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Progress in Disaster Science

journal homepage: www.elsevier.com/locate/pdisas

Regular article

The risk of dying in bushfires: A comparative analysis of fatalities and survivors

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ARTICLE INFO

Article history:

Received 3 February 2019

Received in revised form 5 April 2019

Accepted 8 April 2019

Available online 17 April 2019

Keywords:

Bushfires

Fatalities

Survivors

Shelter

Risk factors

ABSTRACT

A limitation in disaster risk reduction research is the lack of comparative analysis between those who die and those who survive in the same event. This makes it difficult to determine factors that increase or decrease the risk of dying in a disaster. In this paper, we begin to address this research gap by using published data from the 2009 'Black Saturday' bushfires in Victoria, Australia. One set of data comes from a representative postal survey of those who survived the fires, and a second from data on the 172 civilian fatalities in the same fires. The aim is to examine what differences exist between those who died and those who survived the fires. Are there identifiable differences between the two groups, and if so, why might this be – and what does this mean for fire policy and planning?

Two major differences were found between the two groups. First, the demography differed between fatalities and survivors: disproportionately more older people (over 50s) died than younger people (under 18s); and men were much more likely to die than women. Second, the behaviour between the two groups differed: most survivors reported carrying out their intended actions, whereas most fatalities did not (or were unable to) carry out their intended actions; and, most fatalities sheltered, while very few survivors did so. There are caveats to this analysis as the datasets were not intended for comparative analysis of this sort.

These differences hold important lessons for bushfire policy and planning. The analysis highlights the dangers of sheltering passively within a building or structure, emphasising the importance of communicating this particular bushfire safety message.

1. Introduction

1.1. Context

An important aim of disaster fatality data and databases is to identify factors that influence the likelihood of dying. Research on the fatalities of Australia's most devastating bushfires in February 2009 does this [13,17], as does work following Hurricane Katrina in New Orleans [10], and published work from Risk Frontiers on Australian bushfire fatalities [7,8].

However, an important limitation of this type of work is the absence of comparison with those who did not die in the same events. Some findings about fatalities, for example on disabilities, capacities, and planning and preparation levels might also characterise survivors. This makes it difficult to identify attributes and behaviours that alter the risk of dying. Comparative studies can help improve confidence in such assertions. We located very few studies that undertook quantitative comparisons – as discussed below.

1.2. Related studies

There are few published studies that examine disaster survival by empirical comparison with survivors of the same event. However, two studies did this for tornadoes in the 1990s [28,29]. Warning times were very short of the order of a minute or so. Schmidlin et al. found that key risk factors were lack of warnings, being older and being in above ground structures that were destroyed by the tornadoes. Reviews of earlier work by the Schmidlin et al. studies found that age, gender, ethnicity, warnings and shelter were key factors. It is worth noting that mass deaths occurred in some tornado events when community shelters collapsed. Because everyone is sheltering together, the differential vulnerability of different demographics is reduced. Survivors and fatalities of residential fires were compared by Marshall et al. [23], who found that those at high risk were:

"...the very young, older adults... and those impaired by alcohol ... These groups are more vulnerable to fire fatality because they lack the capacity to take 'mature, independent escape action.'"

Much effort has gone into examining the approximately 1000 fatalities from Hurricane Katrina in New Orleans, however, reports do not undertake

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comparative analysis with survivors. Instead, official demographic statistics are used for comparisons. Studies generally found that those who were vulnerable due to age and/or disability were far more likely to die. Brunkard et al. [10] found that more than half the victims were over 75 years old (approximately 6 times the expected rate based on population), many in hospitals and nursing homes also perished, fewer than 10% were under 45 [10]. In addition to those in residential homes and hospitals, there were many with disabilities. Note that the dataset has major gaps. Other Hurricane Katrina studies confirm the age risk, but stress that location was also key, along with issues connected with the process of evacuation [9].

1.3. This study

We set out here to start to fill this gap by undertaking a comparative study of those who died with those who survived the bushfires of February 2009 in Victoria, Australia. The aim is to answer the question: are there identifiable differences between the two groups? This is expected to help with advice on preparedness and behaviour, identification of vulnerable people, and other aspects of fire safety programs.

This paper sets the event and policy context by briefly reviewing the February 2009 fires, and the expectation that those at risk would decide on whether they would evacuate or not. The databases and approach used are set out, followed by an analysis of who was affected by the fires, what their plans, preparations and intentions were, the warnings they received and the extent of surprise, and finally the actions taken. Fire-risk awareness and knowledge are reflected in plans and preparedness. Throughout the paper, the emphasis is on comparison between those who died and those who survived. A section on the limitations of the data and analysis forms part of the description of the method and data.

A limitation of the few published studies using data on both fatalities and survivors is that they do not look closely at intentions and actions. The study reported in this paper extends the earlier work with more detailed data on both fatalities and survivors.

2. The fire and policy context

2.1. The bushfires of February 2009

Predictions and public warnings for the weekend of February 7–8, 2009, were for extreme heat and the worst fire danger day in the Australian state of Victoria's history. By early afternoon on Saturday February 7, these concerns were realised with many intense and fast moving bushfires across the state. The fires burnt about 450,000 ha, claimed 172 civilian lives, the life of one fire fighter, and about 2100 homes, among many other serious impacts [33]. They became known as the 'Black Saturday' bushfires. The weather conditions brought a record high in Melbourne's CBD of 46.4 °C (about a degree hotter than the previous record high and 3 degrees higher than the record for February), higher temperatures elsewhere in the state, very strong winds, and extremely low humidity [22]. The weather and fire danger conditions built on more than a decade of record-breaking hot and dry weather and the most severe heatwave on record the previous week, which had together dried out the state's vegetation and surface water [22,36]. There is a large literature on these fires, both in terms of research papers and reports from a variety of perspectives (for example historian Peter Stanley's book on Steele Creek [31]), and in publications for a less academic audience.

2.2. Bushfire safety and evacuation

Until the 2009 Black Saturday bushfires, the bushfire community safety emphasis in Australia was in the form of advice to householders to make a decision on what they were going to do – taking account of their particular circumstances – and to plan and prepare for that course of action. This approach formed the basis of the policy 'Prepare, stay and defend, or leave early'; known colloquially as 'Stay or go'. It emphasised being prepared to stay and defend a well prepared property, or having pre-defined triggers

to leave well before a fire threatened. Those at risk were to make plans and prepare based on those plans. Plans were to include clear triggers for action, and the intended actions were to have been decided beforehand (see [13]). There was also an implicit assumption that people could judge their own vulnerabilities and capacity to stay and defend or leave early [33], but there was no formal training or certification. This policy was formally adopted by all Australian fire agencies in 2005, although it had long been the unofficial position in some Australian states [15].

The current approach is similar in terms of planning and preparedness, but different in that there is now a strong emphasis on evacuation ([1]; see the final section of [13]). Our focus here is on the policy context at the time of the Black Saturday fires.

3. Method and databases

3.1. The datasets

This study employs a quasi-experimental design using published data about the individuals and households affected by the 7th February 2009 bushfires in Victoria. One set of data is from the results of a major mail survey following the fires, and the other set of data is on those who died in the same fires.

The fatality data is drawn from Handmer et al. [14] and a recent paper on the fatalities [13]. The Victorian Bushfires Royal Commission provided a summary document for each civilian fatality for the analysis reported in Handmer et al. [14]. The police treated the 172 civilian fire deaths as potentially linked to criminal activity and undertook a detailed forensic study of each death. Among other things, the police reports included telephone and text records (the mobile phone network remained largely operational), medical records, details of police interviews, and information on house construction and the surrounding vegetation for each relevant location. Included were details about the level of preparation, warnings received, and intentions and actions on the day, as well as the results of forensic investigations (for example, whether there was evidence of firefighting equipment, including its possible failure; and so on). This resulted in an unusually thorough dataset of deaths from a disaster triggered by a natural phenomenon. For this comparative analysis we have access only to the data published in Handmer et al. [14] and Handmer and O'Neill [13].

The survivor dataset is a result of a mail survey conducted as part of the Bushfire CRC's Black Saturday post-fire research programme. This paper draws on the frequency counts and cross-tabulations published in Handmer et al. [16] as a databook. Full details of the survey method are in Handmer et al. [16] and Whittaker et al. [34]. The mail survey was sent to all households within the burnt area as defined by the DSE,¹ in October 2009. The survey consisted of 83 questions divided into four sections: (1) How the bushfires affected the household and their property, (2) Information and warnings, (3) Before the bushfires, and (4) During the bushfires. For survivors, the survey results provide an assessment of plans, preparations and intended actions before the bushfires, warnings received and actions during the bushfires.

3.1.1. The samples

The survey data comes from a representative sample of about 25% of the households within the fire affected areas, undertaken in August 2009 [16]. The survey forms were sent to all houses within the fire affected areas, and returned 1314 usable questionnaires. The proportion of the sample that lost their homes is about the same as the generally accepted figures for house lost: about one third of the houses in the fire affected areas. The proportion of male and female respondents is approximately equal. While this provides a source of validity for the sample, it could be distorted in other ways. Few of those under 40 responded to the survey, which is a

¹ The Department of Sustainability and Environment (DSE) was a Victorian state government department responsible for management of government land. After amalgamations with other government departments, it is now known as the Department of Environment, Land, Water and Planning (DELWP).

gap in much survey research. It is also possible that those who were particularly traumatised by the fire, as well as those who were unconcerned about the fire risk because of their mobility, might be absent from the sample.

There is an argument that those who left should be excluded from the sample of survivors. In comparisons on planning and preparation the fact that some people left before the fire arrived provides important insights as it was generally the less prepared who left early. We have included these people and show them separately in most of the results. The 78 people in the sample who left early for reasons other than the fire are included for the same reasons: they are shown as part of the group that left early in the results and their levels of planning and preparation are relevant as representative of the general at-risk population.

The fatality data includes all those who died as a direct result of the fires on 7 February 2009. This was defined as those who died within the fire affected areas on Saturday and Sunday, February 7–8. Without the fires, over the same time period and same location there may have been one or two deaths from car crashes, and some deaths from heat stress. We have included all deaths attributed to the fires including the small number of tourists and campers. The fires may have led to additional deaths from smoke inhalation outside the burnt areas. The post-fire enquiry did not attempt to separate out deaths in this fashion, and we are not aware of any published material that does so. Such analysis would be complicated by the impacts of the extreme heat before and during the fires, and by the general difficulties in attributing cause. One fire fighter who died during post-fire operations was not included in the analysis, as we focus on civilian casualties.

3.2. Limitations with the comparison

The two data sets drawn on for this study were not created with the intention of undertaking a comparative analysis. As a result, some data fields and definitions differ between the two datasets. These differences required the aggregation of some data fields to allow a comparison of the datasets, as explained in the following sections on each comparison. Access to both datasets was through published sources as set out above. This was due to dataset availability and confidentiality restrictions.

The fatality data set mostly relied on forensics and third party assessment, while the survivor dataset relied on individuals' self-assessment. For example, the mail survey respondents were asked to assess their level of preparedness and the extent to which they had prepared plans before the Black Saturday fires. It is quite likely that self-assessment of these factors by respondents would differ from that of a third party assessment, as used in the fatality data set.

A number of factors may have influenced the survey responses. It is likely that responses in the mail survey “have been influenced by ‘hindsight effects’ involved in making judgements about the causes of events in the past with the knowledge of results from the present” [34]; also [20]. The extensive media publicity, public discussion and criticism of fire agencies and the ‘Prepare, stay and defend or leave early’ policy following the Black Saturday fires may also have influenced the responses of participants [16].

4. Results and discussion

4.1. Demographics – who died?

The review of comparable work found that age was a key factor in fatalities from natural hazards. Evidence for other demographics was mixed, although gender, disabilities and the influence of alcohol were found to be a significant risk factor in some studies. This part of the comparative study uses official demographic data from the Australian Bureau of Statistics (ABS) on the affected areas as a surrogate for the demographics of survivors.

4.1.1. Age

Black Saturday fatality data showed that older people (70+) were at least twice as likely to die as would be expected [14] from demographic data, however this depends on the statistical area being compared. If we

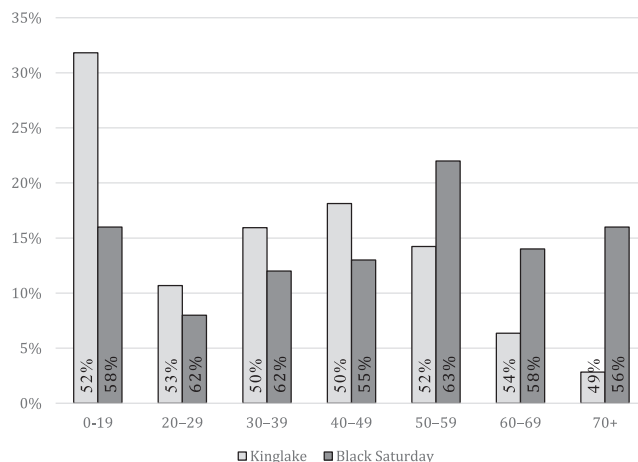


Fig. 1. The 2009 estimated residential population of the Kinglake [6] area, compared to the demographics of the Black Saturday fatalities. The percentages shown within each bar are the percentage of males in the relevant age group. For each age group shown on the horizontal axis, the left column is the proportion of males in that age group; the right column is the proportion of males among the fatalities in that age group. The South West Goulburn statistical area [4] was also used in the analysis. The demographics of the two areas are similar except for the older age groups, where South-West Goulburn has more than double the percentage of people in the 70+ group, compared with Kinglake.

draw on the demographics in the Kinglake statistical area alone, the chance of dying is about 5 times greater. However, many older fatalities came from rural parts of the area where the proportion of people 70+ is high. There is an elevated chance of dying for all those over 50 (Fig. 1).

This pattern is found in other Australian bushfires [18], and in other major disasters such as Hurricane Katrina in New Orleans in 2005 (although here older people were up to 8 times more likely to die than the area demographics indicate), and the 2011 Japanese tsunami [19]. An international comparison of how older people fare in disasters undertaken by HelpAge International [19], finds that older Australians do relatively well. This was found to be due to low exposure (compared with for example, Japan and the US), relatively low vulnerability and high capacity primarily due to relatively good support services and pension coverage [19].

The proportion of older people dying in bushfires is much the same in Black Saturday as in the 1983 fires of Ash Wednesday, and the historic fatality record [18]. However, the proportion of older people in Australia has changed with increasing life expectancy - from 75 in 1983 to 81 in 2009. This suggests that the risk for older people is declining slightly.

4.1.2. Gender

A higher proportion of men than women died in the Black Saturday bushfires, with men making up 58% of the fatalities, and women 42%. This general pattern is also reflected in historical Australian bushfire fatality data [18] where the proportions are about 60% men and 40% women. (These figures include children.) Possible reasons for the gender difference include that on Black Saturday men were more likely to stay with their properties while women were more likely to leave.

4.1.3. Disabilities

Detailed data on disabilities was available for those who died. For survivors, ABS (Australian Bureau of Statistics) data on disability rates for Victoria was used. The ABS defines a disability as “any limitation, restriction or impairment which restricts everyday activities and has lasted, or is likely to last, for at least six months”. Based on this definition, and a national survey in which people self-report, the disability rate for Victoria in 2009 was 18.4% [5]. In the review of Black Saturday fatalities, a figure of 20% was used drawing from a 2004 ABS report. The differences between the 2004 and 2012 ABS reports reflect age adjustments and a slight drop in disability rates across Australia. These figures include the approximately

6% of all people with a “profound or severe limitation in the core activities of communication, mobility and self-care.” [2].

In assessing fatalities, any chronic medical condition listed in the Police summaries of each fatality was classed as a chronic disability. People recovering from major surgery were also classified as having a disability [14]. Based on this approach, 24% of those who died had a chronic disability. In addition to these chronic disabilities were disabilities acquired on the day, from heat, alcohol or injury, amounting to a further 5% of those who died. There was no data on disabilities acquired on the day for survivors.

Comparing chronic disability rates (not adjusted for age) between fatalities and survivors of 24 and 18.4% gives a small difference, which is likely due to the way the different datasets were compiled, and the reality that not all the chronic conditions of the fatalities would constitute “impairment which restricts everyday activities...” [5]. If we compare those with a severe disability the difference between those who died and the population of Victoria is also small: about 7% of those who died had severe mobility restrictions, compared with a Victorian figure of 6% for profound or severe limitations (see discussion above). This suggests that disability was not a significant factor in the risk of dying. It is not an argument that disabilities are not risk factors, but in this case they had at most a small effect on the chance of dying. It is also possible that some with disabilities evacuated before the fires arrived.

Another factor that could have had a disabling effect on the day is the consumption of alcohol or other drugs. The AIHW (Australian Institute of Health and Welfare) [2] estimates that approximately half of all Australians over the age of 20 consume alcohol at least weekly (at the time of the fire). Alcohol or drug use statistics are not available for the two datasets; and comparison is not possible. However, the evidence for the fatalities is that few people were drinking on the afternoon of Black Saturday – which is doubtful given the AIHW findings, and that is was very hot, and a weekend. Overall, there is limited evidence that being under the influence of alcohol, or other legal or illicit drugs, was a significant risk factor in dying on Black Saturday. This is in contrast to other research showing that alcohol can be an important risk factor for fatalities in house fires and floods (e.g. in flood fatalities, ([21]; house-fires, [23]).

4.1.4. Discussion on disability

The global view differs from the above result and argues that those with disabilities are much more likely to die in disasters [37]. In the 2011 Japanese earthquake and tsunami, the fatality rate for people with disabilities was twice that of non-disabled people [37]. People with disabilities have higher rates of mortality and morbidity in disasters due primarily to reduced mobility, and difficulties in receiving warnings. Other factors can be important such as the physical and mental effects of prescription medicine or the loss of essential assistive devices and drugs in an emergency evacuation or fire. In Australia, “1 in 10 used equipment or an aid ...” to help cope with their condition or everyday living [3].

4.2. Plans, preparations and intentions

Australian fire agencies urge all those in fire risk areas to prepare “fire plans”, now called “Bushfire survival plans”. Households are expected to collectively plan what they will do on days of extreme fire risk and when a fire threatens. These plans are to form the basis of bushfire safety preparedness activities and to guide decisions on intended actions, such as when to evacuate. In this section we compare the existence of plans, the level of preparedness, and the intended actions of survivors and fatalities. The section concludes with a comment on house defendability, as it is, or should be, a factor in planning and preparedness.

4.2.1. Plans

A higher proportion of survivors than fatalities reported that they had plans: 63% compared to 47% of fatalities. Data from the survivors does not cover plan quality and consists of self-reported plan existence. It is important to note that about one third of the fatalities with plans were assessed as having undertaken no preparedness activity, suggesting a

limited connection between the existence of plans and sound preparation [13]. Similarly, the fact that half the fatalities had plans indicates that a lack of planning is not by itself necessarily a major risk factor.

For the fatalities, there was some material on plan quality which showed that plans were hugely variable, with some specifying passive sheltering in bathrooms, making assumptions about warnings directly from officials, or that there would be time to get into purpose built fire-refuges as the fire approached. Some plans were not known by all household members, it being assumed that the details would be finalised when a fire threatened. There was no evidence that those who died had contingency plans or plans that could adapt readily to changed circumstances. (This material is drawn from [14]).

4.2.1.1. Discussion. Other Australian assessments have found high levels of plan existence. Eriksen et al. [11] reports that 78% of respondents to their online survey (done through community groups which could have attracted respondents with a relatively high level of fire awareness) had a plan of some sort (written or otherwise), with about 14% having a written plan. McLennan et al.'s [27] compilation of seven post-fire surveys showed that about two thirds had plans, but fewer than 10% had written plans. An earlier eastern Australian study by McLennan et al. [25,26] based on scenarios found lower levels. Just over one third in the McLennan et al. [25,26] study had “a household plan”, with the proportion varying by intention following the general pattern found with Black Saturday fatalities (see [13]): 56% of those intending to stay and defend had plans versus 39% for those intending to leave, and 24% for the undecided. In addition to the issues about self-reporting mentioned above, the reported high levels of plan existence could reflect post Black Saturday increases in fire-risk awareness.

While the idea of plans is sound, plan utility depends on the quality of the plans, the underlying process of planning, and that triggers for action in the plan will be available. Plans can contain actions that can be fatal, such as sheltering in bathrooms [14]. They are also generally made for a specific set of circumstances. Unfortunately, circumstances are rarely exactly as imagined, and it is important that plans are flexible enough to deal with change. People are most unlikely to plan for fire conditions worse than experienced. Similarly, typically they do not consider that key people could be away, ill or overcome by smoke, that there are visitors or important work commitments, that the fire could be accompanied by high winds, or planned escape routes blocked [14]. Another issue is that on Black Saturday 80% of calls to emergency services went unanswered [33], and few received an official warning although most expected one [13].

Insights into plan quality are rare as most research relies on self-assessment of plan existence, and little more. Considerable research effort goes into determining whether people have plans and whether they are actually documented in writing, all based on self-assessment (e.g. [11,27]).

4.2.2. Preparation

There are degrees of preparedness, many actions that constitute preparation; including both tangible measurable actions as well as mental readiness. Only tangible measures are assessed here. Results show that survivors were better prepared than those who died. However, as with fire plans, there are differences in the data sets which call for caution when interpreting results.

4.2.2.1. Fatalities. In the original analysis of fatalities, preparation type activity after 1.30 pm on the day of the fire was considered to be response, and was not counted as preparation [14]. By 1.30 pm on Saturday 7 February, the Kilmore fire had closed the state's main north-south highway and was destroying houses. Three levels of preparedness are recorded, including no preparation:

- To be well prepared to stay and defend (drawing on advice from the Country Fire Authority (CFA) in early 2009), evidence of fuel management around the property, appropriate fire-fighting gear and clothing, and a water supply were needed. The water and delivery systems had to be independent of mains water and mains electricity.

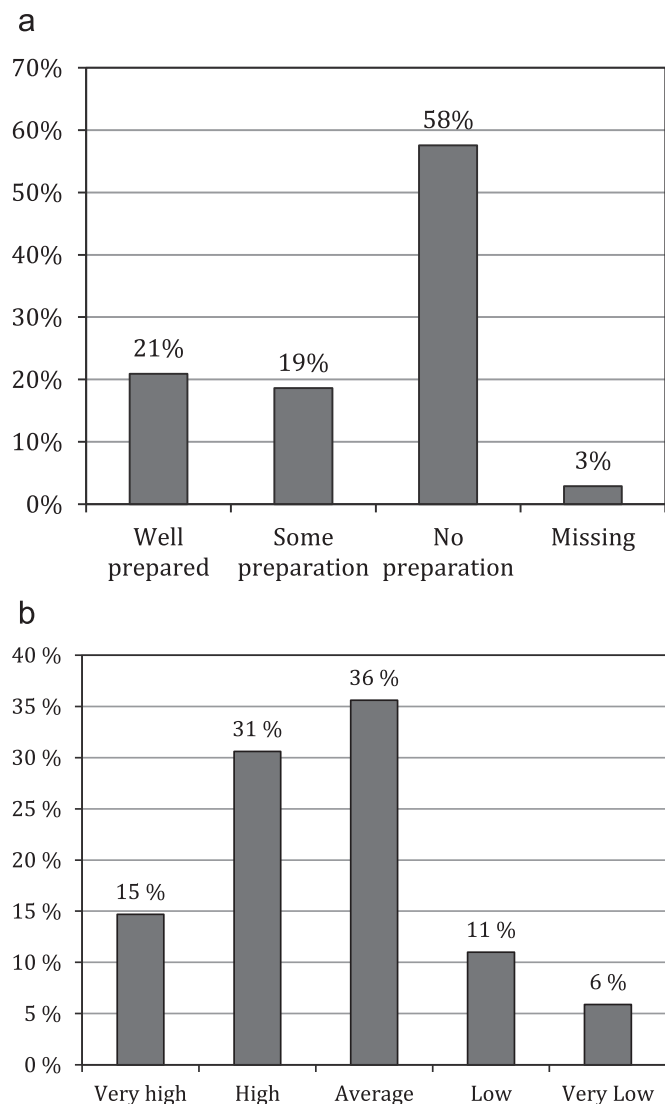


Fig. 2. a: The preparation levels of fatalities (n = 172). Preparation was defined as activity undertaken before 1.30 pm on February 7. b: Question 30 for survivors: "How would you rate your preparedness for the February 7th bushfire?"

- To be classified as having "some preparedness", actions required were less demanding than those of the well prepared category. Evidence was required of a small independent water supply (e.g. buckets), appropriate clothing, appropriate gear and some fuel management.
- To be considered well prepared for evacuation, evidence of a clearly defined destination and trigger to leave were required. Less than 1% were well prepared for evacuation under these criteria.) Whereas 5% of fatalities had made just some preparations (i.e. had a vague idea of a destination and trigger) to evacuate.

Under these criteria about one fifth (21%) were well prepared, about one fifth (19%) had some preparation, and just under two thirds (58%) had no preparation, to defend or leave (Fig. 2a).

4.2.2.2. *Survivors.* To assess the preparedness of survivors we use responses to the survey question: "How would you rate your preparedness for the February 7th bushfire?" The possible responses used "average" preparedness as a subjective benchmark. The result gives a high level of preparedness, with 46% assessing themselves as having "high" or "very high" preparedness (above average), about a third at "average", and only 17% as low or very low (below average). However, other survey questions showed that only 45% had prepared protective clothing on or before the day of the fires

(31% before the day), and 53% had "obtained and prepared equipment such as ladder, buckets and mops to put out spot fires" on or before the day (35% before February 7). These figures suggest that while about one third had taken the actions before the day of the fires, the rest had not, and took action on February 7 as fires threatened (Fig. 2b).

4.2.2.3. *Discussion.* Based on the reported data, survivors were much better prepared than those who died. This result needs to be viewed in the light of a number of issues: the survivors are self-reporting and will likely be affected to some extent by hindsight and optimism biases (Section 3 above). From another survey question, the fact that more than two thirds of the survivors would like to be better prepared also suggests that they might not as well prepared as their stated self-assessment. Critically, their assessment of preparation depends on their interpretation of the "average" level of preparation. In contrast, the preparation levels of those who died were assessed against criteria reflecting CFA advice at the time [14]. Also, it is important to note that for the fatalities, fire related activity after 1.30 pm on the day of the fires was counted as response [14]. By this time the main highway north of Melbourne was cut and townships were being impacted by fires. However, many survey respondents most likely viewed fire related activity as preparation regardless of when it took place, with the result that survivors would count activities as preparation that would be categorised as response in the case of those who died.

Another way of examining preparation among survivors is to examine responses to questions about specific preparatory actions, such as use of appropriate clothing, or ownership of basic fire-fighting gear. When this is done, the level of preparation among survivors before the day of the fire, is similar to the level of those who died.

Taking plans and preparation together, it is likely that survivors were better prepared for the bushfires, although the differences would be small.

4.2.2.4. *House defendability.* No matter how thorough planning and preparation, those who stay implicitly or explicitly assume that their property is defendable and can withstand the fire (see Section 2). However, about 30% of fatalities were in properties of questionable defendability. This was based on police forensic reports and assessment of the vegetation, slope and building characteristics as far as was possible from the police reports [14].

Directly comparable data is not available for the survivors. Instead a proxy was used: defended properties that burnt down are assumed to be undefendable for the purposes of this analysis. During the Black Saturday fires, a 77% survival rate was observed for houses that were defended, compared to a 44% survival rate for unattended houses [35]. Using this

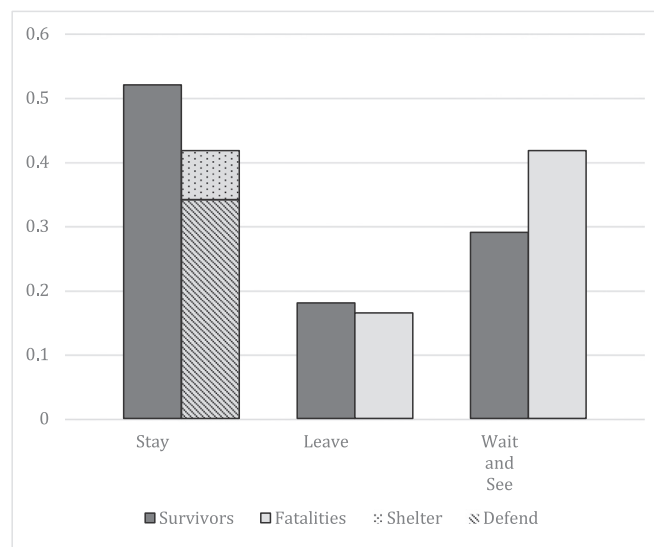


Fig. 3. A comparison of the proportion of intentions using modified categories as discussed in the text. (The vertical axis can be read as percentages, e.g. 0.2 is 20%.)

measure, 23% of properties were categorised as undefendable. Given the uncertainties in the data sets, this represents a small difference from the 30% of undefendable dwellings occupied by those who died.

4.2.3. Intentions

Planning and preparation is ideally directed to behavioural intentions when fire threatens. A notable difference between the intentions of the survivors and fatalities groups is that those who died had a higher level of “no intentions” (or were originally categorised as “wait and see”): 42 versus 29% among survivors. A caveat is that the stay/leave/no intentions categorisation is qualitative and not precise. Nevertheless, slight differences in how individuals are categorised would not affect the overall pattern. Despite this difference, the general pattern of intentions between the two groups is similar as shown in Fig. 3; highlighting again that the differences are factors affecting the risk, but are not categorical. Among both the fatalities and survivors, fewer than 20% of individuals had a firm intention to leave.

The original survey question category of ‘stay and protect but leave if threatened’ contains a significant number of people. This category is potentially ambiguous and could be considered as part of either the ‘stay’, ‘leave’ or ‘no intentions/wait & see’ group. Here a decision was made to combine and categorise these groups as “wait and see” for the purposes of comparison.

Generally, those planning to stay and defend had higher levels of planning and preparation, although the connection was weaker for survivors. Among survivors, people who had a firm plan were slightly more likely to intend to stay throughout the fire:

“Proportionally, 57 percent of those who had a firm plan, and 49 percent of those who decided what to do and were planning it; and 48 percent of those who considered it and decided to do nothing had thought they would be most likely to stay throughout the fire.”

[[16]]

(This is based on the cross tab of survey Questions 26 by 27: “At the beginning of last summer, which of the following did you think you were most likely to do if a bushfire occurred in your town or suburb?”)

For this analysis the fatality database categories for intentions were grouped to allow for comparison with the survivor *Databook* as shown in Table 1a:

The intention categories used in the analysis of the survivor survey were adjusted to allow comparison with the fatalities database as shown in Table 1b (“Other”, with 2.4% of responses, and “Missing”, with 5.1% of responses, have been excluded).

4.2.4. Warnings and surprise

To activate plans or carry out their intentions, people need to know that a threat is imminent. They need to know this in time to avoid being surprised, or caught with insufficient time to activate plans and intentions. The usual approach to reducing surprise and providing notice for taking safety related action, is a timely warning.

4.2.4.1. Warnings. Almost all people received warnings from some source, and there are no clear differences between the survivors and fatalities. Only approximately 10% of both those who died (9.3%) and those who

Table 1a

Categorisation of the intended actions of fatalities. The categories used in the fatalities data were relabelled for comparison purposes. Percentages are of the total number of fatalities.

Relabelled category for comparison	Original categories
Stay	Defend; shelter (8%)
Leave	Leave (16%)
Wait and see	No intentions (16%); wait and see (26%); do nothing (~1%)

Table 1b

Categorisation of the intended actions of survivors, relabelled for comparison. Percentages are of the total number of survivors.

New category for comparison	Original categories
Stay	Stay and try to protect your property throughout fire (48%)
Leave	Leave as soon as you know there is a fire threatening your town or suburb (16%); You would not be at home because you intend to leave on high fire danger days (~2%).
Wait and see	Do as much as possible to protect your property but leave if threatened by the fire (16%); wait and see (9%); wait for emergency services (~3%); hadn't thought about it (~2%)

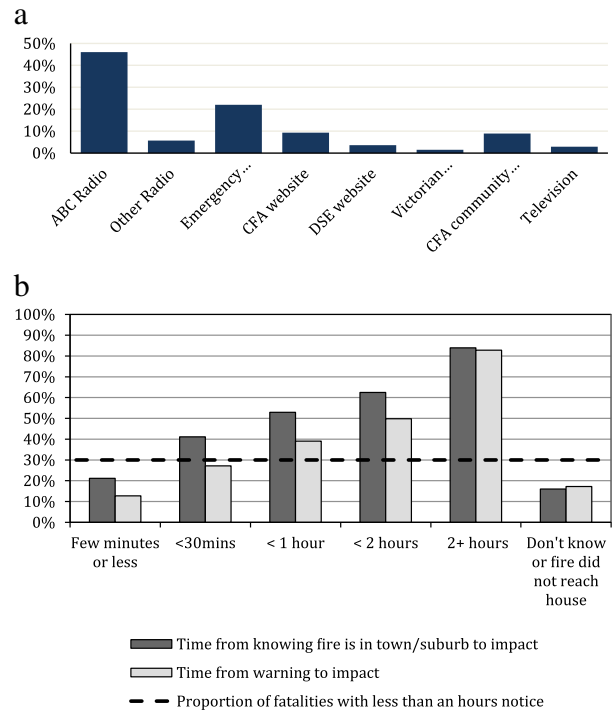


Fig. 4. a. Question 16 for survivors. “Did you actually receive an official warning from any of the following? You may select more than one”. b. Q14 for survivors. “After finding out the fire was in your town or suburb, how long was it before the fire reached your house?” Q21 for survivors. “How long AFTER you got the warning did the fire reach your house or property?” Note that the bars are cumulative along the x axis.

survived (11.1%) received a warning directly from a government official (fire/emergency service worker, police or community meeting – also see below, Fig. 4). Across both groups most people received a warning from neighbours, friends or family members. These warning messages were either about an imminent direct fire threat to the household, or a less specific threat to the area. Others observed environmental cues such as smoke or embers.

A key element of the warning process is confirmation of the threat [30]. This was difficult as both the state bushfire advice line and emergency number were overloaded and did not answer some 80% of calls from people seeking advice or emergency assistance on Black Saturday [33]. For the survivors (quoting the results of Question 13 in the *Databook*, [16]):

“The majority of respondents noted that they first became aware of the bushfire through sensory cues from the environment (smoke, fire embers: total n = 427, 32%). The second most common form of first warning was from family, friends or neighbours (21%). Only 8% were first alerted through ‘official’ warnings (radio, emergency personnel, internet, television: total n = 114).” [Community meetings were added to

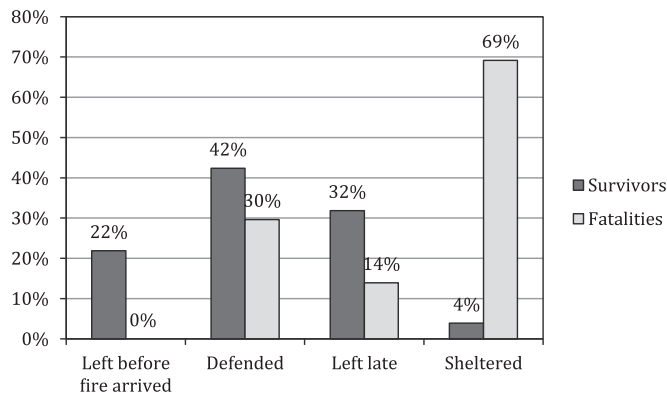


Fig. 5. The percentage of individuals carrying out the specified action. More than one action was recorded for some fatalities, hence the percentages add to more than a 100%.

this for the overall figure of 11.1% quoted above.]

When these warning figures are considered in the context of timing (see the following Section on “Surprise”), it becomes clear that even with warnings, there was very little time for many people to respond.

Since 2009 there have been major changes in Australian warnings for severe events. Recent surveys suggest that some 80% of households now receive text message warnings sent directly to their mobile phones [12]. This could be perceived as a warning directly from an official source, increasing the percentage received in this way from about 10 to 80% – and thereby possibly reducing the numbers who are surprised.

4.2.4.2. *Surprise.* Among the fatalities, 30% were taken by surprise, defined as having less than 1 h between realising that a fire was threatening and fire arrival. Using a similar definition, surprisingly, about half the survivors had less than 1 h between realising that the fire was in their locality and it reaching their house. Of interest too is that of the survivors who received a warning from an official source,² 39% had less than 1 h from the time of the warning to the arrival of the fire at their property (Fig. 4). This is evidence that even though most people (especially among the survivors) were aware that the day was one of total fire ban and a high-risk day for fires, they were nevertheless taken by surprise (using the above definition of surprise), when the fire arrived at their premises.

An important issue not explicitly captured in the data and analysis is the wind change that occurred late on Saturday 7 February. This turned the fire through 90 degrees and turned the long eastern flank of the fire into the fire front which raced towards areas seen as relatively safe. The wind change was forecast accurately, but many of those who needed the information did not receive it. The case of Marysville illustrates the issue: there was an average of about 20 min between the wind change and the time of death for 45 people in Marysville [33].

For the survivors, questions 14 and 21 of the survey are related to timing and serve as proxies for surprise:

- Q14. After finding out the fire was in your town or suburb, how long was it before the fire reached your house?
- Q21. How long after you got the warning did the fire reach your house or property?

Of interest is that by the definitions above, the survivors had less time and were if anything more likely to be surprised than those who died. This is most likely a result of how the data was collected, with questions for survivors referring to a specific warning, or to fire in their suburb. Given this, it is difficult to argue that overall surprise was a key difference, nevertheless it appears to have been a factor in many deaths such as those at

² In the survey, an official warning includes “those from authorities such as the CFA, the police or other emergency services, and ABC radio”.

Table 2

Categorisation of actions in the survey data set. Original categories are those used in the analysis of fatalities. Note that only 1.7% are in the category “stayed and defended but no fire”.

New category	Original category
Leave	Left before the fire arrived
Left late	Left when the fire arrived; Started to defend but left
Defended	Stayed and defended; Stayed and defended but no fire
Sheltered	No defence, but sheltered in house; No defence, but sheltered in structure; No defence, but sheltered outside

Marysville. A possible explanation for this apparent paradox is that the one hour time window used in the analysis of fatalities could be inappropriate, and a shorter time, say a 30 min window, might give a better indication of surprise – with implications for fatalities.

4.2.5. *Actions*

All the plans, preparations, intentions and warnings come together in the actions actually taken. Here, there is a major difference between survivors and those who died (Fig. 5). Over two thirds of the fatalities sheltered passively (in the sense of being immobile), while few of the survivors appear to have done so. Survivors generally left, even if they were late in doing so, or actively defended their property. Over a quarter of the fatalities (27%) sheltered in a small room with one exit, usually a bathroom. In such a location, it was not possible to tell what was happening in the rest of the house, and importantly it was not possible to escape from the burning building.

The data comparisons also show a large difference between those who survived and those who did not in terms of leaving: survivors were successful in leaving without being caught in the fires.

When comparing the two datasets, care must be taken as outlined above under “Limitations”. The distinction between sheltering and defence is not always clear. Fatality data considered the possibility of individuals carrying out more than one action. Some individuals carried out defence tasks and then sheltered. The survivor data is based on a question which asked for a single action: (Question 37): “Which one of the following best describes what you did during the bushfire? Select one only.”

The responses to this question were categorised for easier comparison to the fatalities database as shown in Table 2.

Some survivors sheltered, but generally appear to have remained mobile and able to avoid being caught in flames or severe radiant heat. Blanchi et al. [7] has shown that there is a trend in the actions of those who died in bushfires, with more sheltering and dying inside buildings as the fire danger index increases. A detailed examination of the experiences of some of the Black Saturday survivors who sheltered is set out in McLennan et al. [24].

5. Conclusions and implications

Identifiable differences between the fatalities and survivors of the Victorian bushfires of 7 February 2009, are few, and it is important to appreciate that where they occur they are mostly matters of degree. They represent risk factors which alter the likelihood of surviving but fall well short of guaranteeing it. There is one major exception to this statement, and three important, but lesser, exceptions.

The single major difference is the action taken by those caught by the fires. Almost no survivors sheltered, whereas over two thirds of those who died did so. In this context, sheltering is defined as passive, as in an absence of action and mobility. Out of a total of 119 sheltering fatalities, 34 (20% of the fatalities) undertook some defence before sheltering. The survey had a question about leaving and returning to the property while defending/sheltering: 34% of the survivors who stayed (defend or shelter) indicated that they left their property ‘at some stage during the fire’ (Q60 Did you leave your property at any stage during the fire?). This could indicate that survivors tended to be more active while at their properties.

In terms of intentions on the day, survivors were more likely to have clear intentions. These differences are small and are also subject to important caveats about the different datasets. However, it appears that survivors were more likely to implement their intentions, while those who died generally did not or could not, implement their intentions – apart from those related to sheltering.

The demographic differences found have also been highlighted by earlier work: men were much more likely to die in the 2009 fires consistent with the historical pattern of bushfire fatalities in Australia [18]. Older people were much more vulnerable being at least twice as likely to die as would be expected from the demographic data. This has been shown in earlier work on Black Saturday [13], and is consistent with findings from other comparative research as set out in Section 1. Those with disabilities would be expected to have a substantially higher fatality rate, but there is no strong evidence that this was the case.

Across both fatalities and survivors there was surprise and an absence of official warnings. Although the analysis does not show that this was a risk factor, people are unlikely to activate their plans without warnings or with insufficient time. It was noted in the Royal Commission [33] that many deaths occurred after a wind change late on the day of the fires. Although the change was well forecast, warnings of the change and that large areas would suddenly be engulfed by fire, did not reach many people. The literature on disability and disaster emphasises that warnings are particularly important. Authorities need to ensure that appropriate information is available including timely warnings, and that the more vulnerable, in particular older people, are supported.

There appears to have been a higher level of planning and preparation among survivors. However, any interpretation of this needs to take account of the fact that levels of planning and preparation were also substantial among those who died, that data on plan existence takes no account of plan quality, and that data on both plans and preparedness is problematic. We can say that the absence of preparedness and quality plans is a risk factor in dying.

Much of the analysis reported in this paper has been about staying and defending in that this action was an important part of the community safety policy at the time of Black Saturday. The current approach emphasises leaving early, and there is now research on factors in evacuation (for example, [32]), so it could seem that the analysis is no longer relevant. We suggest that it is relevant: those who intended to leave had relatively low levels of planning and preparation, and vice versa with those intending to stay being generally better prepared. Now the challenge is to have high levels of planning and preparation while intending to leave; and to develop action plans that are flexible and adaptable when faced with changed personal circumstances and extreme fire conditions. Plans need to avoid potentially fatal flaws, in particular to ensure that passive sheltering is avoided.

Conflict of interest

The authors declare that no conflict of interest exists.

Role of funding source

No funders had any involvement with the preparation of this paper. The funders of the original work which produced the data used in the paper, the Victorian Bushfires Royal Commission and the Bushfire Cooperative Research Centre, did not influence the details of the research approach or findings.

Data availability

The data for this study was drawn from published sources freely available on the Bushfire & Natural Hazards CRC website, and in an open source journal paper. For survivors, we used a databook which compiled the results of a mail survey [16]. Data on fatalities was drawn from Handmer et al. [14] and Handmer and O'Neill [13].

Acknowledgements

This paper draws on research undertaken for the Victorian Bushfires Royal Commission through the Bushfire Cooperative Research Centre (CRC) (see [14]). The survey of survivors was funded through the Bushfire CRC as part of the post-Black Saturday Human Dimensions Research Program, co-led by John Handmer and Damien Killalea. Joshua Whittaker acted as fieldwork coordinator. Writing of this paper was partly supported through Saffron O'Neill's ESRC Fellowship (S/K001175/1). Our thoughts are with all those who experienced the Black Saturday fires on which this paper reports.

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