FIRE EMERGENCY NEW ZEALAND

WHAKARATONGA IWI

SMOKE ALARMS: INSIGHTS INTO FIRE-RELATED EXPERIENCES, MOTIVATION AND ACTIONS

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This research was commissioned by Fire and Emergency New Zealand and undertaken by independent researchers. Publication does not indicate Fire and Emergency New Zealand's endorsement of the findings or recommendations.

Smoke Alarms: Insights into fire-related experiences, motivation and actions.

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1. Acknowledgements

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The study was considered and approved by the University of Otago Ethics Committee (20/013) and the ACC Research Ethics Committee.

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2. Research Summary

This research was commissioned by Fire and Emergency to gain an understanding of the role that smoke alarms have played in real fire events in NZ. Interview data associated with 17 real-life unintended dwelling fire (UDF) events was analysed for mentions of the term "smoke alarm" (or similar) and common themes identified and explored. The outcomes of this research will be used to inform national fire risk reduction strategies, including the refining of messaging around smoke alarm use.

This research is a sub-analysis of a much wider study into the impacts of real fire events. Details on the wider studies will not be discussed here but can be found in the below reports:

Lilley R, Graham K, Richardson A (2021) Non-Fatal Fire Related Injuries: The lived experiences of those who have been involved in a house fire event. Report commissioned by Fire and Emergency New Zealand. Fire and Emergency New Zealand, Wellington.

Lilley R, Richardson A, Davie G (2019) Understanding Non-Fatal Fire Related Injuries in New Zealand: 2013-2017. Report commissioned by Fire and Emergency New Zealand. Fire and Emergency New Zealand, Wellington.

Lilley R, McNoe B, Duncanson M (2018) Unintentional domestic fire-related fatal injury in New Zealand: 2007-2014. Fire and Emergency New Zealand Report Number 165. Fire and Emergency New Zealand, Wellington.

Key research findings of the current smoke alarm include the following:

a. **Occupants perception of smoke alarm usefulness** - Occupant's perspectives on the usefulness of smoke alarms during their fire incident varied: those awoken by a smoke alarm valued smoke alarms the highest, while those whose alarms were delayed or failed perceived the alarms to be less useful. However, in general,

smoke alarms were regarded as being important to prevent fire-related harm.

b. **Smoke alarms and sleeping occupants –** Functioning smoke alarms were an important means of alerting sleeping occupants. Participants recalled smoke alarms waking them and generally attributed the smoke alarms to saving them from more adverse fire outcomes relative to their circumstances.

c. **Failure of functioning smoke alarms to raise alarm** - Functioning alarms did not always successfully alert occupants to fires. This observation was associated with occupants discovering the fire before the smoke alarm activated or with occupants that could not perceive the alarm when it was activating, such as in hearing-impaired occupants.

d. **Delayed activation of smoke alarms** – Occupants recalled that their smoke alarm activated sometime after the fire was discovered by the occupants. This was associated with situations where the occupants were close to the fire, the smoke alarm was located in a space remote from the fire/behind a closed door, the fire occurred in an internal building cavity such as a ceiling space or wall cavity, and during slow smouldering fires.

e. **Total failure of smoke alarms to operate –** In some instances the smoke alarm failed to operate at all. Reasons for non-operational alarms are less clearly recalled by the occupants but do include age of alarm and power source.

f. **Smoke alarms trigger investigation actions** - On hearing the activated smoke alarm all occupants reported moving to investigate the sound to confirm what was happening. Some occupants reported having trouble initially not being able to recognize the sound as a smoke alarm: this was associated with slightly longer periods of investigation.

g. **Not possible to make any conclusions on the relationship between smoke alarms and injury or property damage** - Relationships between smoke alarm activation and injury and/or property damage were explored. However, the data proved to be unsuitable for this analysis and no conclusion can be reached either way from this data set.

h. **No strong relationship between how the occupant discovered the fire (smoke alarm or no smoke alarm) and the behaviours that followed** - Occupant's response to discovering a UDF didn't differ markedly by the means to which an occupant was alerted to the presence of fire. Those alerted by alarm potentially evacuated the building more promptly due to the advanced size of the fire. A quick initial evacuation prompted by an active smoke alarm may be followed by re-entry to the building to retrieve personal items.

i. **The presence of a functional smoke alarm is not a guarantee of a safe outcome**

for occupants - Smoke alarms are just one factor in a complex event involving the interaction of occupants, fire circumstances and building characteristics. Smoke alarms are essential for every household but need to form part of a more detailed escape plan to be most effective. Fire events with a working smoke alarm can still result in injuries.

To optimise the opportunities for operational smoke alarms to alert occupants of UDF to the presence of fire the following recommendations have been made from this research.

Recommendation 1: Fire and Emergency continue to promote the installation, maintenance and testing of smoke alarms in residential settings as a means of reducing the impacts of a fire. This should include reminding the public to become familiar with the sound of their smoke alarm so that it is immediately recognisable.

Recommendation 2. Fire and Emergency expands the range of community messages on smoke alarms with the aim of reducing the risk of delayed smoke alarm activation by promoting the installation of smoke alarms in as many spaces as practical in residential settings. This should include the provision of smoke alarms in spaces such as attics and basements. The ready availability of heat alarms for kitchen and dusty spaces should be promoted to ensure all spaces have a form of fire detection. Fire and Emergency should also promote interconnection of residential smoke alarms so that all alarms sound once an activation has occurred in any single alarm in the system. Fire and Emergency should support and advocate for the provision of interconnected smoke alarms as a minimum requirement in future Building Code legislative and regulatory updates.

Recommendation 3: Fire and Emergency investigate and promote widespread use of specialised smoke alarm systems for occupants that may have trouble hearing or comprehending smoke alarm signals. It is recommended to collaborate with health, disability and aged care stakeholders to make appropriate equipment available and accessible to those that need it.

Recommendation 4. Fire and Emergency continue to promote the use of smoke alarms as part of a wider escape plan. Having a working smoke alarm was not enough to prevent some of the occupants in these fire events from becoming injured, especially following re-entry. Injuries are strongly associated with re-entry behaviour (Lilley, Graham, & Richardson, 2021).

Fire safety messaging should include increased focus on the dangers and speed of fire. Escape plans should be further encouraged with additional focus on the benefits of preparing and considering what may be valuable in the home. Occupants should be clear on what they would bring with them in an emergency; and where to find it in an emergency. This may deter re-entry behaviour.

3. Glossary

NFFRI - Non-fatal fire-related injury

UDF – Unintentional dwelling fire

Fire and Emergency – Fire and Emergency New Zealand

4. Background

4.1 Introduction

The signal from an inexpensive domestic smoke alarm is effective at providing early warning to dwelling occupants to a fire event and can make difference between life or death for occupants. Smoke alarm installation has been increasing over time, estimated in 2010 to be installed in 93% of New Zealand homes (BRANZ Limited, 2013). While the overall prevalence and the average number of smoke alarms within homes is increasing, it is unknown what proportion have non-operational smoke alarms with 83% of homes using battery powered alarms (BRANZ Limited, 2013). Despite a high prevalence of smoke alarms in residential dwellings fire-related fatalities still occur in residential dwellings with operational smoke alarms. An examination of fire fatalities in New Zealand from 2007 to 2014, found 56% of fatal incidents reported a smoke alarm present in the dwelling, of which 63% were operational at the time of the fire (Lilley, McNoe and Duncanson, 2019).

Research into the role of smoke alarm performance is commonplace, however, little is known on people's behavioural responses to smoke alarms, particularly in residential settings (Bryan, 2002, Bryan 2008, Harpur 2014). Fire alarms influence behaviours by: 1) warning occupants of a fire; 2) prompting immediate action; 3) initiating evacuation movement; and 4) allowing sufficient time to escape (Proulx, 2020). There is a need for research to understand the role of smoke alarms in alerting people to the presence of a fire event and in influencing a prompt occupant response for a range of unintentional dwelling fire (UDF) scenarios.

The way an individual is alerted to the occurrence of a fire is thought to influence the perception of the threat involved, with much of the work to inform this derived from research based on fire events in commercial or high-rise building fires (Bryan, 2002). The human behavioural response to fire alarm bells and sounders tends to be complex and dependant on what is happening to and around the observer at the time that the alarm signal is first heard (Bryan, 2002). It is common for initial scepticism from occupants as to whether the activated alarm indicated the presence of a fire event or represented a nuisance alarm (Bryan, 2002, Proulx, 2020). The audibility of smoke detector alarms is also known to be attenuated within building structures, particularly lessening their efficacy as an early warning to a fire event when an occupant is sleeping (Bryan, 2002; Thomas & Bruck, 2008).

4.2 Human behaviour during fire

4.2.1 Theories

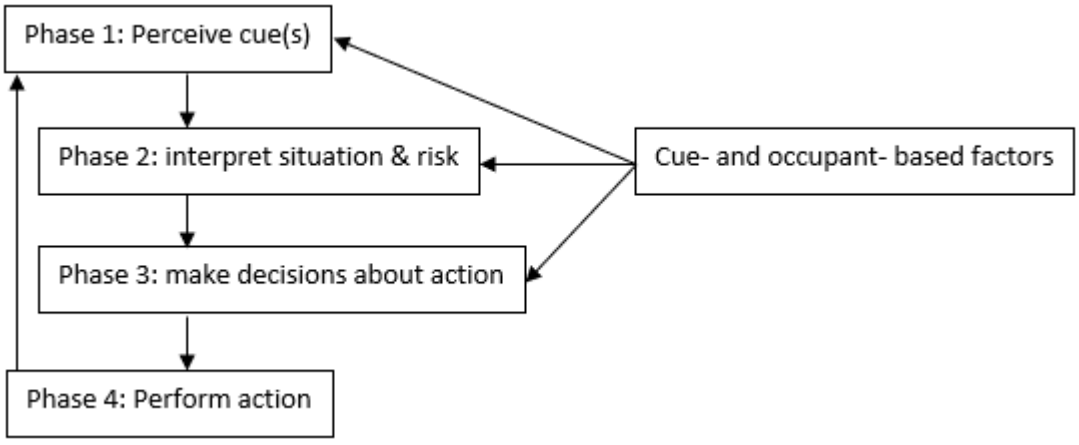
There has been little research into human behaviour in fire events occurring in single occupant residential dwellings with research mainly focused on commercial, industrial or other public building settings (Thompson et al., 2018). Occupancy type and an occupant's

role within the building is known to determine the behaviour of an occupant, with residential occupants more likely to act to save property or possessions (Bryan, 2008, Proulx, 2020).

A recent fire behaviour model (Figure 1), established by Kuligowski, describes commonalities in phased behaviour process of an occupant's response to a building fire (Kuligowski, 2009). In the first phase building occupants perceive or receive environmental, physical (e.g. flames, smoke, or noise) and social cues (e.g. hearing other reactions or receiving warnings from outside of the building). Occupants can additionally perceive more complex conditions and states, including perceived uncertainty, information overload, time pressure, and even their own thoughts or memories from a previous event. In the second phase, the occupant attempts to interpret the information, defining both the situation and the risk to themselves and/or to others provided by the cues perceived during the first phase. The third decision-making phase involves occupants making decisions on what to do next based on their interpretations of the situation and risks. And, finally, occupants may perform the action that they decided upon in the decision-making phase as part of the final phase.

A limitation of Kuligowski's model is that is unable to distinguish between behaviours that lead to occupants sustaining injury in a UDF (Kuligowski, 2009). It also is unable to capture any potential differences in human behaviour based on the form in which the survivor is alerted to the presence of a fire event, such as through smoke alarms. It is a general criticism of this area of research that few studies have examined the influence of smoke alarms on human behaviours in UDF, especially given that smoke alarms are a key intervention in the primary and secondary prevention of fire-related injuries.

Figure 1: Model of behaviour process of occupant response in a building fire (Kuligowski, 2009)



4.2.2 Behaviour in single/family occupant UDF

In response to little previous research to inform a detailed understanding of human behaviour in unintentional single/family occupant dwelling fires, a series of qualitative

interviews was undertaken with surviving occupants of UDF with an emphasis on understanding if there were differences in the behaviours of injured and uninjured survivors (Lilley, Graham & Richardson, 2021). This study expanded the work of Thompson and Wales (2015), examining the experiences, motivation and actions of 10 injured survivors of UDF in the United Kingdom. This New Zealand study found that despite a diverse range of fire experiences canvased during interviews, the experiences, motivations and actions of both injured and uninjured occupant survivors were broadly similar (Lilley, Graham & Richardson, 2021).

A phased behaviour process was observed (Figure 2) with a continuum of responses and actions occurring with common underlying motivations. Occupants balanced the risk of injury with quick actions to reduce a real, or perceived, risk of harm to self/others or to property.

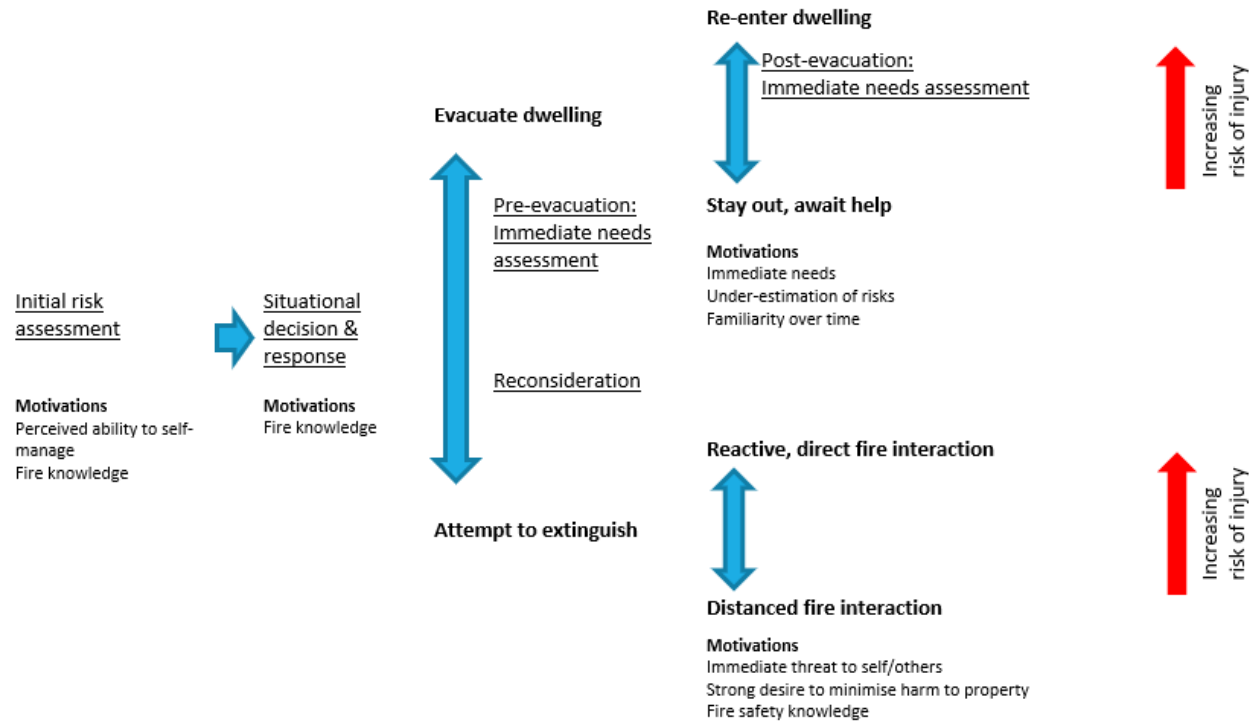
All occupants interviewed undertook a rapid initial risk assessment which took into consideration the fire cues, particularly the size of the fire, and existing fire safety knowledge. There were distinct differences in what fire circumstances were viewed as dangerous by individuals during the initial risk assessment.

A situational decision and response were made. This was informed by fire safety knowledge and perceived risk of injury, and weighed against an urgent need, or strong desire to act quickly to minimise potential harm to self/others or to property. A divergence in actions and motivations was observed in terms of this situational decision-making process, falling into two broad areas of action: evacuating the building; or attempting to extinguish the UDF. Each area was associated with a continuum of behaviours, with initial decisions either reconsidered once initial attempts at extinguishing fires failed, or to meet immediate necessary needs prior to, or after, evacuation.

Injury occurred via one of two pathways on this continuum: 1) direct interaction with fire in combination with a reactive response; or 2) during re-entry to a UDF in the face of strong fire or smoke cues. Other behavioural pathways to non-fatal fire-related injury (NFFRI) may be possible but were not revealed in the current study.

This analysis did not examine any differences in the experiences, motivations and actions according to the means (i.e. alerted by alarm, discovered fire-cues) that occupants were alerted to the UDF and if the response differed according to those means.

Figure 2: Situational map: Understanding the common experiences, motivations and actions of injured and uninjured survivors of UDF (Lilley, Graham & Richardson, 2021).



4.3 Summary

To date, theories of human behaviour have been built using findings predominantly from commercial, industrial and high-density residential buildings only. While recent qualitative research provides important insights into the experiences, motivations and actions of those injured in a UDF, there are some limitations to this work regarding the provision of insights into possible behavioural differences according to the means an occupant is alerted to the presence of a UDF. It is not understood how these experiences, motivations and actions may differ for those occupants alerted by alarm compared with those who responded to other fire cues.

5. Research Objectives

During the analysis of the qualitative data set collected to explore fire injuries in New Zealand (Lilley, Graham, Richardson, 2021), it emerged that there was some raw data surrounding attitudes and responses to smoke alarms which was not going to be captured by the scope of the original fire injury research. A sub-analysis (the subject of this report) was commissioned by Fire and Emergency to explore any behavioural insights around the role of smoke alarms.

The purpose of this analysis is not to explore whether smoke alarms should or should not be

provided. Rather it is intended that the insights gained be used to assist Fire and Emergency to improve understanding the details of how smoke alarms impact fire outcomes. The findings can then be used to refine Fire and Emergency strategy/messaging around smoke alarm use.

Areas and research questions of interest to Fire and Emergency were:

1. Impacts of smoke alarms
    a. What, if any, was the impact of smoke alarms during fire events? Did they alert people? Did people take actions based on noting a smoke alarm activation?
    b. Was there any relationship between having a working smoke alarm and the extent of injuries or property damage?
    c. From the participants perspectives, how useful were smoke alarms?
2. Human response/behaviour to smoke alarms
    a. What actions did participants report as taken after hearing the smoke alarm sounding?
    b. What sort of behaviour during a fire event did smoke alarms encourage/discourage? Was evacuation delayed?
    c. Were there any key differences in occupant behaviour when smoke alarms were present/not present or worked/did not work?
3. Failure of smoke alarms
    a. In what circumstances (fire types, locations, intimacy to the fire, awareness of occupants e.g. sleeping/awake) have smoke alarms have failed to help and what are the reasons why?
    b. What were the modes of failure from smoke alarms, including aspects such as the location of the alarm, sound, power and absence of alarms?

6. Methodology

6.1 Study design

A combination of face-to-face and telephone semi-structured individual interviews were conducted with surviving occupants of an UDF to examine their experiences, motivations and actions in response to the fire.

6.2 Ethical considerations

Ethical approval was obtained from the: University of Otago Human Research Ethics Committee (Ref # 20/013), and ACC Research Ethics Committee for recruitment of an injured sample.

6.3 Data collection methodology

6.3.1 Inclusion/Exclusion criteria

People who had experienced a domestic dwelling fire event in the last 5 years were included in the study. A diverse range of participants whose fire experiences differed with respect to contacting Fire and Emergency and their experience of injury sustained in a UDF were sought.

Inclusion criteria

- People aged 18 years and over who have experienced an UDF event in the previous 5 years (exposed to smoke, fire or flame), with no upper age limit.
- For those experiencing an injury as a result of this fire event, injury was defined as unintentional injury due to exposure to smoke, fire or flame. Therefore, an injury will be identified based on whether the person, at the time of the injury incident, was exposed to smoke, fire or flame and if the fire-event was unintentional.
- People who did not contact Fire and Emergency were also included.

Exclusion criteria

- People who had experienced unintentional fire events involving a fatality;
- Injuries due to intentional injury, such as assault, self-harm; and
- Injuries due to other external causes, such as road crashes or falls.

6.3.2 Identification of participants

Purposive sampling was used to ensure a broad representation of ages, sexes, fire types, households, and geographical areas across participants.

Multiple recruitment avenues were utilised, including advertising in:

- community papers;
- social and health practices;
- community centres (e.g. libraries); and
- social media outlets.

Additionally, specifically to aid the recruitment of an injured sample, a letter of invitation was sent from the research team via ACC to a sample of 400 persons with a fire-related burn injury claims in the previous 12 months.

Target areas were broadly national with community papers used in the Southland, Central Otago, Dunedin, Christchurch, Northland and Auckland areas.

6.3.3 Interview

Prior to the interview being conducted, written informed consent was collected from each participant, including permission to audio-record the interview. Recruitment continued until

data saturation was reached (i.e. no new major themes emerging from interviews), with 31 participants recruited and interviewed.

Data was primarily collected between April and December 2020, with three additional interviews conducted in March and April 2021. Interviewing was disrupted by national and regional COVD-19 pandemic lockdowns between March and August 2020. Most interviews were conducted over the telephone or video calling, while a smaller number were conducted in person.

Interviews ranged in length from 30 to 60 minutes. A $30 koha was provided to reimburse participants for their time. Interviews were digitally recorded and transcribed by an independent company.

Questions in the interviews were broad and open-ended to allow the participants to talk about aspects of their experiences of the fire event that were most important to them using a structured interview guide to ensure key topics of interest were fully explored with all participants. The interview guide (Appendix A) was developed following a review of the literature to identify key theories of human behaviour in response to residential fires (Kuligowski, 2009) and previous qualitative research (Wales & Thompson, 2013). Questions explored: how participants became aware of the fire, the actions they undertook and associated reasons, evacuation from and re-entry into the dwelling, opinions of their actions, and whether with hindsight they would do anything differently.

6.3.4 Smoke alarm sub-analysis

To explore the role of smoke alarms during a UDF event the sample was restricted to 17 UDF incidents (involving 20 individual occupant interviews) where smoke alarms were mentioned within the transcript. Interviews that didn't contain any mention of smoke alarms were excluded. Also excluded were interviews from fire incidents where the fire started outside the dwelling, where the fire was intentional or where the fire event occurred on a person.

6.4 Data analysis

The original interviews were analysed using a grounded theory approach with inductive analysis to generate an abstract theoretical explanation of a social process and to capture interconnected experiences, motivations and actions (Charmaz, 2014).

Coding and analysing of qualitative data were additionally informed by the following questions:

> How do people respond and what are the motivations for these responses?
>
> What did people learn and what does this tell us about what people need to know to respond safely to fires?
>
> What aspects of the situation affected their behaviour? (e.g., size, potential danger)

What aspects of knowledge impacted behaviour?

Further information on the grounded theory analysis of the original interviews is available in Lilley, Richardson, and Graham (2021).

This sub-analysis involved thematic analysis of the 20 eligible occupant interview transcripts. Initially all transcripts were read to become familiar with all the content. During the familiarisation process notes were made about the content of transcripts in relation to the research questions. Following this, previously coded sections of the interviews relevant to the research questions, coded using NVIVO 12, were obtained. Thematic summaries were developed of the different fire experiences, including making notes and diagrams about how these cases were similar and different. Within these comparisons there was a specific focus on differences between occupants who were alerted to a UDF by an activated smoke alarm and occupants alerted by the discovery of other fire-cues.

Quotes have been lightly edited to improve readability and incident numbers have been used to protect individual's privacy.

6.5 Reporting of findings

The findings in this report have been reported without reference to a count or statistical analysis of how often theme, observation or insight appeared in the data. While this a different approach from the other reports in this series, this is a valid means of reporting qualitative data (Hannah & Lautsch, 2011). It is particularly useful where sample sizes are small, or the research line of inquiry falls outside the original line of inquiry for the source data (the original data set contain mentions of smoke alarms, but smoke alarms were not the focus of the interview questions).

However, this way of reporting findings relies heavily on the background and the understanding of the researcher(s) of the subject area. It is this background knowledge that allows the researcher to understand the context that an observation occurs and whether it is interesting/important and worth reporting (Hannah & Lautsch, 2011). The suitability of the experiences of the researcher and the Fire and Emergency subject matter expert in this regard has been justified in section 6.5.1 below.

6.5.1 Background of Researcher and Fire and Emergency Subject Matter Expert

The research and reporting work in this report was carried out by Dr Rebbecca Lilley. Dr Lilley is an expert in injury prevention and has spent four years examining fire data on behalf of Fire and Emergency. Dr Lilley is familiar with background literature in the area of fire fatalities and injuries and was the lead author on the recent series of fire-related injury reports conducted for Fire and Emergency (Lilley, Graham & Richardson 2021, Lilley, Richardson & Davie 2019, Lilley, McNoe, & Duncanson 2018).

Supporting subject matter expertise on behalf of Fire and Emergency was provided by Dr Amy Harpur. Dr Harpur is an expert on human behaviour in fire, with expertise focused

specifically on the circumstances surround fatal fires in the UK and NZ. Dr Harpur has been employed by Fire and Emergency in the National Risk Reduction team as a fire engineer for seven years. Amy has a detailed understanding of fire safety clauses of the NZ Building Code, the Fire and Emergency philosophy to smoke alarm promotion and has provided subject matter expertise on behalf of Fire and Emergency on all the above noted fire fatality and injury studies carried out by Dr Lilley.

The thematic findings and insights in this report have been identified and explored in collaboration with the researcher and the subject matter expert. The detailed analysis and this report was prepared by Dr Lilley: Dr Harpur has provided some context to the findings from a Fire and Emergency perspective and provided minor editing contributions to this final report.

6.6 Generalisability of findings

The findings in this report have some limitations. This is a consequence of the small sample size, and the use of source data that was not originally designed to explore the role that smoke alarms play during residential fire events.

While the findings are not immediately generalisable across the New Zealand population; the importance of the findings should not be disregarded. The findings include several circumstances, situational and human factors that can influence how smoke alarms can impact the outcomes of fire events.

It is rare to have access to this information from real-fire events for research purposes. The expertise of the researcher and the subject matter expert allows some wider context to be put around the findings. The findings reported in part explain some of the wider findings reported in the previous series of fatality and injury studies conducted by Fire and Emergency.

The results are not intended to be broadly generalisable and likely do not capture all potential challenges around smoke alarm effectiveness. However, they do add to the existing body of knowledge on this subject and point to some potential areas where community fire safety strategies based around smoke alarms could be improved.

7. Results

7.1 Participant characteristics

Interviews from 20 individual occupants from 17 UDF incidents mentioned smoke/fire alarms in their final transcripts and were used in the following analysis.

The sample characteristics, while not intended as representative, were broad: participants were predominantly female, of working age, identified as European, and came from the Auckland & Northland region (Table 1).

Table 1. Characteristics of participants in qualitative interviews

Characteristics	n (%)
Sex	
Male	4
Female	16
Age (years)	
<30	2
30-39	4
40-49	3
50-59	2
60-69	4
>70	5
Ethnicity	
Other ethnicities	0
European	20
Region	
Otago & Southland	6
Canterbury	4
Auckland & Northland	10

7.2 Summary of interviewee's awareness of fire

Of the 17 UDF incidents examined twelve occupants were first alerted to the fire by the discovery of other fire-related cues (Table 2). A mixture of fire cues were reported: discovering flames; observing or smelling smoke; hearing noises, such as explosions, in combination with smoke; alerted by family; or observing a "glow in the dark".

Smoke alarms first alerted five occupants. A further three impaired occupants had functioning smoke alarms which activated at the time of the fire, but these were ineffective at alerting these occupants to the presence of fire and have been included in the count of those fires alerted to the fire by fire-related cues.

Table 2: Summary table of interviewee's awareness of fire and responses to the first alert

	n
First alerted to fire by	
Smoke alarm	5
Other fire-related cues	12
Smoke	(3)
Flames	(4)
Other	(5)

A summary table of the circumstances, injury and property damage incurred in each of the 17 incidents is provided in Appendix B.

7.3 Qualitative themes

7.3.1 Alerted to fire: activated smoke alarm

Summary. Smoke alarms were critically important at alerting sleeping occupants of the presence of a UDF. All those asleep at the time of fire initiation were aroused from sleep by activated smoke alarms with all subsequently seeking confirmation of the presence of fire in the dwelling. Confusion was initially experienced when the sound of the smoke alarm was unable to be distinguished from other similar sounds. In situations where the fire was relatively well developed at the time of alarm activation, occupants immediately evacuated the UDF, however this doesn't appear to stop re-entry into the building to obtain personal possessions while awaiting the assistance of Fire and Emergency. Attribution of alarm activation to a nuisance alarm increased the response time to an alarm, with occupants reporting that they ignored the alarm until other fire-related cues were experienced. Smoke alarms had very limited utility in alerting hearing impaired persons to the presence of a UDF.

Key findings

Successfully alerted by activated alarm

Situations where smoke alarms were activated and successfully alerted interviewees of the presence of a UDF occurred at night while sleeping occupants were woken by the alarm. These fires originated in other more distant parts of the house making it difficult to clearly hear the alarm or to experience other fire-related cues. In situations where occupants were awoken by a smoke alarm it was therefore credited with allowing occupants enough warning time to escape the fire and, ultimately, in saving human lives.

> *The other thing that saved us was that we had thought about the fire alarms […] We bought 2 extras, and we put one at the base of the stairwell to the basement, and we put one in under the house, and that was the one that went off.* Incident 10: Electrical fire, occupants sleeping. No injury, house extensively damaged.

In incidents fitting this situation occupants sought confirmation of a fire by seeking out fire-related cues, essentially seeking out the reason for why the smoke alarm had activated.

> *Husband: A noise [smoke alarm], woke me up. I went to find out what the noise was. I noticed there was this trickle of smoke coming across the roof of our living area and told my wife who was fast asleep.*
>
> *Wife: It was a smoke alarm and he then went to our back door, opened that back door and saw there was a big glow coming from the garage which had a glass window leading into the stairs.* Incident 15: Electrical fire, occupants sleeping. No injury, extensive property damage.

Confusion with other sources of alarm sounds

Occupants reported initial confusion between the sound of the smoke alarm and other frequently experienced alarm like noises, such as reversing trucks or a neighbour's alarm. This tended to occur when the activated smoke alarm was distant from the sleeping occupant.

> W*e woke up to a smoke alarm ringing. Initially, I didn't realise what it was because the smoke alarm was in the basement, and it sounded […] like the backing lights on a truck. And I affirmed that it was [fire] […] there'd been trucks going up and down the drive for weeks, and I was annoyed because it was a Sunday morning. So, I leapt out of bed to see what truck it was, and there was no trucks. So, I realised something was going on, so, I wandered through the house, and started to smell smoke. Went downstairs to a basement area and realised the smoke was coming from a very large storage area that we have under the house. And when I stuck my head around the corner, I could see a lot of black smoke, and flames. So, I knew the house was on fire.* Incident 10: Electrical fire, occupants sleeping. No injury, house extensively damaged.

> *I turned on the electric blanket and the heaters to go have a nap and then I went into the lounge to read a book and then I remember waking up to the smoke alarms. So I heard the first one but our next door neighbour always leaves his cat inside so I was like oh it's just another alarm but the one that went above my head and it got louder, like it went off and that scared me and I think I was a bit, but then it got louder, like or maybe that was just my ears ringing but I remember it being so loud, like my eyes were watering. But that might've been the smoke too but I remember it was, like there's no way you could sleep through that.* Incident 15: Heater fire, occupant sleeping. Injured, house extensively damaged.

Initially ignored alarm

Ignoring activated smoke alarms was found in one incident. The occupant ignored the initial intermittent sound of an activated smoke alarm and dismissed the initial sound as a nuisance alarm. In this situation the occupant initially attributed the activated smoke alarm to the fireplace which was operating in the room at the time. It wasn't until the alarm sounded more consistently and the survivor noted other fire cues, including smelling burning wax, that they responded to the fire.

> *They [smoke alarms] went off first, I didn't see anything and I didn't think anything of it. I just thought it was 'cause the fire was on and it was picking up [the controlled fireplace], and then they went off again when the um, when the flames were up [to the ceiling] so then I was like woah, oh my God. I was in the room but I was facing the other way with headphones on 'cause I was studying and then I started to smell something 'cause you could obviously smell the wax from where the candles had been, and my dog was in the room and he started barking.* Incident 1: Candle fire, occupant awake. No injury, limited damage to room of fire origin.

Smoke alarms activated – impaired person

Hearing impairments were present in those who did not respond to activated smoke alarms These occupants with hearing impairments relied on other fire-related cues to be alerted to a UDF.

> *The book falling on the floor woke me […] there was a glow in the room […] I pulled back the curtain and the fire was already alight in the wall. I ran to the bathroom to get towels to smother the flames, but it was racing up the curtains […] I am a little deaf and had not heard the fire alarm ringing. Neighbours had heard it. One, whose son's room faced our house heard the alarm and the windows starting to blow out."* Incident 17: Electrical fire, occupant asleep. Injured, extensive property damage.

> *I was cooking […] And I went out to the lounge, from there I smelt something very strong. I rushed out to the kitchen, and then I saw flames shooting up near the wall. The fat had caught, 'cause if nothing had happened then, the whole kitchen would've gone. It was frightening […] they [smoke alarms] were going off. They were working, but the fire brigade came and put more in […] I am a little hard of hearing.* Incident 11: Unattended cooking fire, occupant awake. No injury, limited damage to room of fire origin.

In a further incident involving two occupants asleep at the time of the fire event in their bedroom, it was reported that the smoke alarms were activated and "blaring" but specifically the occupant didn't recall the alarm waking them up. This incident was caused by an exploding aerosol can close to the occupants, so it is possible that they were concussed to a degree, or had their hearing damaged, in the preceding explosion. While the alarms clearly didn't fail to activate in response to the fire event it was likely that the level of impairment of the occupants has led to this interviewee not attributing being alerted to the presence of the fire in the bedroom to the smoke alarm.

> *Although they [smoke alarms] went off, they certainly didn't wake us up […] we had them in our room, like they were in all the rooms and the hallway and so yeah they were all, like when we woke up it was just deafening, the noise. Yeah. […] No [the explosion and smoke alarms didn't wake us].* Incident 2: Aerosol explosion, occupants asleep. Injured, limited fire damage to room of fire origin.

Re-entry

Once safely outside the building occupants undertook an assessment of their immediate needs. Where an occupant's immediate personal needs were not met, such as they had left behind car keys, mobile phones etc, they re-entered the building to obtain personal possessions left behind in the rush to evacuate.

> *Ran to the neighbours, banged on their window and told them, then went to go back inside to get my phone which I left by the bed, the house was full of black smoke and I couldn't go near it, sort of five/ten minutes at the most.* Incident 13: Electrical fire,

occupants sleeping. No injury, property extensively damaged.

This occurred even in instances where smoke alarms were activating and occupants had visual confirmation of a fire. The presence of a sounding smoke alarm did not deter them from re-entering.

7.3.2 Alerted to fire: discovery of fire cues

Summary. Occupants were alerted to a UDF by discovery of fire-related cue when the fire was typically smaller or in an inaccessible area of the building. In these circumstances, the alarm activated well after the occupant's discovery of the UDF for a variety of reasons including distant alarm locations, shut doors, lack of smoke, intimacy to fire at time of initiation and non-functioning alarms.

Different types of fire cues elicited slightly different responses from occupants. For those discovering flames there was little need to seek confirmation of fire. For cues that are more ambiguous, like noise or smoke, occupants frequently sought confirmation of a fire by seeking out the source of the fire-related cues.

Key findings

Fire discovered early

The early discovery of the fire by occupants before activation of smoke alarms typically occurred when the fire and smoke cues were small in scale or had yet to break out of internal building cavities. These fires were typically discovered early by chance, such as walking back into a room for another reason, being in the room of fire origin at the time the fire started, or in response to a fire-cue, such as the observation, or smell, of smoke.

> *It was in the bathroom and it was an electrical fire, that started in one of those three in one fan-heat-lights in the ceiling and so basically what happened is I was in the shower and had the, I think the fan and the light on and, maybe the heater […] I was just about to finish my shower and I looked up and I could see flames.* Incident 4: Electrical fire in ceiling, occupant awake. No injury, damage spread beyond room of fire origin.

> I *had cooked myself some chips for tea […] I went back to the kitchen to put my plate back. And there was a fire behind the range, going up the wall, flames, and a little bit on the bench.* Incident 7: Electrical fire, occupant awake. Injury, extensive damage to room and roof.

In situations where a fire was discovered early the functioning alarm tended to activate well after the occupant initially responded to the fire cues. Occupants recalled smoke alarms activating after they initiated evacuation of the building (alerting others, gathering belongings etc) or while they were in the process of evacuation. Where a fire was well developed in the dwelling, the late activation of the alarm was considered in occupant

accounts to be a surprise and upon reflection slow activation of smoke alarms was thought by these occupants to pose a greater risk of injury and to their survival.

> *Yeah we have [smoke alarms] … They work but it was like, we were actually out of the house before they went off.* Incident 5: Multi-board electrical fire, occupants asleep. No injury, property extensively damaged.

> *The fire alarms only went off as we were leaving the house […] So, if we'd woken to them, we would've lost our daughter [closest to location of fire]. She would've been gone.* Incident 3: Electrical fire in ceiling space, occupant awake. No injury, property extensively damaged.

Late activation of alarm remote from fire location

A further reason for late activation of an alarm was due to the alarm being remote from the seat of the fire. This typically involved the fire originating in an area of the residential dwelling not monitored by a smoke alarm, such as areas above or below the main interior of the house, and included basements, ceiling spaces and external walls.

> *I smelt something. I thought, "that smells like smoke, that's really weird." I walked into the hallway, and there was flames coming down the outside of the main lounge window […] Interestingly enough, we had fire alarms, smoke alarms, but they hadn't gone off at that time […] The fire alarms only went off as we were leaving the house.* Incident 3: Electrical fire in ceiling space, occupant asleep. No injury, property extensively damaged.

> *It was definitely very smoky. I think, luckily, 'cause the fire alarm is in the hallway, and I think we shut the hallway door, so the fire alarm didn't really go off. So, it really only filled up my kitchen, obviously, if it was like longer, it would definitely hit the smoke alarm.* Incident 6: Oven fire, occupant awake. No injury, limited damage to oven.

Failed alarm

A degree of surprise and confusion was expressed when occupants recalled their experience of failing smoke alarms following a UDF. In this state of confusion in the absence of an activated smoke alarm occupants sought out the reasons for the fire-related cues, including rationalising or questioning why the smoke alarm was not functioning.

> *There was a smoke alarm. But it did not go off. Stupid thing would go off in the middle of the night randomly, when there was no fire. But it didn't go off when that fire happened. We were talking about that afterwards. What use is that stupid fire alarm […] Yeah, that is very strange and actually quite scary […]* Incident 8: Unattended cooking fire, occupants awake. Injury, damage limited to room of fire origin.

> *I had two [smoke alarms] in the passageway, but it wasn't that that alerted me in the end. I think, because the roof was sealed, it was only when I opened the door, thinking I was going to go up there and sort out this little spark that I suspected, that it actually really started, you know, that obviously let the oxygen in, and it just took off. But there wasn't really a lot of smoke. It actually was only when, that's another thing, I think, that was surprising that it was really, really burning wildly before there was any smoke in the actual house itself.* Incident 10: Electrical fire in roof space, occupant awake. No injury, roof extensively damaged.

> *I didn't realise that my house was burning in my basement […] I had been on my mobile phone, talking to my friend, and when we finished talking, was when I started hearing these noises going on […] I was really confused about what was happening. I just got, just billowing in of black smoke. And I slammed the door shut. And the first thing I think was, why isn't my alarm system working? What have I done wrong? Did I leave my oven on? And, you know, I'm looking at the oven, like, because it was by the back door. And then it sort of hit me, my house was on fire.* Incident 12: Multi-board fire in basement, occupant awake. No injury, house extensively damaged.

The reasons for alarm failure were not well understood by occupants and well after the fire event it isn't apparent why they failed.

> *But since that have all been replaced, must have been faulty, perhaps I don't know. But the whole thing replaced now.* Incident 8: Unattended cooking fire, occupants awake. Injured, damage limited to room of fire origin.

One occupant made an effort to follow up with the local Fire and Emergency station as to why their wired-in smoke alarm failed.

> *I actually asked the fire chief then, you know, "how come my fire system didn't go?" And he, "by the time smoke got up into your hallway…," it could attach to my alarm, and he said, "by the time smoke up there, all the electricals had been burnt."* Incident 12: Multi-board fire, occupant awake. No injury, property extensively damaged.

While occupants questioned the failure of their smoke alarm during a UDF, having working smoke alarms were still perceived as being important for preventing future dwelling fires and subsequent fire-related injuries.

7.3.3 Occupant perceptions of the value of smoke alarms

Summary: Occupant perceptions of the value of smoke alarms did vary by the circumstances of the UDF: those first alerted by an alarm rated the value of the alarms extremely high. Regardless of the overall perception of the influences of the alarm to an individual's circumstances, occupants reported that their fire safety practices changed in response to their experience after a fire, citing smoke alarms as being highly important to preventing harm from UDF.

Key findings

Prioritise smoke alarms for harm prevention

Those alerted to the presence of a fire by an activated alarm rated the perceived value of smoke alarms the highest, subsequently promoting smoke alarms and became vocal advocates for installing alarms.

> *We promote smoke alarms, I'm a hairdresser, I talk to my clients all the time about what happened.* Incident 15: Electrical fire, occupant asleep. Injured, extensive property damage.

> *Smoke alarms, most important to have smoke alarms. That's the most important thing ever, I think.* Incident 16: Kitchen fire, occupant asleep. Injured, damage limited to room of fire origin.

> *Where there's more than 1 storey, we have encouraged people to put smoke alarms on all floors. And do the particulate, now there are 2 types, but there's one that's got heat and particulates. So, we've made sure that we pass on the message that the combined smoke alarms are the best ones.* Incident 20: Electrical fire, occupant awake. No injury, roof extensively damaged.

Building consent barrier to upgrading systems

In the aftermath of a fire smoke alarms were re-installed and alarm locations expanded throughout the dwelling. Systems such as sprinkler systems were considered for gold standard protection, however, building consent issues were considered a barrier to including sprinkler systems into a domestic setting.

> *We did consider the idea of putting a sprinkler system in the house that we're building. We kind of decided against it, partly because, we really started considering it when the house had just got consent. Look, we were 3 months getting consent anyway. And because sprinkler systems aren't actually commonplace at the moment, in residential, I'd hate to know how much longer that would've held us up.* Incident 3: Electrical failure, occupants asleep. No injury, extensive property damage.

Despite alarm failure, alarms valued

Despite alarm failure occupants perceived smoke alarms as being high important to preventing harm from fires and had felt they were just unlucky with the circumstance of their fire.

> *I still think they're [smoke alarms] valuable. I mean, we were just bloody unlucky where it [the fire] was.* Incident 3: Electrical failure, occupants asleep. No injury, extensive property damage.

> *I make sure I've got, I've always had smoke alarms, but I'm quite careful that we have smoke alarms in all the right places now.* Incident 9: electrical fire, occupant awake.

Not injured, extensive property damage.

8. Discussion

8.1 Findings

This research provides new insights on the influence of smoke alarms on the outcomes of unintentional dwelling fire incidents. This information can be used to effectively prioritise, and target risk reduction activities focussed around smoke alarm use.

8.1.1 Observable/reported impacts of smoke alarms

This research found smoke alarms had the greatest impact on the outcome of UDF incidents when the occupant was asleep. Smoke alarms sounded, woke the occupants and alerted them to a potential fire. This provided occupants with time to escape. Without the operational smoke alarm, sleeping occupants may not have become aware of the fire until the fire was more developed and escape more challenging or not possible at all. Recent analysis of fire-related fatalities in NZ identified sleeping at the time of fire ignition was a significant risk factor for fire fatalities, drastically reducing the chance of escaping from the fire event (Lilley, McNoe & Duncanson, 2018).

Activated smoke alarms were observed to create initial confusion among some occupants. Occupants reported that they initially assumed the sounding smoke alarm was a reversing vehicle alarms or neighbourhood security alarms. It took additional investigation time before they confirmed that the sound was from their smoke alarm. An investigation period however was not unique to those initially confused. All those occupants first alerted to a fire by a smoke alarm, recounted going to seek out the reason for the activation of the alarm before taking any other action. No-one reported immediately evacuating the building based on hearing the smoke alarm alone.

Alarms were least effective at alerting occupants to an UDF if the occupant was impaired, such as having hearing issues due to age or injury. This finding is particularly concerning given New Zealand's population is aging rapidly. Previous examination of fire fatalities in New Zealand found that fatal fire incidents involving fatalities aged ≥65 years were more likely to have had an operational alarm during a fatal fire incident in comparison to other age groups (50%, compared with 39% and 11% of fatal incidents involving fatalities aged 15-64 and <15 years respectively) (Lilley, McNoe & Duncanson, 2018).

The impact of activated alarms was also limited in situations where the fire was discovered early, prior to the activation of a smoke alarm. In these cases, despite the presence of a functioning smoke alarm other fire-related cues played a vital role in alerting occupants to the presence of a UDF.

The relationship between smoke alarms and injuries/property damage was also explored. However, this was challenging given the interview data was not collected to specifically explore the impact of smoke alarms on fire outcomes. A more focussed and larger data set capturing a fuller range of occupant experiences would be needed to make any reliable conclusions on any such relationship. It was noted however that injuries and property damage did occur in instances where there was a working smoke alarm. This suggests that working smoke alarms by themselves are not a guarantee of a safe outcome for occupants. This should not be interpreted to imply that smoke alarms do not offer a protective factor, rather that smoke alarms need to form part of a larger fire safety strategy for a dwelling.

8.1.2 Occupant perspectives on smoke alarms

Occupant's perspectives on the value of smoke alarms during their fire event varied according to their experience. Participants who were awoken by an activated smoke alarm rated the presence of a functioning smoke alarm the highest, with all expressing sentiments of gratefulness of having been woken by their alarms. Those who were alerted via other fire-related cues felt the alarm was of limited use especially when the alarm was activated late, while occupants considered their smoke alarms "totally useless" if an alarm failed entirely.

However, regardless of how their smoke alarm performed during a fire, the occupants recognised smoke alarms as being key to a home fire safety strategy and were important for preventing injuries in a UDF. For example, while those who experienced a failure of their alarm were disturbed that their alarms had failed it had not dissuaded them of the importance of smoke alarms in domestic fire safety efforts.

8.1.3 Occupants behavioural response to smoke alarms

Those alerted to the fire by a sounding smoke alarm responded to the alarm by seeking out the reason for the alarm's activation. Typically, the fires encountered in this scenario were large and more extensively developed so occupants didn't attempt to self-extinguish the fire. Rather, after investigating the smoke alarm sound, they responded with a prompt, safe evacuation of the building. However, if the fire was small, or contained to an item, occupants invariably attempted to extinguish it with success.

This pattern of behaviour didn't differ markedly from those who were alerted to fires by discovering fire-related cues. Occupants reported the size and spread of the fire as the most likely factor to dictate if an occupant attempted to extinguish the fire or if they evacuated the building.

Surprisingly, while those alerted to a fire by a smoke alarm did gain the benefit of additional time to safely evacuate the building (relative to if they had no functioning smoke alarm), they did not always stay out of the building. Despite being in relative safety once outside,

the same occupants recounted re-entering the building to achieve an action that they could not complete during their prompt evacuation, such as searching for possessions, pets or firefighting. Occupants reported sustaining smoke inhalation injuries at this time of re-entry.

Re-entry behaviour was also observed for those who were alerted to fires by other means, however, more of this group stayed out of the building once out, possibly due to occupants delaying evacuation to take the opportunity to grab items before evacuation. It is possible the level of development of the fire influences this behaviour, however, we are unable to make any conclusions with the current data on this aspect. Notwithstanding other possible motivations and behaviours, current qualitative evidence suggests that activated smoke alarms prompt quicker evacuations compared with other means of being alerted to fire. Prompt evacuations may, however, also result in a higher likelihood of re-entry behaviour as occupants seek to obtain items of importance left behind.

8.1.4 Failure of smoke alarms

The experience of smoke alarm failure was encountered when an occupant was awake and discovered a fire before the activation of a functioning smoke alarm. While technically the alarm didn't fail to activate, in this circumstance it failed to provide an early warning or a prompt for immediate action. Relevant circumstances for late activation of a smoke alarm included: early discovery of the fire (i.e. in room when fire started, low smoke volume); alarm location being remote form the fire, internalised to cavities or shut off from the fire; and fire characteristics (i.e. smouldering materials with small volume of smoke).

In cases where smoke alarms failed to activate occupants were reliant on discovering fire-related cues. The reasons for a non-functioning alarm are not well understood by occupants. Where known, a mixture of modes of alarm failure was suggested by occupants in their accounts including age of the alarm and failure of the alarm power source.

8.2 Strengths and weaknesses of the study

This study has several important strengths.

The semi-structured nature of the original interviews of the experiences, motivations and actions of occupants of a UDF allowed for the secondary examination of the influence of smoke alarms on this group. This is the first such thematic analysis focusing on occupants' responses to smoke alarms in New Zealand and contributes to the sparse international literature in this area. By focusing on smoke alarms this research was able to identify some of the physical attributes of smoke alarm failure that should be considered in future fire safety strategies and programmes by Fire and Emergency.

The main weakness of this secondary analysis of qualitative interview data is this data was not collected specifically for answering the research objectives under consideration. As a result, insights are limited to areas which occupants covered in their general recollection of

their experiences, motivations and actions in response to discovering a UDF. For example, no information was captured on the types of smoke alarms installed in dwellings. While insights will be limited there was enough scope in interview responses mentioning smoke alarms to answer the questions of interest to Fire and Emergency.

The qualitative methodology aims to identify themes from occupant's experiences of a non-fatal UDF. However, the study findings are not readily generalisable to the New Zealand population due to the small sample size and use of a secondary data source. Nor is it possible to quantify the scale of the problems identified to an extent that statistical inferences can be shown.

Insights provided by this analysis is limited to survivors of a UDF. The experiences of those fatally injured in a single/family occupancy dwelling will differ and are not able to be inferred from these qualitative data.

9. Recommendations

Based on the findings presented on the previous parts of this report, this section contains recommendations for Fire and Emergency. It is recommended that the following be considered when designing fire safety programmes based on (or around) the use of smoke alarms in residential settings.

9.1 Continue to promote smoke alarm use with some additional further safety tips

While it is important to note that the presence of a smoke alarm is no guarantee of a favourable fire outcome, it is clear that in the incidents explored in this study they were a significant factor in more serious fire outcomes being avoided. This particularly true for saving lives, as opposed to limiting property damage.

In line with this finding, smoke alarms were generally regarded as useful by those interviewed for this research. This is the case for occupants that benefited from a smoke alarm during a fire and those who did not benefit from them. This is encouraging and strongly suggests that the general public are paying attention to, and acting on, fire safety messages.

Given their protective influence evidenced in this data and that those interviewees in this study show that the public are interested in and acting on fire safety messages, it is important that Fire and Emergency continue to promote the use of fire alarms in residential settings and consider incorporating the following additional advice:

Recommendation 1: Fire and Emergency continue to promote the installation, maintenance and testing of smoke alarms in residential settings as a means of reducing the impacts of a fire. This should also include reminding the public to become familiar with the sound of their smoke alarm so that it is immediately recognisable and distinct from other environmental

sounds.

Recommendation 2. Fire and Emergency expands the range of community messages on smoke alarms with the aim of reducing delayed smoke alarm activation from fires starting in less habited or concealed spaces by promoting the installation of smoke alarms in as many spaces as practical in residential settings. This should include the provision of smoke alarms in spaces such as attics and basements. The ready availability of heat alarms for kitchen and dusty spaces should be promoted to ensure all spaces have a form of fire detection. Fire and Emergency should also promote interconnection of residential smoke alarms so that all alarms sound simultaneously once an activation has occurred in any single alarm in the system. Fire and Emergency should support and advocate for the provision of interconnected smoke alarms as a minimum requirement in future Building Code legislative and regulatory updates.

9.2 Promote smoke alarms for the hearing impaired

This research provided new insights from hearing impaired occupants that are important for an aging population. Elderly are a rapidly growing demographic in New Zealand's population (Statistics New Zealand, 2020) and hearing impairments become more common as we age. As a group, the elderly are already particularly vulnerable, given they have higher risk of succumbing to fire-related injuries (Lilley, McNoe, Duncanson, 2018; Lilley, Richardson, Davie, 2019). This study's finding that smoke alarms are of limited utility for those persons with hearing impairments is important and that future fire safety strategies and programmes need to address this as a priority.

Recommendation 3: Fire and Emergency investigate and promote widespread use of specialised smoke alarm systems for occupants that may have trouble hearing or comprehending smoke alarm signals. It is recommended to collaborate with health, disability and age care stakeholders to make appropriate equipment available and accessible to those that need it.

9.3 Updating current fire safety messaging to deter re-entry behaviour

A surprise finding from this research was that while an activated smoke alarms generally prompts evacuation, they do not seem to deter re-entry behaviour. In the incidents studied here, it was observed that it was not the initial involvement in/exposure to the fire that resulted in injury rather it was re-entry to a dwelling which carried an increased risk of smoke inhalation injuries.

Re-entry was often prompted by occupants returning for personal belongings, pets or firefighting behaviour. Occupants seemed to underestimate the risk posed by re-entry or felt so strongly compelled to re-enter to retrieve something of value that they felt the risk was worth taking at the time (although some expressed surprise and regret at their actions afterwards).

There are two issues that should be addressed to reduce re-entry behaviour. Preparedness should be encouraged so that there is no need to go back in; and the danger and speed of fire need to be clear in the minds of the public so that even if they feel compelled to re-enter, they reconsider knowing that it could put them at increased risk of harm.

An increased focus on strategies, programmes and messaging focused on preparedness for sudden evacuation and for staying out of dwellings following evacuation would benefit every occupant of a UDF.

Recommendation 4. Fire and Emergency continue to promote the use of smoke alarms as part of a wider escape plan. Having a working smoke alarm was not enough to prevent some of the occupants in these real fire events from becoming injured, especially following re-entry. Injuries are strongly associated with re-entry behaviour (Lilley, Graham & Richardson, 2021).

Fire safety messaging should include more focus on the dangers and speed of fire. Escape plans should be further encouraged with additional focus on the benefits of preparing and considering what may be valuable in the home. Occupants should be clear on what they would bring with them in an emergency; and where to find it in an emergency. This may deter re-entry behaviour.

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11. Appendices

Appendix A. Semi-structured interview guide

My name is XXX and I'm a researcher in the Injury Prevention Research Unit at the University of Otago.

For this current project, my colleagues and I are interested in learning about the experiences of people who have been involved in a house fire.

Before we get started, I would just like to get your verbal permission to audio-record this interview. I am now going to ask you to complete a written consent form and also a sheet to collect some basic information on your age, ethnicity, area of residence, and financial security – thank you.

Core Questions	Follow Up questions;
Could you start by telling me about the fire you experienced?	How did you first become aware of the fire? Where did it start? What was the material ignited and what types of equipment were involved? What was the extent of the damage to your residence/property? Were safety equipment/devices (e.g. smoke alarms) in the house at the time of the fire event? If so, were these in working order?
Were you injured?	How did the injury occur? What sort of injury was it? What sort of treatment did you have? In hindsight, do you think the injury could have been prevented in some way? (If so, what sorts of things could have been done? / If not, why not? By whom?)
What actions did you undertake in response to finding the fire? For what reason did you do this action?	If other people were in the house, what actions did they take in response to the fire? Did you attempt to put the fire out yourself? Did someone else attempt to put the fire out? Did you alert anyone else in the house to the fire? Did you alert anyone else outside the house to the fire? Did you contact Fire and Emergency or another emergency agency after becoming aware of the fire?

	Why/why not?
Did you evacuate the property? For what reason did you do this action?	Did others in the house evacuate the property as well?
Did you re-enter into the property? For what reason did you do this action?	Did anyone other than yourself or the emergency services re-enter the property while it was alight? Why do you think they did this?
In hindsight would you do anything differently?	Have your experiences of a household fire changed your fire safety practices in anyway? If so, how? What did you believe the level of physical danger to be for yourself and/or others *at the time* of the fire event? What do you believe the level of physical danger for yourself and/or others was *reflecting back* on the fire event?
What do you think are some of the best ways to prevent people being injured by household fires?	
Is there anything else you would like to share about your experience of a household fire event and the consequences this had for you?	

Appendix B: Summary table of circumstances and outcomes of 17 UDF incidents

Key: Evac – evacuation; S/E – self-exhtinguish; N/A – not applicable; Hosp – hospital, RFO – room of fire origin, occup - occupant.

	Incident Number																
Factor	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Asleep/ awake prior	Awake	Asleep	Asleep	Awake	Asleep	Awake	Awake	Awake	Awake	Awake	Awake	Awake	Asleep	Asleep	Asleep	Asleep	Asleep
First alerted by	Alarm	Flames	Noises + smelling smoke	Flames	Family	Smoke	Flames	Flames	Noise	Smoke	Smelling smoke	Noises + smoke	Alarm	Alarm	Alarm	Alarm	Glowing light
Response	Ignore	S/E fire	Sought out fire	Attempt S/E	Evac	Sought out fire	Evac	Shifted fire, spread fire	Sought out fire	Attempt S/E	Sought out fire	Sought out fire	Sought out fire	Sought out fire	Sought out fire	Sought out fire	Sought out fire
	Delay evac	Alerted family, Evac	Alerted family, Evac	Delay evac	-	S/E fire	-	S/E fire	Delay evac	Delay evac	S/E fire	Evac	Evac	Evac	Evac	S/E fire.	Attempt S/E fire, delayed evac
Fire spread @ discovery	Limited spread in RFO	Limited spread in RFO	Spread beyond RFO	Spread beyond RFO	Spread beyond RFO	Contained to item	Limited spread in RFO	Contained to item	Extensive spread in RFO	Limited spread in RFO	Contained to item	Spread beyond RFO	Spread beyond RFO	Limited spread in RFO	Spread beyond RFO	Limited RFO	Limited RFO
Re-entry	YES	NO	YES	YES	NO	N/A	YES	N/A	YES	NO	N/A	NO	YES	YES	YES	N/A	YES
Injury	N/A	Hosp - burns	N/A	N/A	N/A	N/A	Hosp- smoke	Burns to hands	N/A	N/A	N/A	N/A	N/A	Hosp - smoke	Hosp - smoke	Hosp - burns	Hosp - smoke
Property damage	Limited to RFO	Limited to RFO	House extensive damage	Spread beyond RFO	House extensive damage	Damage contained to item	House extensive damage	Limited to RFO	House extensive damage	Roof extensive damage	Damage contained to item	House extensive damage	House extensive damage	House extensive damage	House extensive damage	Limited to RFO	House extensive damage
Reason for alarm failure	N/A	Occup impaired - concussed	Fire location	Fire location	Smoke alarm age	Fire location	Early fire - lack of smoke.	Unknown	Fire location	Fire location	Occup impaired - hearing	Alarm power failure	N/A	N/A	N/A	N/A	Occup impaired - hearing.

Key: Evac=evacuated, S/E= self-extinguishment, RFO=room of fire origin, N/A=not applicable, Occup=occupant, Hosp=hospital