Submission to Legal and Constitutional Affairs References Committee Inquiry on the use of smoke alarms to prevent smoke and fire related deaths

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Summary

Changes to fire safety related requirements must both be effective and cost-effective in comparison with other provisions that are intended to reduce deaths and injuries in the community.

There are many additional requirements that are possible to improve smoke alarm systems in residential buildings. These include: placing smoke alarms in every room and space where fires might start and that might be occupied by people, interconnecting them so that they all sound when any one of them is triggered, including in each alarm detectors that detect smoke and fire by different means, increasing the sound level emitted by each alarm, changing the sound emitted so that (at the required sound level) it is more likely to awaken the broad range of people who, based on statistics recorded by fire brigades and on studies of coronial data of fire fatalities and fatal fires, are currently killed in fires.

However, each of these changes would result in considerably increased cost. The cost would be highest if the requirements were to be applied to existing dwellings but this would have the greatest and quickest effect. The cost would still be considerable if only applied to new dwellings but would have very little effect initially on deaths and injuries. In this case the effect would increase very slowly as the affected dwellings became an increasing proportion of the dwelling stock.

It is suggested that a concentration on education, community awareness and regulation to further reduce the *occurrence of fires* is a better, and more cost-effective, approach than to increase measures to mitigate the consequences of fires (such as more or changed smoke alarms).

Introduction

The authors have conducted internationally recognised research relevant to this inquiry over the last twenty years. This submission briefly summarises the outcomes of this research in the light of the inquiry terms of reference and makes specific suggestions in relation to some of them. The submission is not written as an academic document, but it is written to reflect the author's research and broader understanding of fire safety gained through many years of involvement and study. The authors are happy to provide further detailed information, data, copies of the papers referred to and answer specific questions if required.

The Context

Improving fire safety requires that changes to fire safety systems (or components in those systems) address the people who are currently killed or injured in fires. The changes must make it more likely that those people currently killed or injured will become aware of the danger more quickly and/or be better able to deal with the dangerous situation while also ensuring that those currently not killed or injured in similar incidents are not made less safe.

Smoke alarms are just one component of the fire safety systems we incorporate in our buildings. They are relevant to such systems in all buildings but are particularly relevant in residential buildings because of the activities that take place in those buildings and because they constitute a visible component of the fire safety system in most residential buildings, particularly single family dwellings.

On average a fire notified to the fire brigade occurs in a dwelling in Australia once in 300 to 500 years with variation over time and location. In fires in dwellings (based on US and Australian fire brigade data) without smoke alarms present there are between five and ten fatalities and between 30 and 60 injuries per 1000 fires, but the frequency of fatalities varies widely depending on the room of fire origin: on average in lounge rooms between 20 and 30 fatalities per 1000 fires, in bedrooms between 10 and 20 fatalities per 1000 fires and in kitchens between one and five fatalities per 1000 fires. These figures mean that assessments of the effectiveness of fire safety system components (such as smoke alarms) and estimates of the effect of changes have to be based on statistical data and cannot be based on accounts of individual fires. While common in press reports of fires it is not possible to say that the outcome of a particular fire was a result of (for example) the sounding of a smoke alarm.

Although almost all fire fatalities (and injuries) that occur in Australia occur in residential buildings (dwellings) the majority of them (houses) have the fewest obvious fire safety related components incorporated in their design. The only obvious fire safety related components are the required smoke alarms but in reality there are many other important components. These include:

- occupant education and training
- plans (whether written or not) and action intended to reduce the ignition of unwanted fires
- plans (whether written or not) of action to be undertaken upon the occurrence of a fire
- means of fire extinguishment (fire blankets, fire extinguishers, garden hose, water containers)
- requirements for exits
- electrical and gas regulations
- regulations in relation to heaters, fire places and chimneys
- regulations and requirements covering equipment and appliances installed and/or used in the building and features in them intended to reduce the risk of fire
- reduced flammable clothing (particularly children's nightwear) and bedding materials
- ventilation requirements
- appropriate housekeeping and maintenance

Consequently, smoke alarms should not be considered in isolation but as one of many components that contribute to the high level of fire safety that we have in buildings in Australia.

Smoke alarms can be thought of as a system that is designed, installed and hopefully maintained for the specific purpose of early detection of fire through the detection of smoke and to warn asleep or awake occupants of a fire with the objective of making the occupants aware of the threat to their safety and allowing them time to safely react. Fires occur in dwellings (with varying frequency) in every room and space and involve every type and form of combustible material that occurs within dwellings. In considering smoke alarms two particular types of fire are often mentioned: smouldering fires and flaming fires. Smouldering fires are generally considered to produce a sufficient quantity of smoke to be of concern, at least in some circumstances, but very little heat; while flaming fires produce more heat and smoke, but sometimes a relatively small quantity of visible smoke.

The smoke alarms used in dwelling smoke alarm systems are usually purchased as individual self-contained units. They may be entirely self-contained, being powered by a battery within the unit, or they may be mains powered (as now required by building regulations) and thus require connection to the electrical wiring of the dwelling. They may also be capable of interconnection so that activation of one alarm will actuate the warning device in connected alarms. Nevertheless smoke alarms themselves may be considered to consist essentially of two components, a detector and a sounder. The detector is, in some way, triggered by the products of the fire, though it may (unfortunately) also be triggered by similar phenomena not resulting from a fire. It is essential that the second method of triggering is minimised to reduce the occurrence of false or nuisance alarms. False alarms should, in an objective analysis of a smoke alarm system, be considered to constitute a failure of the system as they can lead to building occupants ignoring or disabling smoke alarms. The sounder is intended to be activated when the detector is triggered. Its sole purpose is to make occupants of the dwelling aware of the fire.

The domestic smoke alarm system incorporates:

- the fire
- the physical environment
- the smoke alarm(s)
- the human occupants of the dwelling (and occasionally a passer-by)

Each component of the system can have an effect on the other components up to the point that the occupants become aware of the fire by whatever means, at which point the smoke alarm system has served its purpose or was not actually needed in this instance.

It is often assumed that only a smoke alarm will provide warning of a fire. However this is incorrect as indicated by the statistics quoted above. In many cases, if the occupant is awake and close to the fire, they may become aware of the fire without needing to be alerted by a smoke alarm. Humans are extremely good detectors of smoke, unexpected sounds, flickering light and other cues associated with fires. Nevertheless, if the occupant is remote from the fire, or is close to the fire and asleep, they may benefit from the sound of a smoke alarm to become aware of the fire much earlier than they otherwise would. In these cases the proximity of the occupant to an operating alarm sounder and the proximity of a detector to the fire are likely to significantly influence the effectiveness of the smoke alarm system in detecting the fire quickly and in making the occupants aware of the fire.

Interactions occur before and during the fire. The physical environment of/in a dwelling is partly a result of the architectural and structural design of the dwelling but it is also a result of the capabilities, attitudes and behaviour of the occupants. For example, put simplistically, the amount and composition of furniture in any dwelling will vary according to an individual's personal taste and financial situation. Similarly, the condition of the smoke alarm is at least partly a reflection of the capabilities, attitudes and actions of the occupants. Different individuals will have varying capacity to appropriately select, purchase and maintain smoke alarms that is based upon their level of awareness, and their cognitive, physical and financial capabilities. As a consequence the occupants have an influence on the probability of occurrence of a fire, the type of fire, the location of the fire, the availability, type and quantity of fuel, on the condition and operation of smoke detectors and the ventilation conditions.

The actions of the occupants over the long term prior to a fire affect the likelihood of a fire and the environment in which the fire takes place in that they affect the condition of the dwelling, its fittings and contents including the components of the smoke alarm system, and, indeed, whether there is a smoke alarm system at all. The condition of the dwelling and the type and condition of furnishings and other contents are likely to be influenced by occupant characteristics such as age, employment status, income, their physical, cognitive and emotional condition, and many other factors. The occupants are also likely to strongly influence the probability of an unwanted fire: the occurrence of sources of ignition, the availability and quantity of combustible contents (e.g. a smoker's risk of causing a fire is greater than a non-smoker's, a cluttered environment is likely to provide more fuel and greater likelihood of fire spread than a non-cluttered environment). The actions of the occupants immediately prior to or following the ignition of a fire will also influence the outcomes. Important aspects include whether they were:

- directly involved with the ignition of the fire
- intimately involved in the fire at or immediately following ignition
- asleep
- affected by alcohol or drugs (prescription or other)
- physically or mentally impaired

Many of the characteristics of the environment are largely related to the type of room (e.g. a kitchen fire is likely to involve sources of ignition and fuels different to a fire in a lounge or bedroom). The geometry of the room of fire origin (length, width, ceiling height), the number and dimensions of doors and windows and whether they are open or closed, the characteristics of the ceiling (horizontal or sloped, exposed beams, etc.) is likely to influence the fire itself but also may influence the movement of smoke and time of detection for a given smoke alarm. The ventilation of the fire and time of detection may also be influenced by the effects of air conditioning, ducted heating, a ceiling fan and even external weather conditions. The latter, in addition to the obvious effects such as wind, can also influence whether and to what degree doors and windows are open.

The overall layout of the dwelling, the connection of the room of fire origin to other rooms, hallways, stairways, whether the dwelling is single or multiple storeys obviously may influence the movement of smoke and even the fire around the dwelling. Possibly of greatest importance in relation to the physical environment and its effect on the occurrence and development of a fire are the furnishings and other contents of the room of fire origin. Obvious parameters such as the type and quantity of furnishings and the materials used in their construction and decoration may greatly influence the rate of fire development and smoke production.

The type of fire as reflected in the rate of growth, the maximum heat release rate, the rate of fire spread, the quantity and characteristics of the smoke produced is influenced by ignition factors such as how the fire was ignited and the type and form of material ignited. The means of ignition often has a strong correlation with the location (kitchen, lounge, bedroom, etc.) and may have a great influence on the type of fire. So do the type of material ignited (solid, liquid, gas) and the form of material ignited (flimsy fabric, floor covering, furniture, etc.). The products of the fire in the smoke are important because they provide the means of detection of a fire that can be used to distinguish a fire from other phenomena that can trigger a smoke alarm. These include CO, CO2, soot, reduced visibility, heat (changed/changing temperature), flames, etc. Unfortunately in some physical environments there are other sources of the same or similar products. This means that care needs to be exercised in choosing means of detection that are appropriate for the particular location, and even when this is done, some difficulty in distinguishing fires from other sources may occur.

There are two aspects of the location(s) of smoke alarms that are important: their location relative to the fire and their location relative to the locations of the occupants. It is obvious that this potentially leads to opportunities to separate the detector(s) from the sounder(s) and to optimise the location(s) of each of them. In the following it will be assumed that the detector(s) and sounder are not separated, that is, are contained within the one unit which is normally the case with domestic smoke alarms.

A number of aspects are presumed to affect the reliability of smoke alarms. Perhaps the most obvious of these is the power supply for the detector and sounder. Many in dwellings today are battery powered, but it is often assumed (not necessarily accurately) that the connection of smoke alarms to mains power increases their reliability, particularly as such smoke alarms are usually also fitted with battery backup. The assumption of increased reliability may be little more than an assumption if there are other aspects of detector maintenance that are equally important (e.g. keeping them free of dust, not covered or painted, etc.) or simply not disabling them because of frustration at false or nuisance alarms.

The type of detector used in a smoke alarm is known to affect the time at which a detector in a given position will be activated. A wide range of detectors is possible as mentioned above but two types are most common at present in domestic smoke alarms (ionisation and photoelectric). Each type of detector varies according to the specific product of the fire to which they are sensitive. Therefore use of specific detectors to improve the reliability (fewer false or nuisance alarms) in specific locations is possible as some are better at detecting (or more reliably detecting) the type of fires that most frequently occur in some locations and similarly some are less likely to falsely alarm as they are less sensitive to emissions from non-fire occurrences that occur in some locations (steam, smoke, rapid temperature rise, etc.).

Detecting the fire is one essential part of the operation of smoke alarms, making the occupants aware of the fire is the other. This requires the use of some sort of signal that most occupants will become aware of quickly whether they are asleep or awake. Traditionally such signals have been provided by sounds but strobe lights are used in some countries for people with hearing difficulties, and other signals such as pillow or bed shakers (that is, mechanical vibration) are sometimes used, particularly for the hard of hearing. Whatever the warning signal there are a number of parameters that can be varied. If it is recognised that occupants of the building(s) will vary in their ability to become aware of a given signal, then variation of these parameters is likely to affect the proportion of occupants that will respond to a particular smoke alarm. Signal parameters of interest include the volume or intensity, the pitch or frequency, the pattern, etc.

One way of mitigating the problem of having very loud noises in some areas (where the smoke alarms are located) but much softer noises in the areas where, for example the occupants sleep, is to provide more alarms and interconnectivity between them. The intent of interconnected alarms is that the detectors are in appropriate places but the warning is given at high volume at locations of greatest need, for example in places where the occupants sleep. However, it should be noted that the additional components and capability may reduce the reliability of the system by providing more points at which the system can fail.

The reliability of smoke alarms considered as a system is not entirely straight forward. The usual and most obvious measure is whether an alarm detects a fire and sounds a warning at the specified intensity. But reliance on this solely as a measure would fail to appreciate and accommodate the smoke alarm system as a whole. Analysis and estimation of the reliability of the system needs to include consideration of a wide variety of factors including false alarms. If false alarms occur with sufficient frequency to cause the building occupants to disable the alarm or to, in some way, desensitise it to certain types of smoke, then the operation of the alarm system may be compromised. This is why false alarms should be considered a failure of the smoke alarm system. Similarly, if the smoke alarm requires care and maintenance that is burdensome or excessive on the part of the occupant then this also is likely to lead to failure to properly care for or maintain the alarm, and therefore should also be considered as contributing to failure of the system.

The role of occupants in the smoke alarm system during a fire is as a receiver and user of the smoke alarm signal. Once the occupant hears the signal, they need to recognise it for what it is and react to it appropriately – actions may include evacuating, investigating or warning or assisting others. Their ability to do this will vary depending on their state of consciousness (conscious/unconscious) and whether they are asleep or awake. If they are conscious and awake or initially asleep and waken in response to the signal, their cognitive and physical ability to plan and undertake whatever action is appropriate, perhaps very quickly, may be a key factor in achieving a successful outcome. Their ability to react to the signal will also depend on their location compared with the location of the sounder and the other cues or information they perceive. In general, it is reasonable to assume that the further they are from the sounder, the higher the probability they will not hear it, and the further they are from the detector the higher the probability that other fire cues will not be perceptible. Importantly, if the alarm sounds but the occupant fails to respond to it, the system has failed (even though the smoke alarm itself has emitted the signal). There are a number of reasons (other than excessive distance to the sounder or detector) why the occupant may fail to act or not be able to receive or recognise the signal. Some of these are endogenous factors, which means they are characteristics of the person or arise from within the person. These might include disabilities such as being deaf or having a cognitive impairment, having a physical disability or, more simplistically stated, being too young, too old, etc. The reason may also be associated with other factors affecting performance, such as alcohol or drugs, which may not only affect their ability to hear the signal, it may also affect their speed of reaction or their ability to react appropriately at all. These are exogenous factors, or those that occur due to external causes. The individual's interaction with the environment can also be important. For example, the general noise level in the environment may affect the occupant's ability to hear the alarm signal and other conditions in the area at the time may affect their ability to react effectively and without error (e.g. power failure, too dark, smoke too thick, unexpected objects blocking path, locked doors, fire between them and the exit, etc.).

If the occupant hears the alarm signal but deliberately ignores it ("fails to act appropriately") then the system has failed, whatever the reason for this action. This is particularly (but not only) the case if this behaviour is a learned reaction due to previous experience with false alarms (habituation). If the signal to the occupant occurs too late for the occupant to react successfully (either because the signal is too late or because the occupant is unable to react quickly enough) again the system has effectively failed. If the signal is too late for anyone to react successfully then clearly this indicates a problem with the smoke alarm that may be associated with smoke alarm sensitivity to the particular type of smoke and therefore the particular type of fuel involved or something similar. If the problem lies with the ability of the person to react quickly enough, perhaps because of age, illness or disability, then the appropriateness of the device used, or the appropriateness of an alarm system in general, needs to be questioned.

Effectiveness of a Domestic Smoke Alarm System

Many of the factors that influence the effectiveness of smoke alarm systems particularly in relation to reducing occupant fatalities and injuries resulting from fires in dwellings are fairly obvious, but some are not. Obvious factors include:

- the speed of response of the detector(s) (the usual focus)
- the reliability of the detector in responding to and accurately identifying actual fires
- the volume of the signal (sound) emitted

Less obvious factors include:

- the number of alarms in each dwelling
- their positioning in relation to the fires most likely to result in occupant fatalities and injuries (in dwellings: lounge rooms, bedrooms and kitchens)
- their positioning in relation to the locations of occupants most likely to be injured or killed (in dwellings: children and disabled adults)
- their positioning in relation to the locations of occupants most likely to be able to respond to the alarms appropriately (e.g. parents cf. children)
- the influence of the occupants on the operation and reliability of the smoke alarm(s)
- the ability of occupants to become aware of the signals emitted by the alarm(s) (asleep, affected by alcohol or drugs, hard-of-hearing, deaf)
- the ability of occupants to react appropriately (effects of alcohol, drugs, age, physical and mental disabilities, etc.)

Dealing with the obvious factors first, there is always a tension between the first two of these points. In general the more sensitive the detector the quicker the response but the more likely it is to generate false alarms. Thus a balance has to be struck between sensitivity and avoidance of false alarms, and there will inevitably be compromise involved. Another way of treating this issue is to require activation of more than one detector but again this is likely to lead to some delay compared to the response possible with just the fastest detector.

It is widely recognised that the volume of the sound emitted affects the ability of people to hear it. Thus the level that is set determines (along with other factors) the proportion of the population that will not hear or recognise the alarm. Again there is compromise involved because as the level increases a greater proportion of the population will be discomforted and potentially even harmed by the noise, greater power and battery capacity is required and the cost of each unit is greater. It is arguable that these effects should be ignored because it is easy for people to mitigate the loud noise. Other characteristics of the signal that govern the proportion of the population that will not hear or recognise it include the frequency(s), and the pattern of sound emitted. The choice of certain frequencies is now known to affect the proportion of the population that will not hear or recognise the alarm signal. It is less certain that the pattern of sound will also affect this but it appears likely that it will. This is because the signal emitted needs to be immediately recognisable for its purpose, and not covered by background noise or confused with other sounds or signals in the environment.

Returning to the less obvious factors, the first of these, the number of alarms in the dwelling may be considered by some to be obvious, but the fact that in many jurisdictions the number of alarms is not specified and the fact that no balance between number of alarms and their placement and the volume of sound or other factors is included in codes or recommendations indicates that this is not so. It appears obvious that, in general, more is better, likely to bring about earlier detection and, for a given detection level, the more likely the alarm is noticed. However, more is also likely to increase the rate of false alarms and other failures of the system (simply because of more components) and is also likely to increase the level of frustration and annoyance with false alarms and maintenance, and a greater degree of habituation to the signal. It is also likely to bring about greater cost and greater time and effort in installation and commissioning. In relation to maintenance, it appears likely that, in general, less required maintenance would lead to improved alarm reliability. Thus, for example, it is often assumed that mains powers alarms are likely to be more reliable that battery operated alarms. This is probably correct but assumes that the mains power and battery backup (maintained less frequently) are sufficiently reliable and that there are no other maintenance requirements (cleaning, for example) that are neglected as a consequence of less frequent battery checks.

The positioning of alarms is important when it is considered that this could affect the likelihood and speed of detection of fires in certain locations. In terms of saving lives and injuries, it is obvious that it is best to detect quickly those fires that most frequently result in fatalities and injuries rather than for example, other fires that occur (perhaps even more frequently) but that result in fewer fatalities and/or injuries. Thus the location of detectors is an issue.

Equally important is the positioning of sounders in relation to the likely locations of occupants most likely to be injured or killed. There is little point in warning occupants in locations where few people are killed or injured. Similarly, their positioning in relation to the likely locations of occupants most likely to be able to respond to the alarms appropriately is important. For example, the possibility of fires in children's bedrooms might indicate that it is appropriate to place detectors there, but it might be more appropriate to place sounders in parent's bedrooms, or even kitchens or lounge rooms, than place them in the children's bedrooms because it may be more likely that the parents will act quickly and appropriately than young children.

Clearly the occupants of a dwelling exert a strong influence on the likelihood of fires, the type and location of fires, and on the maintenance and continuing operation (reliability) of smoke alarms. Many of the factors involved have been mentioned above and will not be repeated here.

It is appropriate to raise again the ability of occupants to become aware of the signals emitted by the alarm(s) and to react to them appropriately. Again the example of children and parents is a useful example, although it is not the only case worthy of consideration. It has been shown that children are much less likely to awaken to a smoke alarm signal than are adults, consequently it is, in principle, better to provide the signal to the parents, rather than the children. Provided it is considered likely that the children will react appropriately given that they do notice the alarm, then it would be better to provide the signal to both the children and the parents.

Considerations for the Specification of a Domestic Smoke Alarm System

Much of the analysis above is relevant to consideration of standards for smoke alarms themselves and for regulations requiring and specifying details of their use in dwellings.

The analysis reveals that specification of the level or strength of the signal, the location of the detector(s) and signalling device(s), details of the type of signal specified (e.g. for sounds: the frequency(s), pattern(s), etc. of the sounds) to a large degree determines the proportion of the population that would not be aided by the specified smoke alarm system. Currently available information does not allow accurate estimation of the extent of the population that might not be aided by the currently specified smoke alarm systems. If this issue is considered important then further research is warranted and further research is needed.

Similarly, specification of the number and locations of alarms to a large degree determines the proportion of the population that would not be aided by the specified smoke alarm system. Again, currently available information does not allow accurate estimation of the extent of the population in that category.

The domestic smoke alarm system as discussed above is necessarily complex. It is a fact of life that the more complex a system, the more potential there is for it to break down. The purpose of conceptualising the system is to highlight these for the purpose of uncovering areas that would benefit specifically from further development or research, and to work towards minimising the effect of known risk factors.

Some the reasons a domestic smoke alarm system might fail to save the occupant(s) of a residential building (given that the occupant(s) have not already become aware of the fire by other means) include:

- the occupant is intimate with the fire at ignition
- the smoke alarm fails to operate at all
- the smoke alarm fails to detect the fire early enough for an occupant to avoid being killed or trapped so that escape is not possible
- the smoke alarm fails to sound an alarm
- the smoke alarm fails to sound an alarm loudly enough for an occupant to become aware of it early enough (or even at all)
- the occupant fails to hear the smoke alarm (even though it is loud)
- the occupant fails to recognise the smoke alarm
- the occupant fails to (or cannot) respond to an alarm they do hear and recognise
- the occupant fails to respond quickly enough to an alarm they hear and recognise
- the occupant responds to an alarm in a way that (without hindsight) can be termed very risky or inappropriate
- despite responding appropriately the occupant is unable to avoid the fire because their path is blocked in some way

It is notable that it is now recommended that smoke alarms be changed every ten years but alarms when purchased have no use-by date on them and it is likely most households do not keep track of their age. This, combined with the known high non-operating rate (typically 30%) of installed alarms in dwellings, indicates there are major deficiencies in the reliability of current smoke alarm systems.

It is clear from this discussion that detection of smoke is only the first step in successful operation of a domestic smoke alarm system. The system may fail to achieve the objective of occupant safety if any of the reasons mentioned above occur.

In considering many of these possibilities it is important to answer a key question: what proportion of the population will not respond to particular alarm signals? But this question should be refined further. If it is intended to improve the current level of fire safety (i.e. reduce the occurrence of fatalities and injuries) then it is the people currently killed or injured (referred to below as the *at-risk* population) who must be considered.

Characteristics of the at-risk population have been identified in many studies. But perhaps the most poignant such listing of the at-risk population, at least in Australia, is from a study of Coroner's Court records of adult fire fatalities that occurred in Victoria, Australia over the five years from January 1998 to February 2005. Of the 101 adult fatalities of accidental (not suicide or homicide) domestic building fires:

- 53% were smoking a cigarette prior to ignition
- 55% were mentally ill
- 59% were a cigarette smoker
- 66% were asleep at time of ignition
- 71% were male
- 71% were intimate with ignition
- 75% had alcohol or drugs in bloodstream (75% of those aged 19-60 years and 25% of those aged >60 years had a non-zero blood alcohol reading (BAC))
- 80% were alone at ignition
- 82% were not in paid employment (including retirees)
- 84% did not have a working smoke alarm

Most of the fatally injured people had more than one, and most, several of these characteristics. In addition of the adult accidental fire fatalities with a BAC greater than zero, the vast majority could be considered significantly intoxicated:

- 100% had a BAC ≥ 0.05%
- 94% had a BAC ≥ 0.10%
- 57% had a BAC ≥ 0.20%
- 18% had a BAC ≥ 0.30%

In considering these people as both the subject of the fire alarm system and as being involved in the system for its successful operation, it becomes obvious that their capabilities and needs must be considered in designing the system if an improved result is really intended though for many of them it may be impossible to improve the outcome if a fire occurs.

Studies of Awakening People Using Current and Potential Smoke Alarm Signals

A wide range of studies have been conducted:

- 60 dBA (at the pillow) smoke alarm sound in young adults
- 60 dBA (at the pillow) smoke alarm sound in adults and children
- adults subjected to low level simulated fire sounds and light
- children subjected to voices and the current smoke alarm sound at 89 dBA
- older adults (aged 63 to 85 years) subjected to current and potential smoke alarm sounds

- adults and older adults with mild to moderately severe hearing loss subjected to current and potential smoke alarm sounds, mechanical shakers and strobe lights
- sober and alcohol affected young adults subjected to current and potential smoke alarm sounds, mechanical shakers and strobe lights
- adults with and without sleeping tablets subject to current and potential smoke alarm sounds

Consistent results have been found in this research:

- 400 Hz and 520 Hz square wave T-3 sounds have been the most effective means of waking participants - a sound level of 75 dBA (the usual minimum level specified) at the pillow was sufficient to awaken most or all of them.
- The current smoke alarm signal (a 3100 Hz pure tone) awoke substantially fewer participants and was consistently the worst noise tested in this regard
- Bed shaker and pillow shaker devices tested as supplied and at higher intensities were substantially worse than the sounds tested.
- Strobe lights were not an effective means of waking people even at intensities well above those required in standards.

All of the people involved in these studies (except in the first) were primed—they had knowledge of the alarm signals being tested and they knew they would be subjected to a signal. These factors were likely to lead to a better waking response than when the signal was completely unexpected. In addition, the people tested in these studies were not among those in the population most severely affected by their age, disability or condition. The older people who participated were, by virtue of the selection criteria, among the more active older people who were selected to have relatively good hearing amongst people of the same age. The hard of hearing participants had mild to moderate (not severe) hearing loss, and the alcohol affected people were young, not severely alcohol affected and did not have other disabilities. Therefore the results of these studies are likely to under-estimate the proportion of the population who will **not** respond to these signals from deep sleep in an unprimed, unscreened population.

There remain many vulnerable groups not yet tested or that have had limited testing. Such groups include people using other drugs that might affect sleep or response to signals during sleep, the deaf, and people with other physical or mental disabilities that might affect their response to a smoke alarm.

It is not possible to accurately estimate the effect of changes in smoke alarms on the overall fatality rate because needed information is missing: the missing information includes the proportion of the population in each vulnerable or at-risk group, the rate of fire starts for each of these groups (the rate of fire starts might vary considerably from the average over the whole population for some of the groups of at-risk people), the effectiveness of the current and alternative alarm signals in awakening sleeping people for all people in each at-risk group and the current fatality rates for each group. Research to obtain this missing data should be undertaken to facilitate possible further improvements in smoke alarms, and smoke alarm usage and effectiveness.

The Effect of Alarm Location on Smoke Detection and Sound Level at the Pillow

Determining the most appropriate locations for smoke alarms in dwellings requires consideration of the likely smoke sources involved in fires resulting in injury or death, detector type, alarm sound and the alarm brand (or manufacturer) because these factors affect the time taken for smoke detection and/or the likelihood of effective notification of occupants. The authors conducted a project intended to help determine the most appropriate location(s) of smoke alarms in dwellings considering both detection and occupant notification.

The project experimentally determined the loudness of the received alarm sound in real houses and the effect on smoke alarm activation time of the location(s) of smoke using ionization, photoelectric and dual detector (ionization and photoelectric) smoke alarms and a variety of smoke sources. In addition an examination was conducted of fire fatalities that occurred in Victoria between 1998 and 2006 to estimate the changes in fatalities that may occur if smoke alarms in every room or interconnected smoke alarms in every room were required by changed building regulations.

The houses used in the experimental investigations in this project were intended to represent typical Australian houses and the smoke alarms used were purchased in large retail establishments.

The alarm sound level measurements showed that in dwellings the effective notification of occupants can only be achieved with smoke alarms in every room. Without them in every room the sound level in many locations is likely to be too low to achieve reliable notification, particularly of sleeping people but even of many people who are awake. This is generally the case with doors open but always the case with doors closed.

The smoke alarm activation measurements show that in dwellings early detection of smoke can only be achieved with smoke alarms in every room. The time to detection (given a particular smoke source) is shown to be influenced by closed doors, the room in which the fire occurs, the location (room or hallway) of the detector, the type of detector and the smoke alarm manufacturer but the time to detection is particularly influenced by the type and form of the material that is burning.

Early detection **and** notification therefore requires interconnected smoke alarms in every room.

With smoke alarms in the room of fire origin it was found in this project that photoelectric smoke alarms had the highest incidence of non-activation and when they did activate on average took longer to activate than ionization and dual (ionization and photoelectric) smoke alarms. (A range of brands of each type were purchased and used in the testing.)

The coronial records examined indicate that either smoke alarms in every room or interconnected smoke alarms in every room, in comparison with the current requirements for smoke alarms in hallways, might be expected to lead to reduced fatalities resulting from fires in dwellings in Australia. The authors have estimated that smoke alarms in every room in every dwelling could result in up to 30% fewer fatalities and that interconnected smoke alarms in every room in every dwelling could lead to about 50% fewer fatalities. The latter could save about 50 lives per year if interconnected smoke alarms were installed in every room in every dwelling in Australia. Based on an examination of the coronial data the great majority of these predicted benefits would be obtained if interconnected smoke alarms were placed in all bedrooms and lounge rooms and other appropriate detectors in kitchens.

Discussion

In considering improving the level of fire safety in our communities it is important to consider the people who actually die in fires now. It is clear that many of those currently killed (or injured) are vulnerable (or *at-risk*) because of their age, physical or mental condition, use of alcohol or other drugs (prescribed and non-prescribed) and other factors. It seems likely that minor changes to smoke alarm systems would have little effect on the outcome of a fire for most, if not all, of these people.

It may be better to simply redouble efforts to educate people of risk factors associated with deaths and injuries resulting from accidental fires (e.g. excessive alcohol consumption and/or drug use and/or the use of ignition sources such as cigarettes, candles or portable radiant heaters) and to try to continue to reduce the occurrence of fires rather than to try to further mitigate the outcomes. In this regard regulation of the availability of radiant heaters might also be beneficial.

Conclusions

A domestic smoke alarm system is shown above to be a complex system the effectiveness of which may be greatly affected by a large number of factors. It is clear that there are a number of aspects of current smoke alarms and smoke alarm systems that are non-optimal but it is unclear whether changes to some or all of them are warranted on a cost-effectiveness basis because the much greater number of lives lost on an annual basis due to fire is small in comparison with the lives lost due to other accidental and non-accidental causes. Further research in several areas may also be beneficial as identified above.

In relation to the terms of reference for the inquiry we offer the following specific comments.

The use of smoke alarms to prevent smoke and fire related deaths, with particular reference to:

a. the incidence of smoke and fire related injuries and deaths and associated damage to property;

   The incidence of deaths and injuries may be reduced further by changes to smoke alarms, smoke alarm systems and regulations governing their use in buildings, particularly dwellings, but it is not obvious that this would be cost-effective in comparison with means to reduce deaths and injuries due to other accidental and non-accidental causes.

b. the immediate and long term effects of such injuries and deaths;

   No specific comment.

c. how the use, type and installation set-ups of smoke alarms could affect such injuries and deaths;

   This has been covered in-depth above. Many changes are possible that would reduce deaths and injuries. Such changes could be prioritised but further research would be advantageous.

d. what smoke alarms are in use in owner-occupied and rented dwellings and the installation set-ups;

The majority of smoke alarms used in the past were of the battery powered ionization type. The type of detector used does affect the smoke alarm system performance but it is one among many such factors and is by no means the most important. Based on our research the number, locations and interconnection of smoke alarms and the alarm signals used are of greater importance.

e. how the provisions of the Australian Building Code relating to smoke alarm type, installation and use can be improved;

In our opinion the ABC smoke alarm provisions should only be changed if the changes can be shown to be cost-effective in relation to the safety of building occupants in comparison with other possible changes to the ABC and other means of improving life-safety in Australia. Fire safety in buildings should not be considered in isolation.

f. whether there are any other legislative or regulatory measures which would minimize such injuries and deaths; and

No specific comment.

g. any related matter.

No specific comment.

The authors and colleagues relevant reports and publications:

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Britton,M. and Thomas, I.R. (2000) Cost-Effectiveness of Fire Safety Measures in Community Residential Units, 3rd International Conference on Performance-Based Codes and Fire Safety Design Methods, USA, pp.353-364.

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Ball M and Bruck D (2004) The effect of alcohol upon response to different fire alarm signals Proceedings of the Third Human Behaviour in Fire Conference, Belfast, 1-3 October. London: Interscience Communications. pp 291-302.

Bruck D, Reid S and Ball M (2004) Effective emergency arousal of sleeping children. J. Sleep Res. 13 (suppl 1): 103.

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Watts-Hampton, T. (2008) Examination of risk factors and mental health status in an adult accidental fire death population 1998 -2005. Thesis submitted for Honours in Psychology degree, Victoria University. http://eprints.vu.edu.au/

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Ball M, Graesser H, Bruck D and Thomas I (2009). Increased fire death risk for the elderly. Australian Nursing Journal, 16(7), 35.

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Bruck D and Tokley M (2009) Sleep inertia in the context of emergency evacuation; a review of what we do and do not know. In Shields J (ed.) Proceedings of the Fourth Human Behaviour in Fire Conference, Cambridge, July, pp. 355-362.

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Thomas I, Bruck D and Barnett M (2009) Is consideration of evacuation relevant to most fire fatalities? Using the CESARE Coronial Database to Investigate the Utility of ASET/RSET Calculations. In Shields J. (ed.) Proceedings of the Fourth Human Behaviour in Fire Conference, Cambridge, July, pp. 411-420.

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Thomas I and Bruck D (2010) The Time of Activation of Smoke Alarms in Houses - the effect of location, smoke source, alarm type and manufacturer, and other factors. NFPA Suppression, Detection and Signaling Research and Applications Conference, Orlando, USA, http://www.nfpa.org/assets/files//PDF/Foundation%20proceedings/The_Time_of_Activation_of_Smoke_Alarms_in_Houses-Thomas_and_.pdf

Thomas, Ian and Dorothy Bruck (2010) Smoke Alarms in Dwellings: Timely Activation & Effective Notification, Technical Report, CESARE, Victoria University, Melbourne, Australia

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Thomas, Ian (2011) Limitations in Measuring Performance in Performance Based Design, Fire Safety Asia Conference (FiSAC), Singapore, October 2011

Bruck D and Thomas I (2012) Community-based research on the effectiveness of the home smoke alarm in waking up children. Fire and Materials 36(5-6), 339-348 (Invited contribution)

Xiong, L., Bruck, D., & Ball, M. (2012). The key personal, environmental and behavioural factors contributing to smoking material-related residential fire fatalities. 5th International Human Behaviour in Fires, September, Cambridge, UK. pp. 606-611.

Xiong, L., Ball, M, & Bruck, D. (2014). Utilization of the Haddon Matrix to Organize Factors of Survived Accidental Residential Fires: Frequencies for Human, Agent, and Environment-related Variables. 11th International Symposium on Fire Safety Science. University of Canterbury, New Zealand, February.

Lykiardopoulos, C. P., Bruck, D., & Ball, M. (2014, September). The effect of hypnotics on auditory arousal thresholds in older adults. Journal of Sleep Research. 23, 96-96.

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Thomas, I, Bruck, D and Ball M (2015) Fire Alarm Waking Effectiveness For Alcohol Impaired Adults, Proc. International Symposium on Human Behaviour in Fire, September, Interscience Communications.

Xiong, L., Bruck, D., & Ball, M. (2015). Comparative investigation of 'survival' and fatality factors in accidental residential fires. Fire Safety Journal, 73, 37-47.

The Authors Research and Experience

Dr Ian R Thomas

BE (Hons) Monash University (Civil Engineering) 1968
PhD Monash University, Thesis: Reinforced Concrete Hyperbolic Paraboloid Shell Structures, 1972

Experience

Dr Thomas retired in March 2011. From then until March 2014 he was an Honorary Professor with Victoria University, Melbourne, Australia where he presented lectures for graduate courses in fire engineering, supervised PhD students and was involved with several fire engineering research projects.

From 1999 to 2010 Professor Thomas was Director of the Centre for Environmental Safety and Risk Engineering (CESARE) at the Victoria University (VU). In this role he was responsible for wide ranging research on fire safety in buildings and on risk management. He was particularly interested in the effectiveness of fire safety systems, the behaviour of fires in enclosures and in the role and behaviour of building occupants in building fire safety systems. Improvements led by Professor Thomas to CESARE-Risk, a building fire risk-cost model developed at the Centre, resulted in it being described by an international review committee as the "most advanced risk/cost model in the world".

Professor Thomas was also responsible for the supervision of PhD and Masters (by research) students and the conduct of graduate courses including the Masters (by coursework) and Graduate Diploma in Building Fire Safety and Risk Engineering.

More recent initiatives in fire safety research led by Professor Thomas include the development of the CESARE Coronial Fire Fatality database followed by the CESARE Fire Survivors database. These databases collect details of the circumstances of fires and details of the people involved in the fires and have led to insights into the characteristics, behaviour and differences between people killed in fires and people who survived building fires.

Professor Thomas was a pioneer of the change in fire safety practice from the prescriptive approach to the performance based engineering approach. He has been highly influential in Australia changing from fire protection largely related to structural stability of buildings to a systems approach involving the highly dominant variables of human response, fire behaviour, and active systems such as sprinklers and alarms. He has been active in developing risk based analysis of fire safety systems and in improving the performance based risk analysis model, CESARE Risk and validating its predictions against the fire record.

Through studies of the fire record, simulations and risk analyses and studies of human behaviour, particularly in relation to sleeping and other activities that increase the risk of injury and death from fire, he has initiated and contributed significantly to an improved understanding of behaviour and personal characteristics that indicate increased risk of involvement and harm in fires. Thus he brings a unique perspective through his broad experience and understanding of the many factors that increase risk of fire and of becoming a fire casualty.

This has been recognized internationally in several ways. Professor Thomas, with his colleague Ms P Brennan presented two papers at the 2001 International Symposium on Human Behaviour in Fire, the most prestigious conference in this subject area. One paper, entitled "Victims of Fire? Predicting outcomes in residential fires" was chosen as the keynote paper for the conference, the second paper was "Predicting evacuation response and fire fatalities". Ms Brennan and Professor D Bruck also from Victoria University also presented a paper on "Recognition of fire cues during sleep". The research for this paper arose as a result of recognition while developing and validating CESARE Risk that human response while sleeping must be better than had previously been assumed, as was indeed shown to be the case.

Professor Thomas and two colleagues won the Chapman Medal given by the Institution of Engineers, Australia, for the best paper published in 2001 in the Australian Journal of Structural Engineering, (Bennetts, I.D., Poh, K.W. and Thomas, I R., A Framework for Fire Engineering Design, Australian Journal of Structural Engineering, Vol SE3, Nos I & 2, 2000, pp 9 22). Professor Thomas and Dr Ian Bennetts were awarded the Jack Bono Engineering Communications Award by the Society of Fire Protection Engineers (USA) for the paper published in Volumes 12 and 13 of the Journal of Fire Protection Engineering that has most contributed to the advancement and application of fire protection engineering. (Bennetts, ID and Thomas, IR, “Performance Design of Low-rise Sprinklered Shopping Centers for Fire Safety”, JFPE, v12, n4, 2002)

In 2014 Ian was awarded the Kunio Kowagoe Gold Medal for outstanding contributions to fire science and engineering through innovation, impact of his publications, practical applications and training of students and young fire safety engineers by the International Association for Fire Safety Science.

From 1979 to 1999 Professor Thomas worked at the BHP Melbourne Research Laboratories. Initially he was responsible for research projects in structural engineering, particularly on steel structures, but also dealing with concrete structures. This was followed by responsibility for the Structural Engineering Group at the laboratories involving research, code development and engineering design of structures in fire, structural engineering and mechanical testing. He progressed to the position of Manager Engineering Research in 1983. In this position he was responsible for the management of research in the structural, fire, mining and transport engineering areas. During the period at BHP Research he was particularly involved in research on fire engineering, particularly on improved design methods for building fire safety systems.

In 1989 Professor Thomas helped initiate and was involved in the Warren Centre project on Fire Safety and Engineering that led to the adoption of performance based design for buildings in Australia. He was also extensively involved in the development of a draft National Fire Safety Systems Code for the Building Regulations Review Task Force (an Australian government body) and the subsequent Fire Code Reform Centre. During this period he was particularly interested in the use of risk based approaches to design for fire safety in buildings and in the influence on the level of fire safety in buildings of human behaviour and activities.

From 1972 to 1979, following completion of the research for his PhD, Dr Thomas worked for Johns Perry – Johns and Waygood Ltd. This provided considerable experience of structural steelwork design, development of steel building systems and methods of design and analysis of steel structures with particular emphasis on connections and fatigue. During this period involvements included work with the Australian Institute of Steel Construction (AISC) on standardized structural connections (including co-authoring the book Standardized Structural Connections, Part B: Design Models, published by the AISC) and membership of several Standards Australia committees including the Steel Structures Code Committee and the Crane Code sub-committee on crane structures.

Emeritus Professor Dorothy Bruck

1. Current Positions

Emeritus Professor Psychology Discipline
College of the Arts, Victoria University, Melbourne, Australia

Sleep Psychologist Clinical private practice since August 2009
(Niddrie, 3-4 hrs/fortnight).

2. Academic Qualifications

Ph.D, La Trobe University, 1991
Thesis: Dietary intake and sleepiness after glucose in narcolepsy.

Phlebotomy Certificate, RMIT (Health Sciences), 1986

Tasmanian Teacher's Certificate, 1980

BA (Honours), University of Tasmania, 1978

3. Professional Memberships

Psychology Board of Australia
Registered as a psychologist (1984 - current)

Australian Psychological Society
Full Member (1981- current)

College of Health Psychologists, Australian Psychological Society
Academic Member (2011- current)

Sleep Health Foundation
Board Member (2011 - current) (inaugural Board of Directors)
Chair, Marketing and Communications Committee

Australasian Sleep Society
Founding Executive Member (1988)
National Secretary (1992 and 1993)
Member, Research Committee (2005- 2010)
Continuing Member (since 1988) (also Member, Special Interest Groups on Insomnia and Neurology & Sleep)

European Sleep Research Society
Member (since 2002)

Heads of Departments and Schools of Psychology in Australia (HODSPA)
Member (1995-2005)

Australian Hypnosis Society
Member (2009-2010)

4. Chronological List of previous positions

2013 Research Program Leader, Centre for Cultural Diversity and Wellbeing, Victoria University
2010 (six months, sabbatical) Visiting Researcher, Murdoch Children's Research Institute, Melbourne
1995 – 2005 Head, School of Psychology, VU
2005 (six months, sabbatical) Visiting Researcher, Centre for Safety and Risk Engineering, Melbourne
2003 Promotion to Professor (level E), VU
2002–2003 (nine months) Acting Deputy Dean, Faculty of Arts, VU
2000 (six months, sabbatical) Visiting Researcher, Centre for Safety and Risk Engineering, Melbourne
1995 Promotion to Associate Professor, VU (level D)
1994 (five months, sabbatical) Visiting Researcher, Kings University, London, UK
1994 (seven months, sabbatical) Visiting Researcher, University of Ottawa, Canada
1990 Promotion to Senior Lecturer, Western Institute, Melbourne
1988 Appointment as Lecturer, Western Institute, Melbourne
1986-1987 Sessional Tutor, La Trobe University, School of Behavioural Science
1985-1987 Ph.D. Student at La Trobe University and Recipient of a Commonwealth Postgraduate Scholarship
1983–1984 (fifteen months) Researcher at the Max Planck Institute for Psychiatry, Munich, West Germany (on a Rotary Foundation Scholarship)
1979-1984 Guidance Officer, Education Department of Tasmania

5. Monograph

Bruck D (2006) Teenage Sleep: Understanding and helping the sleep of 12 to 20 year olds. (E- book, ISBN 1 86272 667 1) Wellness Promotion Unit, Victoria University, Melbourne, Australia. (13,000+ downloads from 2006-2010 and now averages 1,000+ downloads a year)

6. Articles in Refereed Journals and Proceedings (full length) (Total = 75)

7. Conference Papers – Abstracts refereed and published in a journal supplement (Total = 55)

8. Invited presentations – professional forums (26 presentations, list available on request)

9. Conference presentations- abstracts refereed prior to presentation (71 presentations, list available on request)

10. Research funding (external) (Total = 26 grants, over $2.3 million, list available on request)

11. Victoria University Funding (Competitive) (Total =13, list available on request)

12. Reports

Xiong L, Ball M and Bruck D, (2015) Literature Review of the Risk and Causal Factors for Accidental Residential Fires. Report for the Country Fire Authority, June 2015 Melbourne: Victoria University. (72 pages, industry report)

Grossman M, Bruck D and Stephenson P, 'Victoria Police Cross-Cultural Training Practice and Procedures: A Research-Based Review for the 21st Century', Victoria Police, 2013.

Xiong L, Ball M and Bruck D, (2013) Comparative investigation of survival and fatality factors in residential fires. Report for the Metropolitan Fire Brigade and Country Fire Authority, August 2013 Melbourne: Victoria University. (201 pages, industry report)

Thomas I and Bruck D (2010) Smoke alarms in dwellings: timely activation and effective notification. Report for the Australian Building Control Board based on ARC Linkage Project

Bruck D and Thomas I (2007) Waking effectiveness of alarms (auditory, visual and tactile) for adults who are hard of hearing. The Fire Protection Research Foundation (USA)

Bruck D, Thomas I and Ball M (2007) Waking effectiveness of alarms (auditory, visual and tactile) for the alcohol impaired. The Fire Protection Research Foundation (USA)

Bruck D, Thomas I, and Kritikos A (2006), Investigation of auditory arousal with different alarm signals in sleeping older adults. The Fire Protection Research Foundation (USA)

Sharples J, Bruck D, Cherednichenko B, Kruger T (2005) Getting to know your community- A guide to gathering qualitative information, Community Building Resources Service for the Office of Community Building, Department of Victorian Communities

Sharples J, Bruck D, Cherednichenko B, Kruger T (2004) The Effective Practice Review of Information Gathering Practices in Community Building. Community Building Resources Service for the Office of Community Building, Department of Victorian Communities

Brennan P and Bruck D (2001) Report on reaction of adult to fire related cues while sleeping. Building Control Commission

13. Legal consultancy work

Expert witness in case involving a child and smoke alarms, New York, USA, 2002.
Expert witness on role of head trauma in development of narcolepsy, Queensland, 1999.
Expert witness on role of stress in development of narcolepsy. Victoria, 1991.
Expert witness on role of war time trauma in development of narcolepsy. Victoria, 1989.

14. Other consultancy work

Consultant, 'Clinical Trial of an Intervention to Reduce Fatigue and Improve Safety and Health in Firefighters' Grant from the US Department of Homeland Security Assistance to Firefighters Grant Program with Chief Investigator Dr Charles Czeisler, 2012- 2015.

Consultant, Murdoch Children's Research Institute, (Parenting in Pictures Website)

Consultant, Murdoch Children's Research Institute, Centre for Adolescent Health (Univ of Melbourne) and Orygen, Information sheet for adolescents on sleep.

Consultant (with Dr G Kennedy), NSW Central West Division of General Practice to produce a GP Mental Health Supplement on Sleep Disorders, 2002.

15. Awards and Scholarships

Vice-Chancellor's Career Achievement Award 2012.
Harry C. Bigglestone Award for Excellence in Communication of Fire Protection Concepts, March 2009, awarded by the US Fire Protection Research Foundation, the National Fire Protection Association and Fire Technology journal (with VU colleague Professor Ian Thomas).
William Casey Award - Best speaker, 10th Fire Suppression and Detection Research Application Symposium, Orlando, Florida, USA, February 2006.

Vice Chancellor's Medal for Excellence in Research Team Category (Human Behaviour in Fire Team) 2005.

Vice-Chancellor's Medal for Excellence in Research Team Category (Wellness Promotion Unit) 2002

Vice Chancellor's Citation for Excellence in Individual Researcher Category (Faculty of Arts), 2000.

Best Paper at Fourth Asia-Oceania Symposium on Fire Safety and Technology, Tokyo, 2000.

Commonwealth Postgraduate Research Scholarship, 1985-1987.

Rotary Foundation Scholarship to undertake sleep research in Munich for one year, (Max Planck Institute for Psychiatry), 1983-1984.

Australian Psychological Society prize for Honours results, University of Tasmania, 1978.

Sir Phillip Fysh prize for results in Psychology 2, University of Tasmania, 1976.

Department of Education Teaching Studentship for university study, 1975-1978.

American Field Service Scholarship to study in USA for one year, 1973-1974.

16. Academic Leadership & Governance Roles

University level leadership

Member, University Research Committee (as the elected Faculty rep 2010/2011, previously as DVC nominee 2009 and 2008)

Presenter, at least one annually at VU seminars on research development (2006 - current)

Author, ERA background statement for Psychology (FoR 17) 2010 and 2012

Elected Member, Policy and Planning Committee of the Education and Research Board (2008-9)

Vice Chancellor's nominee, Selection Committee – Faculty Dean (2005)

Member, Advisory Board, Centre for Environmental Safety and Risk Engineering (2002-2009)

Co- founder, VU Social Diversity and Community Wellbeing Key Research Area (2000)

Vice Chancellor's nominee, University Professorial Promotions Committee (1998-2001)

Elected staff representative, Western Institute Council (1990-1991)

Elected NTEU Executive member (1988-1991)

Faculty level leadership

Member, Faculty of Arts Research Committee (2000- mid 2012)

Member (ex-officio as HOS) Faculty of Arts Board of Studies (1995-2005)

Dean's nominee on numerous faculty promotions and sabbatical committees (1988-2005)

Chair, Faculty Public Relations and Development Committee (1998-2002)

Psychology Courses Selection Officer (1990-1993)

Elected staff representative on Faculty of Arts Board of Studies (1990-1993)

School level leadership

Head of School of Psychology, Faculty of Arts (1995-2005)

School Research Coordinator (2006 - mid 2012)

Founder and Coordinator, VU Sleep Laboratory (1993-current)

17. Mentoring

Mentor, Women in Leadership Program (annually, except when on sabbatical) (2002-current)

Mentor, Office for Research Mentor Scheme, 2010

Ball M and Bruck D (Mentor Investigator), Research Development Grant (VU), 2010, $22,000

Hosking W and Bruck D (Mentor Investigator), Research Development Grant (VU), 2008, $15,500

Mentor, Faculty Early Career Researcher (School Sport and Exercise Science) at the request of the Associate Dean (Research and Research Training). Two since 2008

Mentor, School of Social Sciences and Psychology Early Career Researchers (in my role as School Research Co-ordinator). Three since 2008

Mahon C and Bruck D, (Mentor Investigator), Research Development Grant (VU), 2007, $18,000

18. Curriculum Development and related activities

Coordinated the development of a revised Psychology 1 curriculum and oversaw its implementation (2008-2010)

Coordinated the development of the new first year Foundations of Psychological Research subject (2009 -2010)

Revised and delivered new curriculum for third year unit, Psychological Assessment (2006-2012)

Oversaw initial development and evaluation of lecture podcasting for Psychology 1 (2008)

Coordinator of the Bachelor of Arts (1993)

Led the development of the Psychology Honours course (1992) and the curriculum for the Theoretical Constructs core subject

Developed the curriculum of Psychobiology third year elective (1990) Cognitive Psychology third elective (1989) and Psychology 2 (1988)

Pedagogy
Chosen as one of 38 national ‘best practice’ teachers for Pascoe R et al. (2003) The lettered country. (Teaching practices discussed in Section 5 of the book) http://nla.gov.au/nla.arc-40447

19. Subjects Taught at VU

Deliver a lecture series annually in Psychology 1 on one or more of the following topics: Sleep and Circadian Rhythms, Memory, Perception, Developmental Psychology, Health and Stress
Psychology 1, 2, and 3 laboratory classes
Undergraduate seminars in Psychological Assessment, Psychobiology and Cognitive Psychology

Honours seminars in Theoretical Constructs and Reading Seminars
Postgraduate seminars in Health Psychology

20. Postgraduate Supervision (all as Principal Supervisor unless stated otherwise) (See Attachment 3 for extracts of student comments on their supervision)

Completed Ph.D.s

1. Bernadette Hood, Information processing in narcolepsy, 1998
2. Russell Conduit, Induction of visual imagery during REM and NREM sleep, 2000 (Co-supervisor)
3. Reina Michaelson, Development and Evaluation of the Child Sexual Abuse Evaluation Program, 2001 (received Vice Chancellor' Medal for Most Outstanding Doctoral Thesis)
4. Angela Bliss, Menopausal Transition: Psychosocial Aspects and the Role of Melatonin in Psychogenic Symptoms, 2005
5. Michelle Ball, Cognitive processing during sleep: the role of signal significance and participant characteristics, 2007
6. Michelle Barnett, Risk Factors and Incidence of Residential Fire Experiences Reported Retrospectively, 2008
7. Brooke Davis, An Investigation of the Sleep Beliefs of Elderly Women: What Is Good Sleep and How Is It Achieved? 2009
8. Kathryn McDonald, Perspectives on effectiveness: What works in a juvenile fire awareness and intervention program? 2011
9. Chris Lykiardopoulos, The implications of drug use on behaviour during fire emergencies. Funded by a Centre for Safety and Risk Engineering (VU) Scholarship, 2010-2014

Completed Professional Psychology Doctorates (Clinical and Clinical Neuropsychology)

1. Michelle Morandin, Automatic behaviour in individuals with narcolepsy, 2005
2. Melissa Galea, Subjective sleep quality in the elderly; relationship to anxiety, depressed mood, sleep beliefs, quality of life and hypnotic use, 2007
3. Melissa Tokley, Sleep inertia and alcohol impairment in young adults: neurocognitive effects and interactions, 2009
4. McIllyton Clever, Sleep quality, beliefs and attitudes about sleep: A comparison of Caucasian Australian, Zimbabwean and Ghanaian immigrants resident in Australia. 2011
5. Danielle Gatti, Eating behaviours and attitudes in narcolepsy and their association with sleepiness and mood, 2012
6. Chelsea Dolan, Developmental Perspectives on Community Beliefs and Attitudes about Sleep 2013
7. Stephen Gray, Risk Factors Associated with Suicide by Fire, 2014
8. Cathie Stevens, Investigation of naturalistic sleep/wake behaviour in Chronic Fatigue Syndrome, 2014
10. Esma Kurt, Development of a screening tool for the Juvenile Fire Prevention and Intervention Program, 2014

Completed Master's Theses (n=3)

Completed Honours Theses (n=16)

21. Reviewing

Australian Research Council (ARC) Grant Peer Reviewer (2009 - current)

Lead Reviewer on U.S. National Institute of Health Grant #10120756, 2006

Peer Reviewer for numerous journals (e.g. Lancet, Medical Journal of Australia, Physiology and Behaviour, Sleep, Journal of Sleep Research, Behavioural Sleep Medicine, Fire Safety Journal, Fire Technology, Fire and Materials, Psychosomatic Research, Sleep Medicine, Journal of Nervous and Mental Disease, Journal of Forensic Document Examination, Neurology, Biological Psychology, Journal of Fire Protection Engineering, J Psychosomatic Obstetrics and Gynaecology)

Examiner, approximately nine PhD and D. Psychology theses from around Australia.

22. Conference Organization Roles:

Member, Programme Committee, Human Behaviour in Fire Symposium, Cambridge, September 2012

Member, Conference Organizing Committee (as delegate for the Australasian Sleep Association), Australian Health and Medical Research Congress (mid 2009 – end 2010)

Member, Conference Organising Committee, Australian Sleep Association Scientific Symposium (2008, 2009)

Programme Coordinator, Ninth European Sleep Research Society Congress, Munich, July 1984.

23. Other service to the profession and wider community

Changes to the US National Fire Protection Association Code 72 changes in smoke alarm signalling (for 2010 and 2014) and the Australian Standards Code on Smoke Alarms (2011) for the hearing impaired have been made based directly on the work of Professor Ian Thomas, Dr Michelle Ball and myself.

Narcolepsy and Overwhelming Daytime Sleep Society (Australasia).
Founder (1986)
Public Officer (1986-2001)
Awarded first Life Membership (1989)
Professional Advisor (2001- current)
Invited Speaker – annually at society meetings on a variety of sleep topics

Melbourne Sleep Psychologists Professional Development Group, Co-founder and Member (2011-current)

Convenor (and Speaker), Second National Narcolepsy Community Conference, Melbourne, October 10th (2009)

Workshop Leader, Sleep Health for Young People, CanTeen Weekend Program, Dandenong Ranges, Victoria (2006)

Developed and presented workshop on classroom kit for EEG scoring of sleep stages, PsyEd Psychology Teachers (Year 12) Conference (2002-2009 annually)

Developed and presented VU Sleep Laboratory workshops for Year 12 students (typically over 6 workshops annually involving 100+ students, 1993 - 2006)

Organiser, Sleep Problems in Young People Workshop, Victoria University (1993)

Convenor (and Speaker), First National Narcolepsy Community Conference, Melbourne (1988)

24. Media (sample)

Articles discussing research findings based on interviews or research publications involving Bruck or comment

The Conversation, Eight hours is enough – more sleep could lead to an early grave. 25/3/15, over 540,000 hits

Women's weekly. The science of sleep. Jan 2015
The Conversation, Chill out: disturbed sleep plays havoc with your mood and mind. 12th July 2013, http://theconversation.com/chill-out-disturbed-sleep-plays-havoc-with-your-mood-and-mind-15994
Depression link for young women with insomnia (article on new research by D. Bruck and M. Jackson). http://www.theage.com.au/national/depression-link-for-young-women-with-insomnia-20130405-2hcep.html 6th April 2013, The Age and Sydney Morning Herald

Huffington Post , Chronic Fatigue Syndrome, How does it affect sleep, 15th January 2013, http://www.huffingtonpost.com/dr-michael-j-breus/chronic-fatigue-sleep_b_2441869.html?utm_hp_ref=health-and-fitness&ir=Health%20and%20Fitness

Women's Weekly, "Tired of being tired" June 2012

Time Magazine, "Children Sleep Right Through Alarms", March 25th 2011
http://healthland.time.com/2011/03/25/children-sleep-through-fire-alarms-study-shows/

New Scientist, "Baritone smoke alarms wake the deepest sleepers", 20th October 2008 (item on new alarm signal research)

Time Magazine, "While you were sleeping" (Incorporates an interview with Bruck on dreams), 16th April 2007

Shiftwork (Jan 2000,) "Your call" (Cover story), vol. 5, no. 1, p. 1.

Fire Prevention, "Sleeping children ignore smoke alarms", in News section, vol. 306. Jan/Feb 1998

New Scientist, "Raising the alarm", Issue 2073, 15th March 1997

Time Magazine (cover story) "The Trouble with Sleep" (Bruck's work on narcolepsy discussed), 26th June 1989

Non-refereed articles authored by Bruck

Bruck D "One step further" contribution to Psychology text book by Burton, Weston and Kowlaski (Third Edition – 2012)

Bruck D (2003) National Fire and Emergency, "Waking up to Smoke Alarms", Nov- Dec, 23-27.

Bruck D (2001) "Waking up to reality" Fire Prevention Journal, July.

Bruck D (1999) Preface. In Sleep – Too Much or Too Little, Narcolepsy and Overwhelming Daytime Sleep Society, Melbourne. p. 1.

Bruck D (1999) "Dietary Aspects of Narcolepsy" In Sleep – Too Much or Too Little, Narcolepsy and Overwhelming Daytime Sleep Society, Melbourne. pp. 13-15.

Other media

Conducted many, many media interviews on TV, radio and for the print media in the last two decades. For example, in 2008, for a research project, gave 42 radio interviews, an interview for a TV morning chat show and received coverage in 18 print media articles. My research has also been featured on the TV science show "Towards 2000" and three TV news segments, two breakfast shows and two current affairs programs. My research has also received coverage in the US print and electronic media.

25. Miscellaneous

Featured (as one of 34 'eminent ex-students') in "Hobart High to Hobart College, 1913-2013: A Revolution in Education" to be published in 2013 as part of the Old Hobartian Centenary.

Qualified as a University First Aider (Level 2).

Member, Victoria University Ski Team, Falls Creek Corporate Ski Races, 2002, 2004, 2006.