

WHERE, WHY AND HOW ARE AUSTRALIANS DYING IN FLOODS?

ABOUT THIS PROJECT

In order to provide an evidence base for policy and practise, the *Analysis of human fatalities and building losses from natural disasters* project is measuring and gaining a greater understanding of the impacts of natural hazards in terms of the toll of human life, injuries and building damage. Trends over time are being analysed in the context of emerging issues such as an ageing population, population shifts and changing building codes.

AUTHORS

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SUMMARY

This *Hazard Note* documents the analysis of the circumstances surrounding fatalities due to flooding in Australia from 1900 to 2015. The investigation includes exploring the socio-demographic and environmental factors surrounding the deaths. Overall there have been 1,859 fatalities within the 115 years, with distinct trends in relation to gender,



▲ Above: THE HIGHEST PROPORTION OF FLOOD FATALITIES IN AUSTRALIA HAVE OCCURRED WHEN VICTIMS WERE ATTEMPTING TO CROSS FLOODWATERS. PHOTO: COUNTRY FIRE AUTHORITY.

age, activity and reason. The most deaths have occurred in Queensland and New South Wales. The majority of fatalities are male (79%) with children and young adults (<29) making up the greatest proportion of the fatalities.

The data shows a statistically significant decreasing death rate from 1900 to 1960. Although a very slight decrease in death rates is discernible between 1960 and 2015, it is not statistically significant. The female-to-male fatality ratio has increased since 1960, increasing from 16.9% females from 1900-1959 to 28.3% from 1960-2015.

An increase in fatalities associated with motor vehicles is evident in recent decades, and in particular, 75% of all fatalities

associated with 4WD vehicles has been observed in the last 15 years.

Measuring and understanding the impacts of natural hazards in terms of the toll on human life is a fundamental first step to enabling efficient and strategic risk reduction. Outcomes of this research have significantly contributed to the Prevention of Flood Related Fatalities Working Group of the Community Engagement Sub-committee of the Australia and New Zealand Emergency Management Committee with their investigations into preventing flood fatalities. The research will also influence policy, practise, education initiatives and resource allocation across emergency management.

CONTEXT

Fatalities from floods are a major cause of natural hazard deaths around the globe. Here in Australia, floods are ranked second (following heatwaves) in terms of the total number of natural hazard fatalities since 1900 (see Table 1, right). The June 2016 flooding in New South Wales and Tasmania led to a number of deaths and hundreds of rescues, while the September and October 2016 flooding across South Australia and Victoria also resulted in a number of rescues. These recent cases, once again, highlight the significant dangers of floodwaters. This research suggests that many flood deaths are avoidable.

TABLE 1: AUSTRALIA'S TOP FIVE NATURAL HAZARD KILLERS

HAZARD	PERIOD OF COVERAGE	FATALITIES
Extreme heat ¹	1900-2011	4,555
Flood ²	1900-2015	1,859
Tropical cyclone ⁴	1900-2015	1,208
Bushfire ³	1900-2011	825
Wind storm ⁴	1900-2015	495

¹ Coates *et al.*, 2014

² Haynes *et al.*, 2016

³ Blanche *et al.*, 2014

⁴ Recent updates to PerilAUS

BACKGROUND

Despite the significance of flood mortality, both within Australia and worldwide, few studies have explored the trends and characteristics associated with flood fatalities in detail. Within the Australian context a number of questions remained unanswered, including:

- What are the socio-demographics of people who die in floods?
- What were the circumstances, capacities, knowledge and motivations that led to the choices that ended in a fatality?
- What are the spatial and temporal trends within the data?
- What is the relationship between the fatalities and the hazard characteristics?
- Were any of these deaths avoidable?

In order to answer these questions, this study provides a longitudinal and in-depth analysis of the social and environmental circumstances that led to each fatality. The results show clear trends over time in terms of exposure and vulnerability. A scientific approach to the collection and analysis of this information provides governments, emergency service agencies and the wider community with the empirical evidence on which to base effective decision-making.

RESEARCH ACTIVITY

The project was completed in two steps:

1. **Updating the data held within PerilAUS, Risk Frontiers' database of historical natural hazard impacts.**

PerilAUS is a database of impacts and consequences of natural hazards in Australia, largely based on material collected from the media, government departments and published literature. It was deemed a good basis for this project due to the length of period covered, the wealth of descriptive detail concerning the hazard impact and the inclusion of data about any fatalities caused by that hazard. However the database needed to be augmented and verified through the use of coronial inquest reports. This information provided additional and more detailed data about the social, demographic and environmental circumstances of each fatality.

2. **Statistical analysis to determine the lives lost and the environmental and social circumstances surrounding those fatalities.**

The data was analysed in relation to informing the understanding of the circumstances surrounding the deaths and how this information could best be

utilised for emergency management policy and practise. This included a longitudinal analysis of the resulting statistics, examining demographics (age, gender), location (state), seasonality and circumstances surrounding the fatality – both environmental (e.g. the event intensity) and social (e.g. factors around the decisions or actions which led to death).

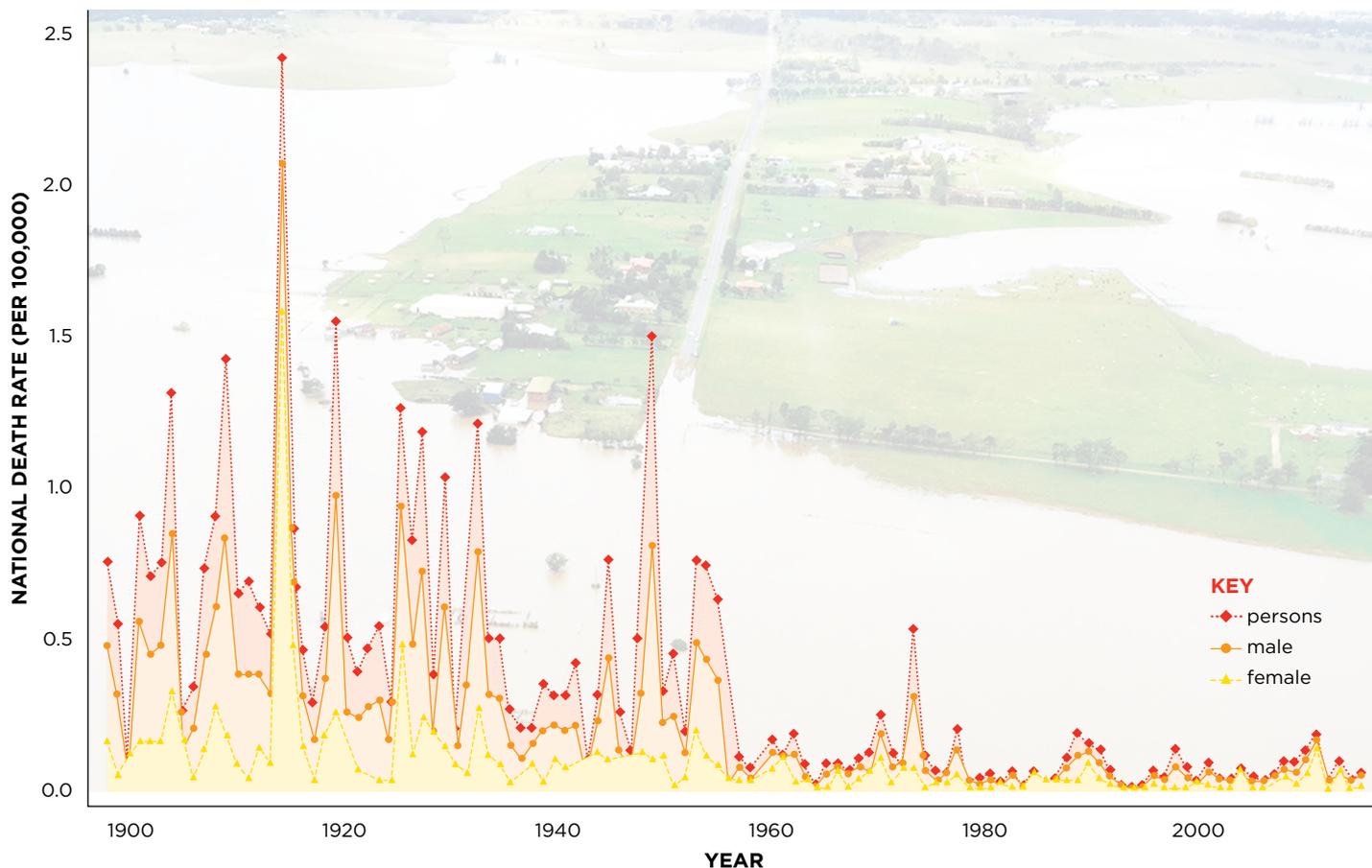
RESEARCH OUTCOMES

Demographics

Overall there have been 1,859 fatalities since 1900, with distinct trends in relation to gender, age, activity and reason. The majority of these deaths occurred in events where one or two people died. The analysis of flood severity against numbers killed per event indicates that the majority of fatalities occurred in minor or moderate floods. The greatest percentage of women died in urban settings in a local flash flood or a low-level short duration flood.

The majority of the fatalities are male (79.3%), with children and young adults (<29) making up the greatest proportion of the fatalities. Overall, flood death rates show an interesting trend (Figure 1, below).

FIGURE 1: DEATH RATES DUE TO FLOOD 1900-2015



**TABLE 2: FLOOD FATALITIES BY ACTIVITY PRIOR TO DEATH AND GENDER, 1960-2015
(% OF COLUMN TOTALS)**

ACTIVITY	MALE FATALITIES	FEMALE FATALITIES	FATALITIES WHERE GENDER UNKNOWN	TOTAL FATALITIES
Attempting to cross bridge/causeway/crossing/culvert/ford/watercourse	183 (46.6%)	80 (55.2%)	2 (25%)	265 (48.5%)
Attempting to cross floodwaters away from watercourses (water over fields/town)	17 (4.3%)	3 (2.1%)	0 (0%)	20 (3.7%)
Engaged in an activity near the water (on the bank/bridge)	32 (8.1%)	11 (7.6%)	0 (8.3%)	43 (7.9%)
Engaged in an activity in/near stormwater drain	21 (5.3%)	9 (6.2%)	0 (0%)	30 (5.5%)
Engaged in an activity in the water (rescue, swimming)	48 (12.2%)	12 (8.3%)	0 (0%)	60 (11%)
Engaged in an activity on the water (boat)	22 (5.6%)	1 (0.7%)	0 (0%)	23 (4.2%)
Engaged in an activity not near usual watercourse (e.g. in their home)	28 (7.1%)	18 (12.6%)	0 (0%)	46 (8.4%)
Other	2 (0.5%)	1 (0.7%)	0 (0%)	3 (0.6%)
Unknown	40 (10.2%)	10 (6.9%)	6 (66.7%)	56 (10.3%)
Total	393 (100%)	145 (100%)	8 (100%)	546 (100%)

Between 1900 and 1959 there is a significant decrease in flood fatality rate (slope = -0.05449, $p < 0.02$). This means the fatality rate was decreasing by 0.055 deaths per million in the population per year. In contrast, from 1960-2015 the fatality rate has been decreasing by 0.00645 per million in the population per year. However, this decrease in flood fatality rate is not statistically significant. It is likely that investments in flood mitigation, technology, warning and communication systems, and the work of emergency service organisations such as the State Emergency Service, have had a major impact on death rates, particularly in the years following World War II. However, the negligible decrease in flood fatalities since the 1960s raises questions about the efficacy of current risk mitigation and education strategies. With all the work in this area, should the death rate have decreased further? It may even be possible that structural mitigation, such as levees, have actually increased risks – as development continues people may assume they are protected and as such do not prepare or evacuate in time. Furthermore, the significantly different proportion of female-to-male fatalities suggests that a gendered approach to risk education and warnings is necessary.

Given the differences in the way of life, and the trends seen in the data since 1960,

a detailed exploration of this data will be provided below. There have been 546 fatalities since 1960; similar to the overall dataset the majority are male (72.2%, $n=394$), with children and young adults (<29) making up the greatest proportion (44.5%, $n=243$).

Geographic and seasonal trends

The highest numbers of fatalities since 1960 have occurred in Queensland and NSW, with the toll in these two states accounting for 76.7% of the fatalities during this period across the nation. However, the death rates per capita highlight the increased level of risk in the Northern Territory, where the fatality rate per capita since 1960 has been five times as great as NSW and more than three times as great as Queensland. A seasonal breakdown of deaths by states and territories shows that the majority of fatalities in Queensland, NSW and the NT occurred during summer (the monsoon season in Queensland and the NT, while NSW is often subject to intense downpours), predominantly in December to March. There is also a fairly high proportion of deaths in NSW in June to August that are associated with winter storms. In contrast, deaths in the other states are more evenly distributed throughout the year.

A spatial analysis of fatalities between 2000 and 2015 found that 58% of people died within 20 kilometres of their home.

END USER STATEMENT

Flood fatalities and rescues, as a consequence of risky behaviour, are a constant issue for emergency services. Hundreds of flood rescues were conducted during the September and October 2016 South Australian and Victorian floods, the June 2016 floods in NSW and Tasmania and the April 2015 floods in NSW and Queensland. Many rescues involved motorists trapped in or on their cars. Unfortunately, these floods also resulted in a number of deaths.

This study has highlighted the significant number of fatalities that have occurred as a consequence of flooding compared to other hazards, particularly as a result of driving through floodwater.

Outputs to date have provided significant input to the national Attorney-General's Department-funded project within the Australia and New Zealand Emergency Management Committee, looking at the way forward within government policy and practise to reduce the number of flood fatalities. The project has also assisted the understanding within emergency services of the causal factors of flood fatalities, along with internal awareness within NSW SES.

- Dr Elspeth Rae, Planning and Research Officer, NSW State Emergency Service

Activities and motivations

Information on activities at the time of death and the motivations for these were obtained from coronial inquest reports, particularly witness statements. Results are presented in Table 2 (page 3). The highest proportion of fatalities occurred while victims attempted to cross a bridge, causeway, culvert, or road (men: 46.6%, n=183; women: 55.2%, n=80). The most common intended destination of those who died was their home. The second highest activity for females at the time of death, accounting for 12.6% of all female fatalities, was being engaged in an activity not near a usual watercourse, for example, driving through a town or near their home and being

surprised by flash flooding. For men this was the fourth highest cause of death (7.1%).

Engaging in activity in the water (e.g. attempting a rescue, swimming etc), was the second highest for males and the third highest for females, accounting for 12.2% and 8.3% of fatalities respectively. Engaging in an activity near the water was the third highest action resulting in a fatality for men (8.1%) and the fourth for women (7.6%). The majority of these victims who were in or near the water at the time of their death were recreating, with children and young people (<19 years) accounting for the greatest proportion of these fatalities. A significant cause of these deaths was children playing in or near stormwater drains.

FURTHER READING

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Haynes K, Handmer J, McAneney K, Tibbitts A, Coates L (2010), Australian bushfire fatalities 1900-2008: Exploring trends in relation to the 'prepare, stay and defend or leave early' policy, *Environmental Science and Policy*, **13**(3), 185-194.

Capacity to act

Analysis of flood fatalities since 1960 suggests that the majority of victims were capable of independent action (55.5%) and aware of the flood (60.8%). However, the speed and/or depth took them by surprise, reducing the victim's capacity to act.

Higher proportions of deaths occurred amongst two clear demographic groups - children and women who were following the decisions of others, and children and youths who were on their own or in a group. Of this latter group, the majority were boys.

Car-related fatalities

The numbers of fatalities on foot have remained steady since 1960 and this remains a high proportion of flood-related fatalities (25.3% of all fatalities since 1960). However, fatalities associated with vehicles make up the greatest proportion, accounting for 41.9% of fatalities since 1960 (n=229). In particular, fatalities associated with 4WD vehicles have increased steeply over the last two decades (75% of 4WD deaths have occurred since 2000). The vast majority of those driving a motorised vehicle were men (81.1%), while the gender breakdown of passengers shows that 53.4% were female and 46.6% were male. A fairly large proportion of the fatalities among children and youth are associated with vehicles (34.1%), the majority of whom were passengers. Where the time of death was known, the majority of all those in a vehicle perished at night or during twilight (63.4%), when visibility was poor.

RESEARCH IMPACT

The results of this research have significantly contributed to the Prevention of Flood Related Fatalities Working Group of the Community Engagement Sub-committee of the Australia and New Zealand Emergency Management Committee with their investigations into preventing flood fatalities. This report was prepared by the NSW State Emergency Service, with a working group comprised of policy makers, practitioners and researchers involved in flood risk management from Australia and New Zealand. In addition, the NSW SES has used the findings of the research for community outreach, internal awareness raising and training purposes.

The research received a high commendation award at the 2016 Floodplain Management Australia conference. The award was given to highlight excellence in terms of the quality of the research, its utility for end-users and the interactive presentation delivery.

FUTURE DIRECTIONS

There has been limited research to date that rigorously evaluates the efficacy of existing education, incentives and structural measures (e.g. the use of barricades to prevent a car being washed off a road) in reducing loss of life in floods. In order to prevent life loss and ensure efforts are targeted effectively this needs to be addressed. In relation to the findings of this project and in discussion with end-users, particularly the NSW SES, the following research priority areas are highlighted:

- Evaluate messaging and terminology used with different socio-demographic groups - women, men and children;
- Evaluate the efficacy of education, incentives and enforcement of new laws relating to floods;
- Evaluate signage options and smart technology for warning people about flood waters and dangers well ahead;
- Better understand the decision-making processes of those who do and do not drive through floodwaters;
- Investigate the behaviour of people in vehicles, and in particular, how passengers can be educated and empowered to influence driver behaviour.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

Hazard Notes are prepared from available research at the time of publication to encourage discussion and debate. The contents of *Hazard Notes* do not necessarily represent the views, policies, practices or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire and Natural Hazards CRC.

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