Beyond technology: a holistic approach to reducing residential fire fatalities

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Most fire fatalities occur in people's homes. Between 1991 and 1996 there were 550 fatalities as a result of residential fires in Australia (Newton 1997). This figure represents deaths that occurred in residential structures, including accidental or preventable fires, those which were deliberately lit, and cases where the cause was undetermined or there was insufficient information from which to draw a conclusion.

In 1994, house fires accounted for 66 per cent (n= 96) of all fire injury deaths in Australia. Between 1979 and 1994 there was a decline of around 35 per cent in the overall rate of death attributed to fire, flames and scalds in Australia (Australian Institute of Health and Welfare National Injury Surveillance Unit 1997), residential fire fatalities remain a significant preventable cause of death, particularly for some vulnerable groups in the community.

Such fatalities have hitherto not received the attention they deserve, perhaps because deaths in residential fires represent a diffuse disaster. In a large-scale disaster centred on a readily identifiable location, entire communities are alerted to the destruction and loss of life, and invariably there is a post-incident investigation which examines both the causes and responses to the disaster. In addition, such investigations generally attempt to develop strategies to prevent subsequent occurrences.

Although deaths due to fire are routinely investigated as individual incidents by fire services, the police, and coroners, fire agencies do not generally keep a detailed record of the wide-range of circumstances surrounding fire-related deaths, and published studies on fire-related fatalities are not extensive.

Nevertheless, it is generally well understood that some groups in the community are more vulnerable to the risk of fire, and that most residential fire fatalities are the result of widely recognised causes. But beyond this general level of awareness, and although there has been a steady decline in the rates of death from fire in Australia (Australian Institute of Health and Welfare National Injury Surveillance Unit, 1997), the role of fire services and their contribution to the prevention of fire fatalities has received little analysis to date. It is unclear whether initiatives to reduce the incidence of fire-related fatalities are really effective or whether current approaches are likely to achieve further reductions in the future.

Scope of the problem

Traditionally, fire service performance measures have been based upon the ability to provide an efficient response to fires and other emergencies. As a result, the focus of the industry's activities has been on the response and suppression of incidents. 'In effect, the regular occurrence of incidents [has] provided both the need and justification for maintaining and increasing personnel and equipment to react effectively when incidents occur … Thus, very little attention and few resources have been allocated to dealing with the 'causes' of emergency incidents or addressing community vulnerability' (Smith et al , 1996).

Recently, there has been increasing recognition world wide that incident response represents only one component of managing the risks that fires pose in our community, and there has been a shift towards a wider acceptance of the principles of risk management (Smith et al, 1996). The risk management approach involves developing a thorough and detailed understanding of the nature of risks facing the community, the development of strategies to reduce the likelihood of disasters occurring and the minimising the consequences when they do occur. It demands that organisations diversify their activities to utilise a range of community intervention, mitigation and prevention programs as a means of addressing risks.

However, to be effective, fire prevention strategies need to target those populations at highest risk, and the circumstances that are most likely to result in death (Barillo and Goode 1996a). A recent study undertaken by CFA Risk Management Department aims to provide a clearer picture of the circumstances surrounding residential fire fatalities and from this process to propose strategies for further action.

In the past, the CFA's activities have also generally been focused on protecting life and property from the effects of *wildfires* in rural environments. However, in recent decades, there have been significant changes in population distribution and settlement patterns throughout Victoria that have seen diminishing populations in rural and inner metropolitan areas and a shift to suburban fringes and regional centres (McKenzie 1994). As a result, the CFA's role in protecting communities from *urban and residential fires* is rapidly expanding. This change provides an additional impetus for the CFA to develop strategies to address the risks of death and injury due to residential fires among those most vulnerable.

Over the past decade the characteristics associated with domestic fire fatalities have been well documented, most recently by the Department of Emergency Services Queensland, which conducted a national survey of residential fire-related fatalities (Newton 1997). These studies identify the young, the elderly and those under the influence of alcohol as being particularly vulnerable. Cigarettes and radiators are found to be common causes of fatal fires in homes.

The CFA study does not replicate this work but, by using coroners' records, examines in detail the circumstances surrounding residential fire fatalities in order to understand the factors contributing to them, assess the effectiveness of various preventative measures and identify effective strategies to prevent residential fire fatalities.

It focuses on deaths that occurred as a result of residential fires within Victoria. All such fatalities that occurred between 1 January 1992 and 31 December 1995, and where the Coroner's investigations are complete, were studied, together with the types of fire events. For the purpose of the research residential fire was defined as any unintentional fire that occurred in a place of permanent residence. This included houses, units, flats, caravans, bungalows and sheds. Fires in special accommodation facilities were not examined. Sixty-six residential fire fatalities which resulted from 54 fires were examined during the course of the study.

Data on each of the fatalities was collected from the 'death cards' on each case located at the Coronial Services of Victoria. The circumstances surrounding each residential fire fatality were analysed using a conceptual framework that classifies factors identified as contributing to the event by both 'space' and time. This framework is known as Haddon's Matrix and is used amongst professionals in injury prevention fields (Berger and Mohan 1996).

For the purpose of this research, Haddon's Matrix has been used to identify the range of physical, social and environmental factors contributing to the fatality. It identifies factors related to the host, the agent, and the environment. In analysing fire related injuries and fatalities, the 'host' refers to the human factors in the incident such as the person involved in the fire, The 'agent' refers to the energy transmitting factors such as heat source and fuel. The 'environment' includes both the physical and the social environments. The phases of the event are identified as a chronological sequence of pre-event, event and post event (see *Figure 1*).

	Host	Agent	Environment
Pre-event			
Event			
Post-event			

Figure 1: Haddon's Matrix

Definition and classification of fire fatalities

Currently fire-related fatalities are not clearly defined, and the complexities associated with the nature of fire-related fatalities are poorly understood. Differences in the definitions, classifications, and record maintenance systems between the fire and coronial services result in a low correspondence in the numbers of fatalities identified by different agencies. The implications of this are significant. Without a common definition and classification sytem for fire-related fatalities, performance measurement, monitoring and research becomes more difficult and less meaningful.

Clearly, there is an urgent need to develop a classification system which recognises the diverse range of circumstances in which fire-related fatalities occur. There is also a need to review and update existing methods of record collection and maintenance. This task is currently being addressed, in part, by Monash University, which is developing a National Coronial Information System in association with the Australian Coroners Society. Their work is complemented by that of the Australasian Fire Authorities Council (AFAC) and the Industry Commission in the development of performance monitoring measures for the fire services.

Situational factors

Fatalities in residential fires are the result of a complex chain of events and involve the interaction of multiple factors and and occur in a range of situational circumstances. These include the fact that the most common time of fire ignition is between midnight and 8 a.m., that fires are most likely to start in the bedroom or kitchen, and that certain months, usually the colder months, have a higher number of fatalities. These situational factors were also identified in this study. Similarly, this study confirmed the findings of other studies which found that the most common causes of fatal residential fires were cigarettes and heaters.

Many studies have found that not everyone is equally at risk of fatal residential fires. High risk groups are the elderly and the very young (Newton 1997; Barillo and Goode 1996a; Australian Institute of Health and Welfare National Injury Surveillance Unit 1997), persons with physical or mental disabilities (Runyan et al 1992), and people under the influence of alcohol or other drugs (Barillo and Goode 1996b). Although there was a small group of cases examined during this study in which the victims could not be identified as belonging to a high risk group, the majority of victims fell into the high risk groups identified in other research.

Identification of high-risk groups, descriptors of the timing and location, and the identification of common causes of fatal fires, such as cigarettes and heaters, focus on the situational and 'technical' factors of fuel and heat source. Such information is essential to understanding the nature of the problem but is only part of the answer; it does not provide an understanding of why people die in such fires. The purpose of this study, however, was to understand in more detail the factors that explain why people die in residential fires.

The human factor in fatal fire events

The results of the CFA's study indicate that there are several types of fire events that characterise fatal residential fires. There are also several sets of factors which, if present, will increase the risk of a fatal fire.

Research on the common causes of fatal fires, such as cigarettes, radiators and faulty appliances, is often the focus of studies of fire fatalities (see, for example, Barillo and Goode 1996a). However, such a focus over-emphasises the technical aspects of the hazard. This study attempted to investigate the interaction between the people involved, the agent, and the hazard in more detail. It identified five types of fire events which commonly result in fatalities. These fire events are generally the result of some human action, either directly or indirectly, bringing together a heat source and fuel. These fire events are:
- unsafe use or disposal of smoking materials
- inappropriate use of a heat source for heating, cooking, lighting or other purpose
- flame accessible to people unaware of the potential dangers of fire
- faulty electrical appliances or wiring
- a disabling event causing direct contact with heat source.

The role of the victim or of other people present varies from direct involvement, due to carelessness or ignorance, through to indirect contribution due, for example, to failure to use a barrier around the heat source. It is important to recognise the wide range of contributing actions such as neglect of maintenance, unsafe practices in a wide range of situations, carelessness and fireplay. The direct human contribution is significant in the majority of cases examined, while in some situations the behaviour of the victim or another person contributes less directly (as with use of faulty electrical appliances or when the victim suffers a fall and comes

into contact with an unprotected heat source).

The major causes of residential fires as a whole are not the same as the types of fires identified in this research as the ones which result in fatalities. Typically the five most common causes of house fires are cooking equipment, heating equipment, incendiary or suspicious circumstances, electrical distribution systems and electrical appliances (Newton 1997). But many fires of these types and others are not fatal. In order to understand why people die in residential fires it is necessary to consider the factors which make a fire fatal in one situation but not in another. The results of this study reveal that there are a range of factors which place the people involved at greater risk.

Factors contributing to residential fire fatalities

Analysis of the factors contributing to fatal residential fires has identified three sets of factors which greatly increase the risk of a fire being fatal. Firstly, the study identified pre-existing factors that reduce the capacity of the person to respond effectively to the fire event:

- impaired physical or psychological condition e.g. frail, intellectual disability
- reduced capacity due to temporary state of victim e.g. asleep, intoxicated
- the person lives alone or in an isolated situation.

The second set of factors relates to the increased risk of fire due to the physical environment or human behaviour. Four key factors were identified:

- habitual or incidental behaviour concerning the use of fire agents e.g. a radiator on while asleep, leaving matches within reach of person lacking fire awareness
- presence of materials conducive to fire ignition and fire spread e.g. flammable liquids not properly stored, poor maintenance of appliances, high fuel loads in dwelling
- nature of dwelling e.g. mobile home
- known fire risk behaviour or situation not addressed.

The third set of factors relates to the circumstances that contribute to the victim's response to the fire being ineffective. Six key factors were:

- person responds inappropriately, e.g. remains in dwelling or re-enters building;
- there is no appropriate escape route, e.g. windows are barred, deadlocks are locked or the key is unavailable

- lack of suitable fire protection or extinguishment equipment
- there is no effective warning system
- the victim is directly involved with, or in close proximity to the fire.

In most cases a combination of these factors was present.

Certain types of fire events are more likely to be fatal, and these generally result from the interaction between certain human actions and a range of hazard agents. It is also clear that there are factors which increase the level of risk for some people more than others.

Figure 2 shows the relationships between the factors contributing to residential fire fatalities. The model indicates that the factors identified are in fact indicators of vulnerability which define certain groups as high risk. The model also demonstrates that it is the exposure of the vulnerable person to the hazard event which defines the event as a fatal fire.

Vulnerability

The factors that increase the likelihood of a fatal fire define the vulnerability of people to the hazard event. Hence, the elderly are more vulnerable partly because they are often frail and less mobile and thereby unable to respond effectively. The intellectually disabled are at greater risk because they are often less aware of the dangers of their behaviour. Similarly, people who are heavily intoxicated are less likely to become aware of a fire and are less able to respond appropriately to fire cues. Those who live in mobile homes or homes with barred exits are less able to escape, and those who live in low socio-

economic circumstances are more likely to have faulty appliances or find it necessary to use them in unsafe ways. The study also revealed that there are usually several factors which together define the vulnerability and therefore compound the risk.

Effectiveness of current protection measures

Research on fire fatalities tends to focus on identifying the demographic and situational factors associated with fatalities. Often it is only in final paragraphs that attention is given to prevention issues.

For the purpose of this research an expert panel was used to assess the effectiveness of fire interventions. The assessments by this panel cast significant doubt on the likelihood of current forms of intervention achieving further reductions in residential fire fatalities. A range of typical fire prevention and response measures were selected for assessment, including:

- installation of smoke alarms and warning systems
- design of product or materials to reduce fire risk
- use of on site firefighting equipment
- fire service emergency response
- fire safety publicity
- interactive fire safety education.

The panel was provided with details and circumstances of a sample of the 66 residential fire fatalities and asked to assess each intervention measure as to whether it would be likely to prevent the fatality, uncertain whether the intervention would prevent the fatality, or unlikely to prevent the fatality.
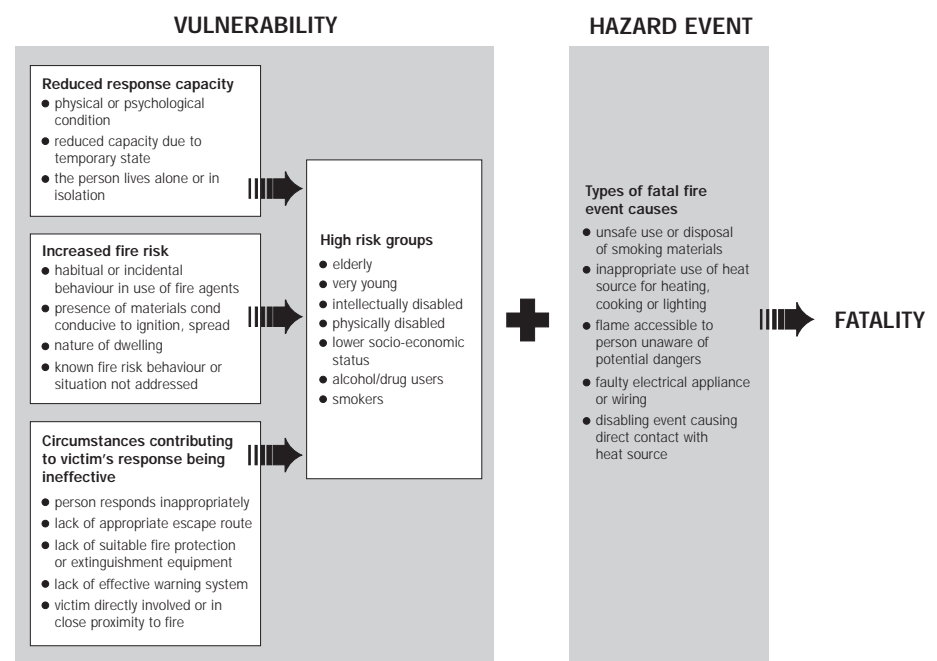

Figure 2: Residential fire fatality vulnerability model

No form of intervention, with the exception of smoke alarms, was rated as more 'likely' than 'unlikely' to be effective in the cases considered. Although there were some cases where smoke alarms were 'likely' to be effective, this assessment often assumed that the person would be alerted to the warning despite the effects of alcohol and other factors, and would be able to respond effectively. The installation of smoke alarms, particularly in residences of high-risk individuals, must continue to be a priority. However, it is unlikely that this measure alone will make a significant difference unless it is accompanied by a range of other preventative measures to reduce the risk of fire starting, and others to enhance the capacity of the occupant to respond effectively.

In a number of cases, product design or fire-resistant materials were considered likely to be effective in preventing ignition or restricting the fire spread but were generally assessed as unlikely to be used, for a variety of cost and practical reasons. In the longer term, changes of this sort may be effective and there is clearly an important advocacy role required to encourage the implementation of measures such as safer product design, use of materials in furnishing which are less toxic, use of child-proof lighters, self-extinguishing cigarettes and other such measures.

On-site firefighting was not assessed as likely to prevent the fatality because the fire was usually too advanced and the victims were often unable to use such equipment. The characteristics of the high risk groups mitigate against the effective use of fire fighting equipment, making this an unlikely intervention strategy for reducing fatalities.

The fire service response was also considered unlikely to prevent the fatalities because, as other studies (Squires and Busuttil 1996) and anecdotal evidence suggest, the fatalities are likely to occur before the fire service is able attend and effect rescue. To achieve further reductions in response time would be prohibitively expensive and even then would be unlikely to ensure the arrival of the fire services before many fatalities occur. This is not to suggest that current levels of response capability can be allowed to decline. However, further improvements in community safety are more likely to come from investment in other more preventative forms of intervention.

The dissemination of fire safety messages and information such as fire safety publicity in the form of brochures, posters and media advertisements is unlikely to be effective in achieving a reduction in fatalities. Publicity materials may raise awareness of the fire risk but are unlikely to change behaviour or address the factors that define vulnerability. Furthermore, those who are most vulnerable are less likely to have access to, or to be interested in, the messages such material contains. Publicity material may be more useful in raising awareness in those responsible for the care of those most at risk of fire. However, it needs to be in a form which is more appropriately directed at those at highest risk and supported by a range of other more direct measures to address the factors which increase vulnerability.

Interactive fire safety education in the form of home safety audits and face to face safety education offers a greater prospect of changing behaviour and reducing vulnerability. An interactive approach increases the impact of safety messages and provides the opportunity to address specific risk factors in particular situations. However, a major drawback is the difficulty of identifying and gaining access to high risk individuals and the cost of personnel to deliver such programs.

In a number of the cases presented to the expert panel, residential sprinklers were identified as a potentially effective means of preventing fire spread and the consequent fatality. Whilst they may provide adequate protection in some circumstances, there are several limitations. Where the victim is directly involved in the fire, as in disabling events or cooking accidents, sprinklers are unlikely to be effective. Similarly, where the fire starts in the same room as the victim, the effects of the fire may be fatal before sprinklers are activated or become effective. Furthermore, the use of sprinklers to reduce the vulnerability of high risk groups requires that such individuals are identified, and are able to afford the installation of sprinklers. Sprinklers need to be considered simply as one component of a fire protection 'package'.

This study of factors contributing to residential fire fatalities and the effectiveness of fire intervention measures highlights the complex nature of residential fire fatalities and the difficulty of devising a simple strategy for reducing the number of fatalities. Countermeasures that focus on dealing only with the hazard agent provide only part of the solution.

A holistic approach

It is characteristic of the fire and emergency services and the fire protection industry that, when considering residential fires, the focus is on the hazard or cause of the fire. The dominant paradigm is to view the fatality as the result of an event in the physical environment. One of the consequences of this view is to focus on technological solutions. For fire services this has traditionally meant seeking to improve suppression and response capability through the use of better communications, equipment and distribution of resources. Similarly, fire protection focuses on the development of more effective technical systems through use of detection equipment, engineering design, suppression equipment and so on. These are essentially environmental interventions that do not require the active involvement of the user.

These external forms of intervention which make structural changes to the environment, and which require limited or no action by the individual to reduce the risk have been widely implemented in industrial and commercial environments. But whilst these measures have significantly improved fire safety in these settings over a long period of time, residential fires remain the main source of fire-related fatalities.

Widespread domestic application of these technological solutions is much more difficult to achieve because of the long time span involved in replacing buildings, and the relatively high cost, which is typically borne by individual property owners. In residential settings the reliance on technological solutions has traditionally meant there has been a public reliance on fire service response, and measures such as smoke alarms, residential sprinklers and safer product design. Despite the steady decline of fatalities in all types of situations, residential fires remain the major cause of loss of life from fire.

Reliance on technological measures is unlikely to be effective. Smoke alarms are useless if residents do not understand the need for regular maintenance, and legislation to make smoke alarms mandatory will be ineffective if householders do not know how, or are not able, to respond appropriately to warning signals. The study also suggests broad-scale media campaigns are also of limited value on their own because of the range of factors involved, the complexity of interaction, and the difficulty in achieving changes in

individual behaviours. Furthermore, such measures are not equally applicable as different groups in the community are not vulnerable in the same ways.

The results of this study suggest that a shift in focus from the hazard agents to the vulnerability factors may be more productive in addressing the problem of residential fire fatalities. The interaction between the victim (or others) and the hazard agent, and the existence of multiple factors contributing to vulnerability, also means that it is unlikely any one counter measure is likely to be totally effective.

Proposed strategies

Effective fire intervention strategies require a different approach from that currently adopted by fire services. A new paradigm for fire intervention would involve a more holistic approach which recognises the complexity of the problem and employs a range of integrated measures to address the specific needs of vulnerable groups in the community. As a result of the study, the following strategies are offered for addressing the prevention of residential fire fatalities.

Identify the needs of high risk groups in community.

This study has identified three major sets of factors which define vulnerability to residential fires. These factors are, in many respects, manifestations of a range of personal lifestyles and behaviours in particular social situations.

Generalised notions of personal and community safety will not necessarily provide insight into the needs of high risk groups. The key task is to develop an understanding of how people in these high risk groups or those responsible for their care perceive the risks in the context of their own situation. Similarly, measures to improve safety are unlikely to be accepted and implemented if the people concerned find them impractical, inappropriate, and irrelevant. If fire services are to meet the needs of the community they must first understand those needs.

Consultation and collaboration with members of high risk groups, those responsible for their care, and other stakeholders is essential, if effective strategies are to be developed.

Shift the focus from dealing with hazard agents to addressing vulnerability of high risk groups.

The traditional focus on technological solutions to deal with hazard agents underestimates the role of human

actions in contributing to fatal fire events, and diminishes the significance of the range of largely personal and social factors which define vulnerability. The research suggests that to address these human factors will require a major shift in focus. Effective fire prevention strategies must involve dealing with a range of social issues in order to address the risk factors which increase the vulnerability of particular groups. Issues such as alcohol and drug use, low socio-economic status, lack of access to resources and facilities, and social isolation are more significant in determining the likelihood of a fatality occurring. In order to deal with these issues it is necessary to address the human dimensions of the problem.

Employ a range of measures to address specific fire safety issues

The study suggests that fatalities occur amongst the 'hard to reach' in the community: those who are less likely to be exposed to traditional fire intervention and safety measures. It is therefore unlikely that any single intervention will provide a solution. An integrated approach, using a variety of strategies targeted to address the needs of particular groups, is more likely to be effective.

To address issues of fire safety among vulnerable groups in the community, also requires a strong advocacy role in promoting effective interventions and supporting the requirements of these groups. It could be argued that fire services have lagged behind other organisations who have taken an active role in raising issues relating to particular safety issues in the community. For example, a strong advocacy role has been undertaken within the community on the need for swimming pool fences, restrictions on gun ownership, and in raising awareness of domestic violence amongst many others.

Furthermore, because many in the high risk groups are unable to take full responsibility for their own safety, effective measures need to involve others in improving safety. Family members or members of the local community need to be supported and provided with appropriate resources to ensure the safety of those vulnerable to fire. Whether this means raising awareness of the risk, directly resourcing people to improve safety, providing training in identifying potential hazards, installing fire warning or protection systems, or some combination of these

measures, promoting and supporting greater community responsibility for dealing with the needs of high risk groups is more likely to be effective than broad-scale, generic solutions.

To actively engage people in taking responsibility for their own safety or that of others in their care requires that they:

- appreciate the danger or have an awareness of the risk
- have appropriate information so that they know what to do to address the risk
- have the resources to put effective strategies into place.

Empowering communities to take responsibility for themselves or those in their care is more likely to be effective than relying on the traditional approach which promotes dependence on the response capability of the fire service. A number of existing CFA programs such as *Community Fireguard*, *Juvenile Fire Awareness and Intervention Program* and *Residents at Risk* employ this approach. The task is to develop a range of multi-faceted programs to address the factors which make people vulnerable.

Develop an intersectoral approach to address community safety issues

Those who are vulnerable to fire are also more likely to be the victims of other forms of injury and death. In particular, the very young and the elderly are vulnerable to a range of injuries in the home and elsewhere. Furthermore, a number of the risk factors which determine vulnerability to fire are the same as those which contribute to other injuries (Harrison and Cripps 1994).

There are many sectors such as local government, health facilities, government departments, community services and welfare agencies that share responsibility for the safety and welfare of vulnerable groups. The development of an intersectoral approach to dealing with community safety issues reduces duplication and also takes advantage of the synergy resulting from the activities of various sectors reinforcing each other rather than operating in isolation or in opposition. Traditionally, fire services have been very narrow in their approach to fire safety and have encouraged the notion that it is their responsibility to deal with fire, usually, as discussed, through the application of technological approaches to improving suppression capability.

In order to address the needs of those most vulnerable to residential

fires, the fire services urgently need to form partnerships with a wide range of other organisations which deal with safety issues and work with the same groups in the community.

Both at the organisational and at the local level, fire services need to place greater emphasis on developing networks and learning to work effectively with a range of community organisations, many of which have different perspectives and ways of working from those traditionally employed by fire services. This has major implications for the recruitment and training of personnel in the fire service of the future.

Concluding comments

Reducing the rate of death from residential fires is a key challenge facing fire services around Australia. However, the results of this study suggest that the traditional focus on fire service response, suppression, and technological solutions is unlikely to contribute significantly to further reductions in fatalities.

The study has highlighted the role of social and behavioural factors in residential fire fatalities. It suggests that attention needs to shift from technological solutions to activities that address the human dimension of the problem and from dealing with hazard agents to addressing the vulnerability of high risk groups. In conclusion, the results suggest that future efforts to reduce loss of life from residential fires will only be effective if the fire and emergency services explore opportunities to employ a more diverse range of strategies to address the problem.

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