is generally the case, the
cost-benefit analyses can also include analyses measuring the sensitivity of the results to variations.

The major benefit from the proposal examined in this report are the lives saved as a result of fires not starting in upholstered furniture, or as a result of fires developing more slowly and allowing occupants time to escape.

The decision criterion used is, therefore, cost per life saved. The same criterion has been used in other recent studies (Wade and Duncan, 2000; Beever and Britton, 1999; DTI, 2001). If the net cost is significantly less than the ‘value of statistical life’ currently used in the New Zealand land transport sector, then the proposed new standard is worth introducing. To convince policymakers, this criterion will probably need to be met for discount rates of the order of 5% per annum and higher.

Conclusions and recommendations

The introduction of mandatory standards for the ignition resistance of upholstered furniture and mattresses in New Zealand is unlikely to be cost-effective in terms of the currently adopted value of a statistical life in New Zealand ($2.6 million) and commonly accepted public-sector discount rates. Assuming a medium rate of furniture replacement (6%), an annual additional cost per household of the order of $30, and a discount rate of 5%, the expected cost per life saved is calculated to be around $9.8 million dollars.

Some of the reasons for the lower apparent cost-effectiveness compared to the analysis of the cost-effectiveness of regulations introduced in the United Kingdom in 1988 include:

- The statistical value of human life for New Zealand as used in this study, and as used by the Land Transport Safety Authority (LTSA), is only about one-fourth of that adopted for recent cost-benefit studies in the United Kingdom and in the United States. In fact, if the statistical value of human life were taken as $10 million rather than $2.6 million, then the regulation of furniture flammability might just be justifiable as providing a net benefit to New Zealand. However, this is before deducting gains in lives saved in any case from wider use of smoke alarms, and possible declines in the rate of smoking.

- The number of reported fire deaths per 1000 house fires appears to be significantly lower in New Zealand compared to the United Kingdom. One reason for this is likely to be the much lower population density in New Zealand, where most households live in detached dwellings, as compared with high-rise apartment complexes in the United Kingdom.

- The UK analysts assume a substantially greater reduction in fire deaths (70%) from the introduction of the new standards than we do (30%). However, even with an assumed 47% reduction in deaths, our calculated expected cost per life saved is $5.1 million dollars and our conclusions do not change.

- The estimated added cost to households buying furniture in New Zealand is substantially higher than that used in the DTI study for the United Kingdom. The
UK analyses have the benefit of actual experience of the new standards. Also there are economies of scale possible in the British and European markets unattainable in Australasia. Even so, it is not easy to reconcile the cost assessments used in the UK studies with the expected costs provided by New Zealand manufacturers and distributors.

- To achieve satisfactory cost-effectiveness ratios from the introduction of mandatory standards for upholstered furniture and mattresses in New Zealand, the additional average cost of fire-retardant treatment or other means to achieve the required level of performance would need to be reduced to around $10 or less per household per year, or about $150 on the cost of an average lounge suite purchase.

- To reduce uncertainties in the assumptions required for this cost-benefit study, more detailed data in routinely collected datasets, such as the Fire Incident Reporting System (FIRS), concerning the number of fire incidents, deaths and injuries and the extent that upholstered furniture and mattresses contributed to them as items first ignited and as items principally responsible for development of the fire, would be greatly beneficial; and

- Accurate estimates of production costs associated with compliance with standards are also needed. Within the scope and timeframe of the current project it was not possible to assess the extent to which estimates may have been underestimated in the United Kingdom or overestimated in New Zealand.
Appendix 3

Hand rolling cigarette papers as the reference point for regulating cigarette fire safety

M Laugesen, M Duncanson, T Fraser, V McClellan, B Linehan, R Shirley

Tobacco Control 2003;12:406–410


The research project described in this article was developed by M. Laugesen, T Fraser and the candidate. The candidate was responsible for the literature review, and oversight of the cigarette testing by fire engineers. The final article was jointly written by the candidate and M. Laugesen.
Abstract

**Aim:** To compare the burning characteristics of the tobacco and paper of manufactured and hand rolled cigarettes, and set a fire safety standard of manufacture to largely reduce the fire risk from discarded cigarettes.

**Methods:** (1) Cigarette extinction test of ignition strength: 40 cigarettes per brand, lit and placed on 15 layers of filter paper, in accordance with ASTM test standard E2187-02. (2) Citrate extracted by 0.1N hydrochloric acid from cigarette papers and from tobacco in manufactured cigarettes, the supernatant analysed by high performance liquid chromatography using ultraviolet visual light spectrophotometer. (3) Survey of 750 nationally representative adults age 18 years and over, by telephone, including 184 smokers.

**Materials:** (a) New Zealand made Holiday, and Horizon, and US made Marlboro manufactured cigarettes; (b) US manufactured Merit with banded paper; (c) Holiday, Horizon and Marlboro hand rolling tobaccos, hand rolled in Rizla cigarette papers; (d) manufactured cigarettes as in (a), reconstructed using Rizla hand rolling cigarette papers.

**Results:** 1. (a) For each brand of manufactured cigarettes, 40/40 burnt full length; (b) for Merit banded paper cigarettes 29/40 (73%) burnt full length; (c) for each brand of hand rolled cigarettes 0/40 burnt full length; (d) 0/40 manufactured cigarettes reconstructed with Rizla hand rolling paper burnt full length. 2. Citrate content: (a) In manufactured cigarette papers: 0.3–0.8 mg; in tobacco of manufactured cigarettes: Holiday 0, Horizon 0, Marlboro 8.8 mg; (b) Merit: in banded paper 0.418 mg; in tobacco 10.23 mg; (c) In hand rolled cigarettes: in the papers < 0.08 mg; in hand rolled tobacco 13.3–15.0 mg; (d) In hand rolling papers of reconstructed cigarettes: < 0.018 mg. 3. Requiring manufactured cigarettes to compulsorily self-extinguish when left unattended was supported by 67% of smokers, 61% of manufactured cigarette smokers, 82% of hand rolled smokers, and by 68% of non-smokers.

**Conclusion:** The wrapping paper is a key determinant of whether or not unpuffed cigarettes burn their full length. Using international test methods, popular brands of manufactured cigarettes all burnt full length, but none did so when re-wrapped in hand rolling cigarette paper. This provides a ready-to-hand smoker acceptable standard for reducing ignition potential from manufactured cigarettes, as a basis for regulation or litigation.