A 10 YEAR NATIONAL REVIEW OF LAKE, DAM AND LAGOON DROWNING DEATHS

2008/2009 to 2017/2018

ROYAL LIFE SAVING AUSTRALIA

Australian Government

ABOUT ROYAL LIFE SAVING

Royal Life Saving is focused on reducing drowning and promoting healthy, active and skilled communities through innovative, reliable, evidence based advocacy; strong and effective partnerships; quality programs, products and services; underpinned by a cohesive and sustainable national organisation.

Royal Life Saving is a public benevolent institution (PBI) dedicated to reducing drowning and turning everyday people into everyday community lifesavers. We achieve this through: advocacy, education, training, health promotion, aquatic risk management, community development, research, sport, leadership, participation and international networks.

Printed copies of this document are available upon request. Please contact:
PO Box 558 Broadway
NSW 2007 Australia
Phone: 02 8217 3111
Email: info@rlssa.org.au

Royal Life Saving Society – Australia
The drowning prevention research of Royal Life Saving Society – Australia is proudly supported by the Australian Government.

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CONTENTS

255

PEOPLE DROWNED IN A LAKE, DAM OR LAGOON IN AUSTRALIA

1 JULY 2008 - 30 JUNE 2018

Sex

87%

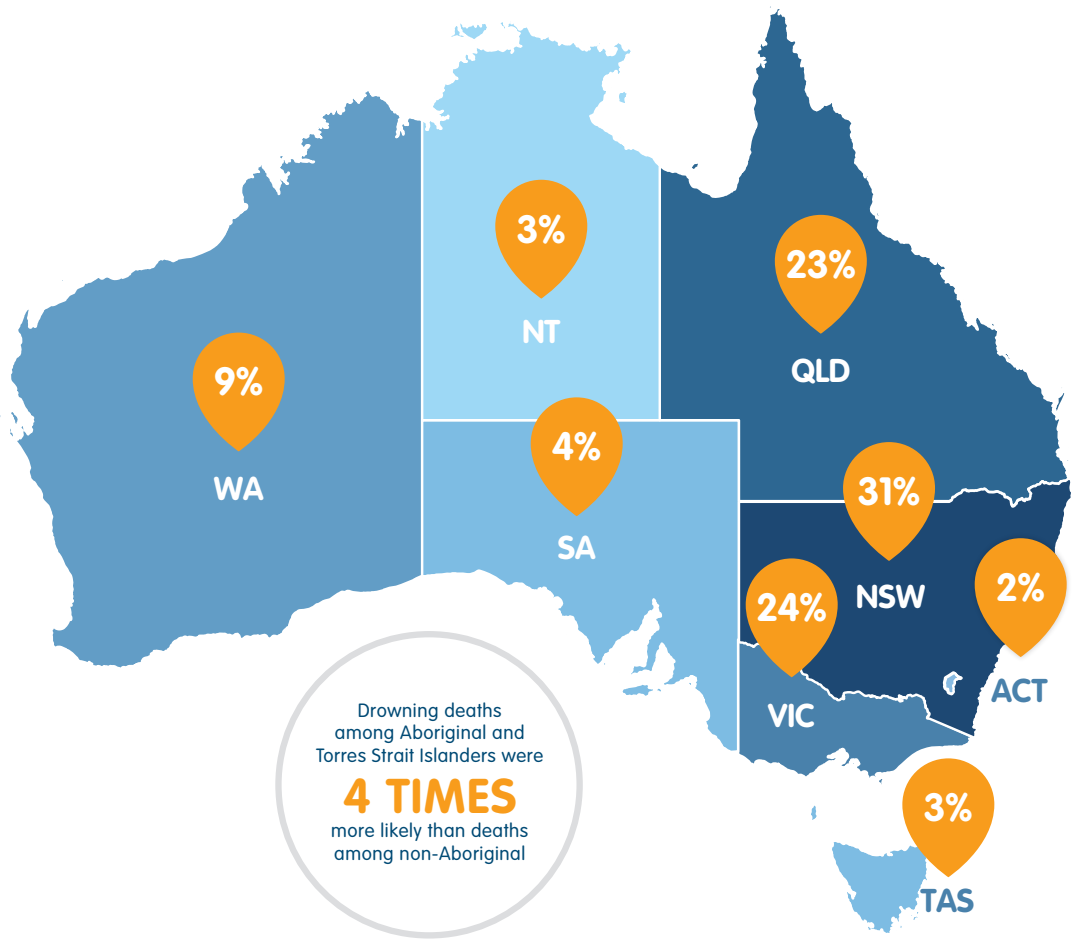
13%

Age

25-34 YEARS 15%

45-54 YEARS 12%

State and Territory breakdown

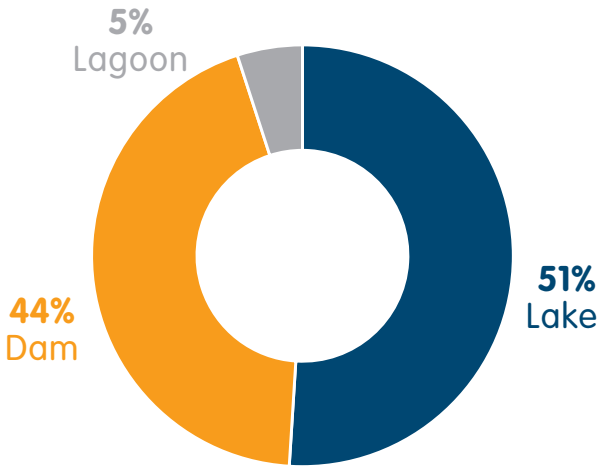


Drowning deaths among Aboriginal and Torres Strait Islanders were

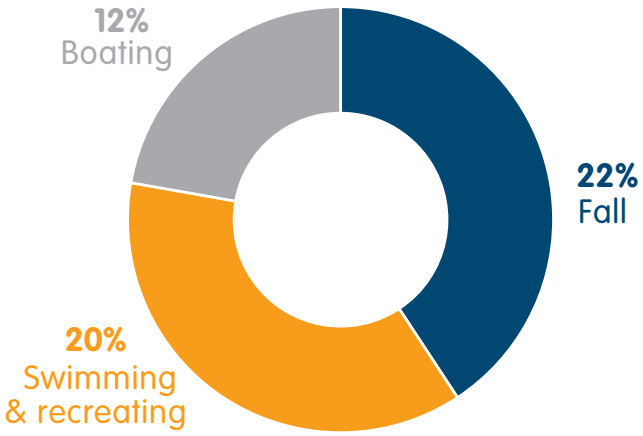
4 TIMES

more likely than deaths among non-Aboriginal

Location



Activity



Circumstances

24%
Of the time CPR was administered

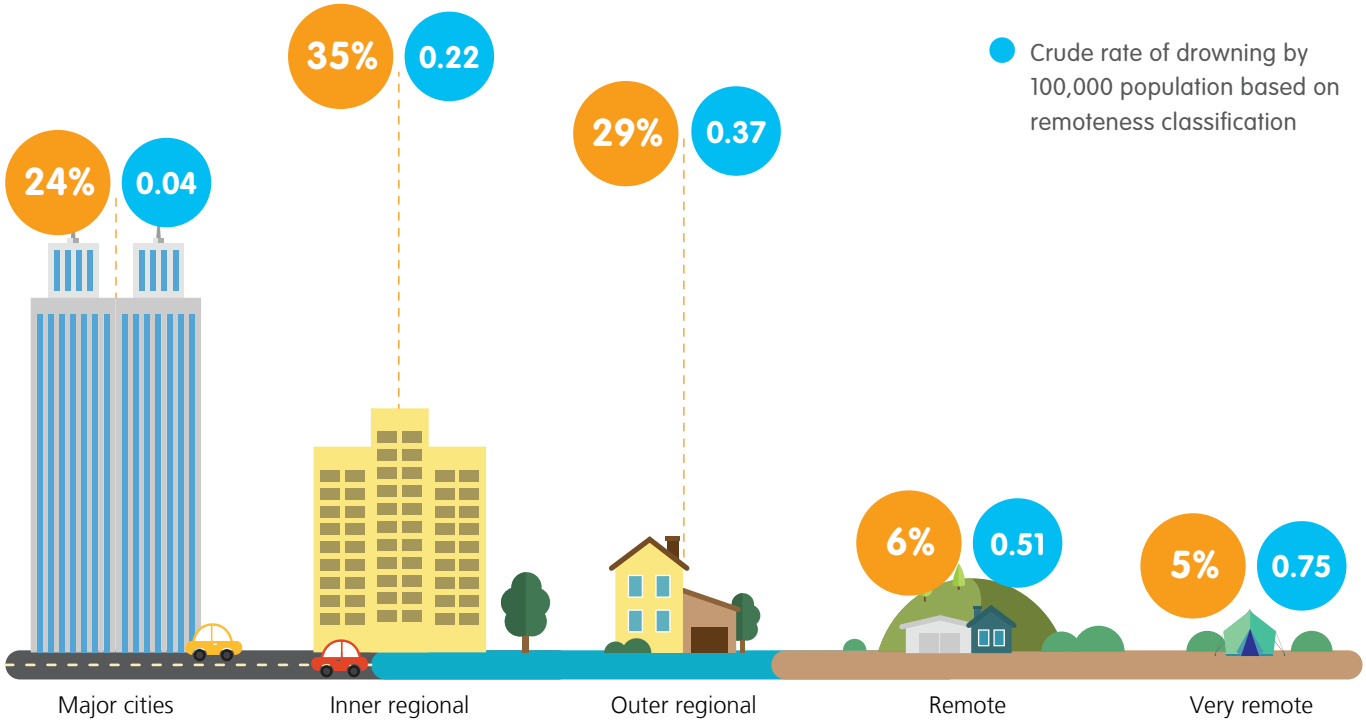
42%
Were alone at the time of drowning

36%
Visibility of the person was lost during the incident

84%
Of drowning deaths resulted in a search for the person

Remoteness of drowning location

Drowning in a lake, dam or lagoon in very remote locations was 18x times more likely than major cities



KEY FACTS

Over the past ten years (1st July 2008 to 30 June 2018):

- 255 people drowned in in lakes, dams and lagoons, accounting for 9% of total drowning deaths in Australia.
- 51% occurred in a lake, 44% in a dam and 5% in a lagoon.
- Males accounted for 87%, females 13%.
- The leading age groups were of people aged 24 - 34 years (15%), followed by 45 - 54 years (12%).
- The highest crude drowning rate recorded was in the 0 - 4 years age group (0.18/ 100,000 population), followed by the 75 years and over age group (0.17/ 100,000 population).
- Aboriginal and Torres Strait Islander people were overrepresented in the drowning statistics.
- People born overseas accounted for 22% total drowning deaths.
- 29% of people who drowned in lakes, dams and lagoons were known to have resided in areas of low socioeconomic advantage.
- 27% of people who drowned in lakes, dams and lagoons were employed and 18% were retired.
- The highest number occurred in NSW (N=79, 31%), followed by Victoria (N=61, 24%) and Queensland (N=58, 23%).
- The Northern Territory recorded the highest crude drowning rate of 0.41 deaths/100,000 population.
- Over half (54%) of all dam drowning deaths took place on private or a residential piece of land.
- 59% of drowning deaths occurred in major cities and inner regional areas, and 11% occurred in remote or very remote locations.
- As rurality increased, so did the crude drowning rate, with remote and very remote recording a rate of 0.51/100,000 and 0.75/100,000.
- 36% of drowning deaths occurred in summer and 22% occurred in spring.
- Drowning deaths in dams were more common in autumn and winter, whereas drowning in lakes and lagoons occurred most frequently in summer.
- Over half (53%) of all drowning deaths occurred on a Friday, Saturday or Sunday.
- Falls were the most common activity prior to drowning (22%), followed by swimming and recreating (20%) and boating (12%).
- For males, the most common activities were swimming and recreating (21%), and a fall (20%).
- For females, the most common activities were a fall (33%), and swimming and recreating (18%).
- In lakes, the most common activities prior to drowning were swimming and recreating (27%) and boating (19%).
- In dams, the most common activities prior to drowning was a fall (37%), and non-aquatic transport (14%).
- Alcohol was known to be involved in 31% of drowning deaths.
- 74% of alcohol-related cases recorded a BAC ≥0.05%.
- 92% of alcohol-related deaths were male.
- The 18 - 24 years age group accounted for the highest proportion of drowning deaths involving alcohol (21%).

- 56% of all Aboriginal and Torres Strait Islander cases reported a positive alcohol reading, compared to 28% of non-Indigenous cases.
- Northern Territory recorded the highest proportion of alcohol-related drowning deaths (78%), followed by the ACT (50%).
- Drugs were known to be present in 32% of drowning deaths.
- 45% were known to involve illicit drugs, males accounted for all of these drowning deaths.
- The most commonly detected illicit drug was cannabis.
- 11% of all lake, dam and lagoon drowning deaths were known to involve both drugs and alcohol.
- 96 people (38%) were found to have a pre-existing medical condition.
- People aged 65- 74 years were most likely to record a pre-existing medical condition (79%).
- 12% of all people participating in watercraft and boating activities were known to be wearing a lifejacket.
- Of known swimming ability, 71% of cases were recorded as poor or non-swimmers.
- 2% of all lake, dam and lagoon drowning deaths were known to be flood-related.
- 4% of drowning deaths were known to be multiple fatality events.
- In 24% of cases, CPR was administered.
- The person was known to be alone at the time of drowning in 42% of cases.
- In 107 drowning deaths, the person was known to be with others at the time of the incident, of which, 92 deaths resulted in a loss of visibility of the person in the water.
- 84% of drowning deaths recorded in lakes, dams and lagoons resulted in a search for the person.

An overview of drowning deaths in lakes, dams and lagoons compared to rivers, creeks and streams compared over the same time period:

- More children aged 0 - 17 years drowned in lakes, dams, lagoons (21% vs. 9%).
- More drowning deaths occurred in the morning in lakes, dams, lagoons, whereas a higher proportion of drowning deaths in rivers, creek and streams occurred in the evening.
- A higher proportion of drowning deaths in lakes, dams, lagoons occurred in inner regional and very remote locations.
- A higher proportion of drowning deaths due to boating and swimming and recreating in lakes, dams and lagoons.
- Drowning deaths associated with non-aquatic transport were more common in rivers, creeks and streams.
- A higher proportion of drowning deaths in rivers, creeks and streams involved alcohol.

EXECUTIVE SUMMARY

Background

Swimming and aquatic recreation activities have become synonymous with the Australian identity. Given Australia's vast landscape and the remote nature of a large portion of the Australian population, inland waterways such as rivers, creeks and streams, lakes, dams and lagoons have become common areas for recreation. Recreational uses of these areas varies greatly from swimming and recreating, and boating, to enjoying picnics and fishing.

Engaging with these natural aquatic environments can increase the risk of drowning due to the changeable conditions and added factors such as geographical remoteness, unsupervised children and alcohol consumption. Over the last ten years, Australia has recorded consistently high numbers of drowning deaths in inland waterway locations. Consequently, the Australian Water Safety Strategy identified inland waterways as a priority area for reducing drowning deaths, under goal five.

Over the ten year period of this study inland waterways accounted for 35.5% of all drowning deaths, the single most common location for drowning deaths in Australia. Drowning deaths in rivers, creeks and streams have previously been examined in detail, therefore this report focuses on the drowning deaths that have occurred in lakes, dams and lagoons over this period.

Methods

All unintentional, drowning deaths in Australian waterways classified as a lake, dam or lagoon between 1 July 2008 and 30 June 2018 were included. For the purposes of this report, the following definitions have been used:

Lake

A lake is typically a large body of water within a body of land, separated from the ocean. The term "lake" or "pond" as part of a water body name is arbitrary and not based on any specific naming convention, but for lakes is usually restricted to those water bodies greater than one meter deep when full. In general, lakes tend to be larger and/or deeper than ponds. A lake, by contrast to a pond, has an "aphotic zone," meaning there is an area deep enough that sunlight can't reach the bottom.

Dam

A dam is defined as a barrier constructed for the retention of water, water containing other substances, fluid waste or tailing. The barrier stops or restricts the flow of water or underground streams.

Lagoon

A shallow body of water separated from a larger body of water by a barrier (such as islands or reefs) connected, at least intermittently to the larger body of water, by one or more restricted inlets.

The information for this report has been drawn from the Royal Life Saving National Fatal Drowning Database, and cross-checked against the National Coronial Information System (NCIS), Royal Life Saving State/Territory offices and media reports. This report contains information correct as at 29 January 2019. As of this date, 85.5% of cases analysed were closed (i.e. no longer under coronial investigation).

Results and discussion

Between 1 July 2008 and 30 June 2018 (a period of ten financial years), 255 people drowned in a lake, dam or lagoon in Australia. This represents 8.9% of all drowning deaths in Australia during this period with a crude drowning rate of 0.11/100,000 population. The highest number of deaths occurred at lakes (51.0%), followed by dams (43.9%) and lagoons (5.1%).

Males were significantly overrepresented in the data, accounting for 87.1% of all lake, dam and lagoon drowning deaths. The largest number of drowning deaths occurred among those aged 25-34 years (15.4%), followed by those aged 45-54 years (12.2%). A total of 26 drowning deaths in lakes, dams and lagoons were of children aged 0 - 4 years. This represented 10.2% of the total drowning deaths in this study.

New South Wales (NSW) recorded the highest proportion of drowning deaths (31.0%), followed by Victoria (23.5%). The distribution of lake, dam and lagoon drowning deaths was fairly uniform across all States/Territories with the majority of deaths occurring in lakes. Queensland was the exception where dams represented 65.5% of the drowning deaths compared to lakes and lagoons, 29.3% and 5.2% respectively.

Of the drowning deaths, 59.7% occurred in major cities or inner regional areas, and 11.5% occurred in remote or very remote locations. When the crude death rate was applied to the population a positive correlation was seen between remoteness and number of drowning deaths. As rurality increases, so did the crude death rate of drowning deaths in lakes, dams and lagoons. Remote and very remote locations had a crude death rate 12.7 times (0.51/100,000) and 18.7 times (0.75/100,000) greater than that of major cities (0.04/100,000 population).

When examining drowning deaths by ethnicity, more than half of those who drowned in the location were born in Australia (52.9%), with 22.4% born overseas, country of birth was unknown in 25.1% of cases. The most common countries of birth represented were New Zealand (12.3% of the overseas born deaths), England (8.8%), followed by Germany and Italy (7.0% each). The crude drowning rate for international born individuals was 0.09/ 100,000 population compared to the Australian born crude death rate of 0.08. Each location was not equally distributed in causation to the international born crude drowning rate. The lake location had an international born crude drowning death rate of 0.05/100,000 population compared to the dam location of 0.03 and lagoon location of 0.01/100,000 population of international born residents. From the crude rates, along with the total figures displayed, it can be understood that dam locations were not as heavily impacted by ethnicity compared to lakes.

Seven percent (7.1%) of the drowning victims identified as Aboriginal or Torres Strait Islander. The crude drowning death rate was 0.28/100,000 Aboriginal and Torres Strait Islander population, four times greater than non-Indigenous Australians with a crude drowning death rate of 0.07/100,000 non-Indigenous population.

A diverse range of activities were being undertaken immediately prior to death at lakes, dams and lagoons. A fall into water accounted for one-fifth (21.7%) of deaths, followed by swimming and recreating (20.4%), and boating (11.8%).

Drowning deaths occurred all year round, with the highest proportion occurring in summer (36.5%), followed by spring (22.8%) and winter (20.8%). When broken down into individual lake, dam and lagoon categories, there was variance between seasonal distributions. Lagoons featured more highly in the cooler months, while drowning in lakes and dams was more common during the warmer months. More people drowned on weekends than weekdays, 22.0% occurred on a Sunday, and 15.3% on a Saturday. The most common time of drowning across all three locations was in the afternoon (12:01pm and 6pm), with almost half (47.8%) of deaths occurring in this time band.

Alcohol was recorded in 30.6% of all fatal drowning deaths in this study. The recorded toxicology levels ranged from 0.0 g/L to 0.4 g/L. A blood alcohol concentration (BAC) equal or greater than 0.05g/L (the legal limit for operating a motor vehicle) was deemed to be a contributory factor in a drowning death. In 74.0% of cases where alcohol was known to be involved, alcohol was deemed to be a contributory factor to drowning.

This distribution was consistently seen across all three locations, 77.8% of all alcohol-related cases in lakes, 69.0% of alcohol-related cases in dams and 75.0% in lagoons recorded BAC ≥0.05g/L.

When examining the contribution of pharmaceutical substances (both legal and illicit drugs), 82 cases (32.2%) recorded a positive reading for drugs, of which 44.0% contained an illicit drug (either illicit drugs, non-therapeutic levels of a licit drug or a combination of illicit and therapeutic drugs). The distribution was fairly uniform across all three locations in this study. There were 27 cases (10.6%) known to involve both drugs and alcohol. Of these cases, 55.6% involved illicit substances.

This study found that 96 cases (37.6%) were recorded to have some type of pre-existing medical condition. Commonly occurring types of pre-existing medical conditions included: cardiovascular conditions such ischemic heart disease and arrhythmias, neurological conditions such as epilepsy, neurodegenerative and cognitive conditions such as dementia and Alzheimer's and the consequences of alcoholism. This was very consistent across all three inland waterways.

When analysed by activity, 12.0% of people participating in boating and watercraft activity were known to be wearing a lifejacket. The dam location has a lower response of unknown lifejacket users and a higher response of no life jacket use. From these results, activities being undertaken at a lake (such as watercraft and boating) are more likely to be wearing a lifejacket than the same activities being undertaken at a dam.

Swimming ability was recorded in only 31.0% of the cases. Of those, 70.9% were considered a non-swimmer or a poor swimmer. The distribution of swimming ability was consistent across all three locations, with non-swimmers and poor swimmers heavily recorded in the data.

From analysis of the fatal drowning cases in all lakes, dams and lagoons, apart from the identified risk factors, there were several other factors that either influenced the occurrence of the drowning deaths or influenced the outcome of the drowning deaths.

A total of five drowning deaths known to be flood related (2.0%). It should be mentioned there was a very high prevalence of drowning deaths during 2009-2010 period, which recorded levels of flooding across much of NSW and Queensland. It is possible that the deaths during this time were not directly due to the flood activity, however the flood itself led to the filling of lakes or dams that were previously dry, increasing access and drowning risk. This was not captured in the data due to coding definitions. No information was available at the time of this study to examine the impact that flood and/or drought played on the incidence and prevalence of lake, dam and lagoon drowning deaths. This should be highlighted as an area for further research and investigation.

In this study, 4.3% of cases were multiple fatalities where more than one person drowned during the same event. Multiple fatality events most frequently occurred when swimming and recreating (36.4%) or boating (27.3%).

Over one quarter (29.0%) of those who drowned in the study were known to reside in areas of high socioeconomic disadvantage. Drowning deaths that occurred in dams recorded the highest proportion of low socioeconomic disadvantage (31.3%), compared to lakes (27.7%) and lagoons (23.1%).

Dams were the only location to record work-related drowning deaths. Work-related drowning occurred in 32.2% of dam drowning deaths. Private or residential dams had a significantly larger proportion of work-related drowning deaths than public access dams, 43.3% compared to 10.0% respectively (of cases where status of the dam was able to be determined). This could be associated with the main activities being undertaken at these different locations. From all work-related drowning deaths, 65.5% took place on an agricultural property. By examining only the private or residential dams, 85.7% of all work-related deaths were based in the agricultural industry. Of the work-related deaths at the dam location, 59.3% of work-related drowning deaths occurred when the person was working alone.

Cardio Pulmonary Resuscitation (CPR) was delivered in 61 cases (23.9%) occurring in lakes, dams and lagoons during the study period. In 107 drowning deaths the victim was known to be with others during the event. Of these cases, 92 deaths resulted in lost visibility of the person in the water during the event (86.0%). Lost visibility was also seen to impact CPR attempted administration rates, with CPR administered in only 43.5% of cases (compared to 100% of cases where visibility of the person was not impacted). From the 92 deaths that experienced losing visibility of the person (often due to water quality), 95.7% ended with a search for the victim's body. In total, 84.2% of all lake, dam and lagoon drowning deaths involved a search for the body (or body retrieval).

Conclusion

Previous studies have highlighted the sustained high numbers of drowning deaths recorded in rivers across Australia, with limited investigation into other inland waterways. This report demonstrates that over the past ten years, a similar sustained trend can be seen in lakes, dams and lagoons. Further effort is needed to reduce drowning statistics at these locations and provide awareness to relevant communities to increase understanding of the risks of drowning associated with activities in these aquatic locations.

Differentiating between drowning deaths in rivers, and lakes, dams and lagoons is an important hurdle in the prevention process. While the locations share many similarities, there are common trends unique to the individual setting of a lake, dam or lagoon, especially emerging trends between private/residential water bodies in comparison to public access water bodies. Further investigation differentiating between inland environments would be warranted.

This research highlights the need for a holistic, multi-strategy approach to drowning prevention in inland waterways, with specific recommendations based on the variation in drowning age and activity across the different locations. Children aged 0 - 4 years and older Australians (65 years and over) were overrepresented in most locations, as were males aged 18 - 34 years in the lake environment.

The cases examined in this study aimed to identify patterns of behaviour by both adults and children that contribute to drowning deaths unique to lakes, dams and lagoons. Drowning prevention measures in these locations, especially those in remote areas, need to go beyond the realm of usual drowning advocacy strategies. The results of this study highlight the issue of visibility in a drowning incident in these locations, and support the implementation of strategies such as the promotion of child safe play areas and targeted public awareness campaigns for these unique aquatic environments.

It is important to appreciate the complex socioeconomic and demographic factors in rural and remote areas, and the challenges faced translating these into effective preventative actions like learn to swim programs, community education programs, or policy documents.

There is unfortunately no single strategy that will prevent all rural and remote drowning deaths in these environments, therefore a wide variety of strategies targeting a range of age groups, aquatic locations, and activities will be required to reduce drowning deaths in this marginalised high-risk population.

SPECIFICALLY, THIS STUDY HIGHLIGHTS

- An increased risk at dams on agricultural farm locations
- Supervision of children and the need for child safe play areas for children on rural properties with access to inland waterways
- Need and importance of CPR training to improve drowning outcomes, particularly in remote locations
- A heightened risk of drowning in regional and remote areas, highlighting the need for strategies such as modern telecommunications and skilled telephone triage training for emergency service providers
- The lack of swimming ability and the need for swimming and water safety programs in regional and remote locations
- The need to raise awareness within the Agricultural industry to the risk of drowning on rural properties, specifically with dam locations

RECOMMENDATIONS

Our experience of successful injury prevention strategies indicates that a reduction in burden is best achieved through specific targeted interventions using the four-portal approach of education, improved design (e.g. of environments, safety barriers and safety equipment), legislation and rescue and resuscitation. Although lakes, dams and lagoons, all have some interconnecting overarching risk factors, a successful prevention strategy will need to incorporate specific strategies unique to each location.

While approaches to prevention are transferable, specific prevention strategies and measures should be tailored for specific types of exposure. In general, most children drown in or around the home. This risk is amplified if the "home" environment includes large bodies of water, such as agricultural dams, or backing onto natural lakes. Rural locations in Australia are comparable to low-income countries when considering the risk of drowning in this respect. Drowning prevention measures in rural areas of Australia need to go beyond the realm of current advocacy strategies for success.

From the study the following recommendations have been made:

Policy

- Greater engagement between RLSSA, National Coronial Information System (NCIS), State/Territory Coronial Offices and State/Territory Police to enhance collection, entering, and reporting of data including:
  - the toxicological profile, pre-existing medical conditions, swimming ability, country of birth and time in country.
- Partnerships between governments, communities, industry, private sector bodies and public health agencies should be created to address drowning in the lake, dam and lagoon environment. While the type of strategies to prevent drowning in the three locations may vary, cooperative efforts at every level are essential.
- An agenda to address drowning in lake, dam and lagoon environments, with targets appropriate to the local situation, should be set up by every State/Territory. Due to the high sustained rates of drowning fatalities, the main focus needs to be on primary prevention strategies addressing contributing factors such as:
  - Work-related activity on rural properties with inland waterways
  - Reasons for fall (e.g. lack of supervision or medical condition)
  - Environmental risk factors
- Investigation into the regulations around the placement of life buoys and other public rescue equipment at lake, dam and lagoon recreational areas. This could be expanded to include regulations regarding the placement of life saving devices on rural farms where a dam exceeds a certain size (for example, defibrillator access or rescue equipment similar to the Royal Flying Doctors medical chest program).
- Mandatory fencing and warning signs should be considered in public access lake, dam and lagoon environments, especially those that have parks/play gyms located near water.

Research Agenda

- To enable the comparison of data and the sharing of experiences and intervention strategies more effectively between inland waterway locations, the following will need to be achieved:
  - the collection of consistent epidemiological data
  - the use of standard definitions relating to the lake, dam and lagoon environment
  - improved coding of drowning such inland waterways.
- Further research to examine the effectiveness of drowning prevention measures is required, such as providing instruction in swimming and survival skills, and CPR.
  - The design and evaluation of interventions in specific settings (lake, dam or lagoon) will need to be a focus of ongoing research to establish a change effect.
- Utilise the findings on geographical location of public access areas with drowning deaths to partner with local council authorities to design, implement and evaluate effective, locally targeted drowning prevention strategies for these areas.
- Investigate the coronial recommendations associated with drowning deaths in lakes, dams and lagoons to identify common themes and potential additional strategies for reduction.
- Explore the benefits of conducting qualitative research with males aged 15 - 34 years regarding recreational activities undertaken in lakes, dams and lagoons, and attitudes towards risky behaviours such as consuming alcohol and drugs, and comparison made to the known situations in river locations.
- Explore the benefits of conducting qualitative research with children aged 1 - 4 years regarding drowning incidence in rural agricultural dam locations, and attitudes towards risky behaviours by both the adult and child.
- Conduct situational and geographical analysis of lake, dam and lagoon drowning black spot environments nationally, comparing those from residential or private properties, to those with public access used for recreating. This analysis would collect data on hazards and risk assessment, and enhance understanding of usage and recreational patterns at known drowning black spots. This model for environmental audits should be piloted at a State/Territory level before utilising the findings to expand nationally.
- Action is required around research and delivery of targeted prevention strategies in rural areas, with drowning prevention strategies tailored to specific age groups in rural areas. Utilisation of current resources in these rural and remote communities is vital, for both the sustainability of programs and buy-in from local residents.

Programs and Advocacy

General

- Develop, implement and evaluate public education strategies to enhance understanding of the legislative requirements and risks associated with operating watercraft whilst under the influence of alcohol.
- Consider a collaborative approach with State/Territory police and maritime agencies to enhance awareness of the rules around operating watercraft, the risks associated with consuming alcohol when operating or travelling on watercraft and encourage increased enforcement through breath testing in public access recreating environments.
- Enhance public education strategies that highlight the risks of consuming alcohol and undertaking aquatic activity in or recreating alongside lakes, dams and lagoons. These strategies should primarily be aimed at males and target those aged 18 - 34 years.
- Explore strategies to:
  - strengthen first responder skills,
  - mitigate the loss of visibility by never swimming alone or wearing high visibility clothing
  - decrease the search time for victims
  - increase the administration rates of effective CPR and first aid, particularly in areas deemed remote and very remote.
- Proven interventions should be implemented in the lake, dam and lagoon environment, where their relevance has been demonstrated in other similar water bodies, such as the elimination of water hazards, the creation of barriers between children and hazards, and the use of personal flotation devices by children.
- Immediate resuscitation, prior to the arrival of emergency service personnel, should be promoted regardless of location. Such resuscitation significantly increases the likelihood of a good outcome – irrespective of age, sex, and duration of submersion or the presence of hypothermia. Education into the apparent neuroprotective effect of hypothermia and the value of prolonged resuscitation in children should be promoted publically.
- Public education campaigns should focus on family education around drowning risks and the need for passive protection around lake, dam and lagoon water sources. These campaigns should assist in developing a culture of water safety as a community, highlighting the benefits of using personal flotation devices and avoiding alcohol while undertaking aquatic activity. Education around the co-existence of swimmers, water skiers and other recreational watercraft users, is also vital in these natural lake, dam and lagoon environments. Targeting and engagement by local government will be essential for success.
- Advocate the value of learning swimming and water safety skills, and knowledge for drowning prevention among all Australians.

The Lake and Lagoon Location

- Prevention strategies for the lake environment need to encompass not only the local constituents but the tourist population who frequent the location, including international visitors. Language barriers, different cultural attitudes to water safety and an increase in risk-taking behaviour by visitors in unfamiliar locations need to be taken into account in prevention measures.
- Accommodation providers that have access to lakes/lagoons should consider supplying guests with water safety information.
- The same accommodation providers should install clear safety signage, emergency phones and defibrillators, and consider ways to restrict intoxicated people utilising the aquatic environment (as per relevant industry guidelines).

The Dam Location

- An expansion of the Keep Watch at the Farm campaign should be investigated to include prevention measures for adults, especially work-related drowning deaths. Partnership with existing advocacy agents, such as Better Internet for Rural, Regional and Remote Australia (BIRRR) should be investigated. Poor telecommunication and mobile network coverage needs to be improved in the rural locations and skilled telephone triage training for emergency service providers to these rural residents is also vital. Training of skilled over-the-phone service providers is only beneficial if the locations where the drowning deaths occur have access to telecommunication services.

Regional and Remote Locations

- Delivery of educational material could prove difficult in rural and remote locations with the target age group under five years of age. These children do not regularly attend school, nor are they usually present in day care centres due to distance. Partnerships with rural community groups (such as the Australian Campdraft Association) and local councils could provide a useful means of delivery for these isolated families. Finding organisations that bring together or aid in delivery of the message is vital for this population.
- The Isolated Parents and Children Association and the Royal Flying Doctors could also provide valuable assistance in the advocacy and delivery of programs.
- It is important to appreciate the complex socioeconomic and demographic factors in rural and remote areas, and the challenges faced translating these into effective preventative actions e.g. learn to swim programs, community education programs, or policy documents.
- There is no one strategy that will prevent all rural and remote drowning deaths in the lake, dam or lagoon environment, therefore a wide variety of strategies targeting a range of age groups, aquatic locations, and activities will be required to reduce drowning deaths in this marginalised high-risk population. Utilisation of established resources and advocacy groups in these communities will hold the key to success.
- Increased engagement with rural and remote communities is needed to ensure that key messages are being disseminated effectively and in a culturally appropriate manner, appreciating the differences between rural and remote residents to their metropolitan counterparts. Given the stoic nature of most rural and remote residents and the ideologies instilled over generations, utilisation of local resources is important in the construction and implementation of public health campaigns and programs. Cultural appropriateness and personal relatability is critical for success.
- Further support and appreciation needs to be given to Distance Education school children and families that are significantly disadvantaged by the public state school funding of swimming lessons. School age children who attend distance education, may have limited access to school swimming instruction during the school term and rely on non-school funded programs, such as private swim schools and swimming clubs in their local communities. With strong relationships previously established, advocacy through these channels could be worthwhile and subsidised programs for these families is worth investigating.
- Industry should consider programs to train and upskill individuals in local communities in the role of swimming teachers, instructors and lifeguards. It is important that trainers within the rural and remote industry are engaged in this process, as a sustainable industry needs to be created. It is also important that pathways for completing learn to swim hours as part of course structure are taken into consideration. The development of program delivery could alleviate the burden currently faced in regards to providing training and support to swim teachers from rural areas.

Aboriginal and Torres Strait Islander people

- Partner with Indigenous groups to develop culturally appropriate strategies to prevent drowning among Aboriginal and Torres Strait Islander communities. Messages should target communities living in remote and very remote areas and address the risks associated with undertaking aquatic activity when under the influence of alcohol and/or drugs and the identification of aquatic risks in the natural lake, dam and lagoon environment.

Children Under Five

- As a substantial attributed burden to the dam drowning rates is from children under the age of five years, access to and affordability of, swimming instruction should be investigated. Targeting only school age children in these rural and remote communities is neglecting a population known to be at higher risk of drowning. The Isolated Parents and Children's Association, local councils and local swim schools all have a role to play in the advocacy and promotion of programs to this age cohort.

Agricultural Industry and Workplace Drowning Deaths

- Partnerships with organisations such as FarmSafe Australia and the National Farmer's Federation would be beneficial in providing education around workplace drowning deaths. As inadequate supervision is also a key risk factor to children drowning on farms, assisted advocacy for in-home-care schemes for rural families with childcare could also be an avenue for investigation.
- Agricultural industry employers should provide water safety information in induction or registration packs, especially if located near aquatic environments and promoting aquatic activities.
- Aquatic risk assessments should be conducted prior to any workplace activities taking place in the aquatic environment (such as fixing water pumps etc.). Training, support and a consultation process should be provided to the agricultural industry in developing the necessary appropriate situational aquatic risk assessments.
- Investigation into the increased supply of recreational or nationally recognised water rescue awards (i.e. Bronze Medallion) should be considered for a reduction in work-related drowning deaths.

BACKGROUND

Swimming and aquatic recreation activities are synonymous with the Australian identity. Given Australia's vast landscape and the remote nature of a large portion of the Australian population, inland waterways such as rivers, creeks and streams, lakes, dams and lagoons are common areas for recreation. Recreational uses of these areas varies greatly from swimming and recreating, boating, to enjoying picnics and fishing.

Unfortunately, when engaging in a natural aquatic environment the risk of drowning is increased with the changeable conditions it possesses and added risk of the unknown factors of the environment. Over the last ten years Australia has experienced consistently high numbers of drowning deaths in inland waterway locations (Figure 1), and as a consequence the Australian Water Safety Strategy has identified inland waterways as a priority area for achieving a reduction in drowning deaths.

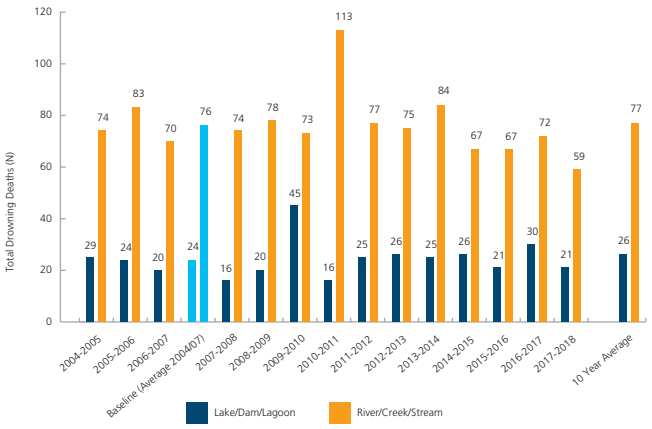


Figure 1. Drowning deaths in inland waterways by location type and financial year, Australia (2004/2005 to 2017/2018), 10-year average

Goal five, of the Australian Water Safety Strategy 2016-2020 directly relates to reducing the deaths in inland waterways. The Australian Water Safety Strategy continues to reflect on the need for drowning reduction strategies to target high-risk locations.

Over the ten year period of this study (1st July 2008 to 30th June 2018) inland waterways accounted for 35.5% of all drowning deaths, the single most common location for drowning deaths in Australia. Rivers, creeks and streams have previously been examined in detail, therefore this report focuses on the drowning deaths that have occurred in lakes, dams and lagoons.

Evidence Based Search

A brief review of the literature and knowledge surrounding drowning deaths in inland waterways, specifically those occurring in lakes, dams and lagoons, was examined and factors contributing to these deaths were outlined. This is not a systematic review, but provides the background of the current study through the identification of impacting factors that will be of importance when informing the development of prevention strategies and polices to prevent drowning in these inland aquatic environments. The review aims to provide an updated understanding of the risk factors for drowning in inland waterways, epidemiology of drowning in lakes, dams and lagoons, the current drowning prevention strategies in place and their evaluated effectiveness. The review also attempts to define the aquatic environment, lake, dam and lagoon, with a universally applicable definition to enhance comparison moving forward.

There has been significant improvement in the reduction of drowning deaths in Australia in recent years, both in absolute numbers and the per-capita risk of drowning.[1,2] There were 249 drowning deaths in aquatic locations across Australia between 1 July 2017 and 30 June 2018. This is a 14% reduction on the 2016/2017 and an 11% reduction on the ten year average.[2] Although the crude rates of unintentional drowning deaths have decreased in Australia during recent years, it still remains one of the leading causes of unintentional injury mortality across all age groups.[3]

There has been an assumption in the past that drowning in developed countries occurs mostly in public, private or backyard pools whilst developing countries mostly report drowning in natural water bodies like that of rivers, lakes, dams and ponds.[4-6] Despite the success of drowning prevention strategies and campaigns, rural aquatic environments, particularly lakes, lagoons and dams, are now emerging as common locations for drowning deaths.[2]

Inland waterways encompass a large variety of water bodies including rivers, creeks, streams, dams, lakes, and lagoons. Although each body of water is unique in its own right, all share an interconnecting risk factors related to drowning deaths. The natural environment in which these water bodies occur can prove dangerous to human health from the environmental hazards that may be present including: physical hazards, cold, heat and sunlight, water quality, algae and their toxic products, chemical and physical agents, impaired visibility in the water and dangerous aquatic organisms.[7]

Inland waterways are responsible for more drowning deaths than any other aquatic location.[1] Each year people of all ages lose their lives in inland waterways across Australia. The most recent National Drowning Report highlighted that drowning deaths in lakes, dams and lagoons recorded a 20% reduction on the ten year average, with swimming recreating in these environments, the leading activity immediately prior to drowning (25%).[2]

With this being said, dams have emerged as a common drowning location for young children.[2] From a study into where children and adolescents drown in Queensland, it was found dams were the most common location for drowning among children 1-4 years of age.[8] This was also reflected in Tasmania, where drowning of toddlers in swimming pools uncommon, with relatively higher drowning rates in ponds (75%), lakes (14%) or dams, associated with rural living.[9]

No study, in Australia or globally, has independently examined the relationship between dams and adult drowning prevalence. This is further reflected in Australia's national prevention strategies. National prevention strategies relating to dams currently have a paediatric focus, including Royal Life Saving Society – Australia's Keep Watch at the Farm campaign, with no national adult drowning prevention strategies recognised. Royal Life Saving's Respect the River campaign addresses many adult drowning prevention strategies in inland river and creek environments, however how well these strategies relate to the situation seen in lakes, dams and lagoons is yet to be investigated. The majority of the studies examining epidemiology of drowning around the world have a paediatric focus, with children under the age of five years prominently featured. As a result, circumstances involved in drowning among the youth and adult population are largely unknown and require further investigation. Progress has been made towards this in recent years, however there still remains significant gaps in the findings. There is limited current evidence examining the incidence and risk factors associated with drowning in lakes, lagoons and dams. This is in part due to the International Classification of Diseases – 10 (ICD10) division of aquatic locations, dividing the deaths into subsets of 'bathtub', 'swimming pool', and 'natural waterway'.[10] The subset 'natural waterway' is a broad encompassing term and includes rivers, creeks, beaches, oceans, harbours, lakes, lagoons and dams, thus does not often allow for the ability to extract data on the lakes, lagoons and dams individually. Those studies that have been identified are summarised below.

In Canada, inland waterway drownings accounted for 73% of all drowning deaths from 1991 to 2013.[11] Lakes and/or ponds alone represented 41% of all Canadian drowning deaths during that same period.[11] A similar picture was painted in Bangladesh, with 60% of all drowning deaths reported during 1985 to 2000 occurring in inland waterways, with ponds representing 36%.[2] Most deaths occurred during the monsoon months in Bangladesh,[12] and 57% of the deaths occurred during the months of Summer in Canada.[11]

A comparison was made between children under the age of five years and drowning location in both the United States and Bangladesh. Lakes featured as a known high drowning prevalence location for both developed and undeveloped countries. It was found in the United States that children under the age of five most often drowned in pools, rivers and lakes, with children in Bangladesh drowning in natural bodies of water including ditches, ponds, rivers and lakes.[13] Australia, unlike the United States and similar to some low income countries appears to have a trend of drowning deaths in dams among children under the age of five.[8] Rural drowning trends across the United States, Bangladesh were found to be similar to Australia, with higher drowning rates as rurality increased.[1] Again in these rural locations, children in the United States were more likely to drown in open water such as rivers, lakes and irrigation channels, whereas children in Bangladesh drowned in ponds, flood ditches, and lakes.[13]

Inland waterway drownings have proved to be a major health risk to rural populations. A study of rural children in China found that children aged 1-4 years were at an increased risk to drowning with the majority of deaths occurring in rives, ponds and lakes, with no deaths occurring in residential swimming pools.[14] Boys have been found to be consistently at a higher risk. Fencing and warning signs were rarely located at drowning deaths locations, with fences not a common feature beside rivers, ponds or lakes in rural China. Like other studies, drowning occurred in close proximately to the family home.[15]

Iran, like many other countries, has reported drownings most frequently occur in rivers, followed by canals and lakes.[16,17] Falls remained the leading activity, resulting in the drowning death, with the majority of lake drowning deaths occurring among residents as opposed to tourists. Children accounted for a large percent of the lake drownings, with the majority of cases occurring during daylight hours. It was shown that indirect supervision played a role in many of these drownings, with the mother (often the supervising parent) was occupied with other activities and not aware that children were playing near water. This highlights the need for family education around drowning risks and the need for passive protection around water sources, particularly those where children play located close to the family home (i.e. residential dams). A similar picture was seen in Tasmania, with the majority of the drownings occurring within 500 metres of the home. Drowning while swimming during daylight hours, during the months of summer and a fall into the water was recorded in 64% of cases.[9] Previous studies have found that the lack of effective barriers between the water body and the child is a risk factor for dam drowning deaths among young children.[18]

Over the last few years, toddlers and young children who drowned in Australia's inland waterways consistently resulted from a fall into the water.[2] However, as people aged and swimming skills and their risk-taking behaviour develops, activities related to drowning deaths are mainly associated to recreating.[2] A nine year analysis of drowning deaths in NSW inland waterways depicts that of the 937 fatal drowning deaths recorded between 1 July 2002 and 30 June 2011, 28% occurred in inland waterways.[19] Lake, dam and lagoon drowning deaths represented 25% of all inland drowning deaths, 97% were male. Watercraft, a fall into the water and non-aquatic transport were the most common activities prior to drowning in these locations. Additionally, alcohol was known to be involved in 27% of all lake, dam and lagoon fatal drowning deaths.[19]

Similar analysis over the same period was seen in the Northern Territory, however an increase in Aboriginal and Torres Strait Islander status and alcohol presence was noted in people aged over 15 years of age.[20] The Northern Territory report made three recommendations, one of which was the importance of developing a culture of water safety as a community, such as using personal flotation devices, and avoiding alcohol when undertaking aquatic activity. No evidence of effectiveness or follow up from the recommendations has been noted to date.

In many low and middle income countries, creating barriers between young children and the bodies of water to which they are exposed, can be an effective measure to prevent drowning. The covering of wells, and dams with grills, creating an embankment or fenced barrier near pond and lake banks, and the building of flood-controlled embankments, are all effective prevention efforts.[21] Similarly, creating fencing around a dwelling, such as the child safe play areas proposed in Australia, where there is a hazard of open water, can also provide protection.[4]

Farm safety researchers in Australia are also investigating the feasibility of a virtual fence, a technology alarm system signalling a child has gone beyond a predetermined perimeter of the home.[22,23] It is being examined to determine if this technology can be applied effectively in a remote setting to increase chid safety especially in relation to the risk of drowning in bodies of water such as dams.[6]

From previous studies it was found that farm drowning deaths in Australia (dams, irrigation channels, troughs and tanks) accounted for 12% of all drowning deaths. This indicates a need for safe play areas on farms.[18,24,25] Drowning prevention measures in rural areas need to go beyond the realm of current advocacy strategies.

Past cases demonstrate the risk of dams on agricultural farm locations, such as:

- the young age of the usual farm drowning casualty
- the need and importance of CPR training
- the value of modern telecommunications and skilled telephone triage training for emergency service providers
- the effectiveness of advanced resuscitation, the apparent neuroprotective effect of hypothermia and the value of prolonged resuscitation in children.[26]

While approaches to prevention are transferable, specific prevention strategies and measures should be tailored for specific types of exposure. Generally, children aged 0 - 4 years drown in or around the home. This risk is amplified if the "home" environment includes large bodies of water, such as agricultural dams, or backs onto natural lakes. Rural locations in Australia are highly relatable to low-income countries with respect to the risk of drowning.[27] Children aged 12 - 23 months who died from drowning in Bangladesh did so in ditches, ponds and dams, reflecting the high exposure to water sources.[13] A study of Australian farm injuries found a similar occurrence, with 78% of drownings in children under the age of five years living on farms occurred in farm dams and irrigation channels.[28]

Lakes are an important and often forgotten part of the tourism industry in Australia.[29-31] Generally defined as open bodies of water, dams or reservoirs, a variety of recreational activities take place at lakes such as boating, fishing, scuba diving and water skiing.[32,33] Because of this, lakes have become a popular destination for tourists travelling to rural and remote areas.[33]

Despite the attractiveness of the location, lake environments pose a range of risks to individuals, especially with aquatic activities. Thirteen percent of all search and rescue operations conducted in the United States National Parks are known to take place at lakes.[34] There has also been additional studies investigating the risk of acquiring coliforms (a broad class of bacteria found in the environment) such as Tularaemia from lakes,[35,36] becoming infected with Schistosomiasis when swimming, boating and rafting around the Great Lakes in East Africa,[37-40] and acquiring Naegleria fowleri infections while swimming in warm freshwater lakes.[41,42] However, there are limited studies examining the effect the relationship between the lake environment and recreating has on human mortality.

An Australian study highlighted the association between drowning and swimming, diving and watercraft collisions, with a large percentage being visitors to the lake destination (including 4.3% overseas tourists).[43] Over one third of the drowning deaths at Lake Powell in the United States occurred in the 10 – 19 and 20 – 29 years age groups,[33] with a similar picture painted in Australia. This supports a recommendation that preventative efforts should be targeted at younger adult individuals in this environment.

Similar to Australian studies,[2] swimming, cliff jumping, shoreline fishing and skiing were prominent activities seen prior to drowning deaths at Lake Powell.[33] Swimming in inland lakes, dams and lagoons cannot be compared to swimming in a pool or sheltered aquatic environment. Swimmers in this environment must co-exist with boaters, water skiers and other recreational watercraft users, as well as be exposed to unexpected drop-offs into deep water, seaweed and other marine life, reeds and dangerous objects buried in the sand including discarded fish hooks. Water conditions, especially visibility, can be unpredictable and strong currents can be fatal for even experienced swimmers. Hypothermia is also a real threat to swimmers in some lake environments, as water temperature is known to be lower even in warmer summer weather. Poor mobile network coverage and the absence of rescue equipment such as life buoys can also complicate rescue efforts when swimmers get into difficulty.

Heggie et al. also highlights the importance of adequately supervising children during travel, such as camping at a lake environment.[33] Half of the deaths that occurred at the shoreline of Lake Powell involved infants and young children who had wandered away from their campsites and fell into the nearby lake.[33] The full global extent of paediatric deaths occurring due to travel and a lack of supervision at lake or inland water body locations is unknown. Parents travelling to lake destinations should be reminded of the distracting nature of the location which may obstruct or provide an obstacle to supervision efforts in an unfamiliar location. Alcohol has been a known risk factor in lake drowning environments.[33] This follows the same trend of Australian river drownings deaths, especially those occurring in the early morning or evenings.[44]

Drowning prevention efforts aimed at the lake environment need to encompass not only the local constituents but the tourist population who frequent the location, including international visitors. Language barriers, different cultural attitudes to water safety and an increase in risk-taking behaviour by visitors in unfamiliar locations need to be taken into account when designing and implementing prevention measures.

In recent years, rivers as an inland waterway have received attention designed to document and reduce the drowning burden,[45,46] however little is understood about the interconnection or differences between various inland waterways in relation to drowning prevalence and associated risk factors. There are very few studies that examine lake, dam and lagoon waterways in isolation from inland waterway systems for drowning prevalence and risk factors. While location specific risk factors and prevention strategies have been establish for rivers, creeks and inland streams, there has not been sufficient research conducted to understand if the prevention strategies are transferable to a lake, dam, lagoon environment or to inform the development of effective prevention strategies for lake, dam and lagoon inland waterways in their own right.

A detailed analysis of population data helps guide advocacy for future drowning prevention strategies. Our experience of successful injury prevention strategies indicates that a reduction in burden is best achieved through specific targeted interventions using the four-portal approach of education, improved design (e.g. of environments, safety barriers and safety equipment), legislation and rescue–resuscitation.[47] It is the aim of this report to examine the drowning patterns of lake, dam and lagoon fatal, unintentional drowning deaths in Australia for the period between 1 July 2008 and 30 June 2018, to compare findings with other inland waterway findings, and assess the feasibility of the aim to reduce drowning deaths in these locations via current prevention strategies.

Defining the location

Estuaries, lakes, dams, lagoons, costal lagoons, river mouths, tidal creeks and similar coastal environments often are regarded as a single broad conceptual class of inland waterways. Brackish, estuarine, paralic and transitional are all terms used in different contexts to attempt to collectively name this group of aquatic environments. The terms used are often generated from a historical perspective and scientific point of view, and always exclude some of the previously mentioned environments.

The National Coronial Information System (NCIS) coding for where location of drowning deaths occur, offers little assistance in defining these inland waterways, as generally they fall into four categories: area of still water (farm dam, pond/pool of water, natural ice), stream of water (river/creek/stream, brook/trickle of water, canal), large area of water (lake, sea/ocean, bay, public dam/reservoir, estuary) and marsh/swamp (bog, mire and wetland).

The naming of aquatic environments in the literature seems to take on two major groupings, hydrological and geomorphic. Although the significance of hydrological attributes is instantly recognisable, geomorphic attributes imply subjacent concepts of geographical scale and hydrological features not expressly formulated in definitions, such as a limited supply of seawater to the system. A consistent definition is needed for defining aquatic locations for multiple reasons. Such a definition to enable comparison of locations within a single country context and to transcend international borders, is required.

The current definition used by Royal Life Saving Society - Australia, in the coding of the National Fatal Drowning Database, defines lake/dam/lagoon locations as a body of water, either fresh or salt water which may vary in size and is surrounded by land. This is also to be applied where water is stagnating (e.g. swimming holes and gorges). It notes that predominately still water and names are used interchangeably within this definition.[48] Royal Life Saving attempts to define each lake, dam and lagoon in their own right. The current definitions are:

Lake: is defined as a body of water (fresh or salt) of considerable size, surrounded by land.[49]

Dam: May be a body of water enclosed on all sides. This may also have one wall and use gravity of water flow to ensure the water remains contained. Dams may vary in size and depth (e.g. sizable recreational dams and/or smaller bodies of water such as farm dams). Often these water bodies are intended to allow access by livestock and for recreational activities. This category also includes reservoirs.

Lagoon: A lagoon is a small, pond-like body of water, especially one that may be connected with a major body of water. A lagoon may also be an area of shallow water separated from the sea by low sandy dunes.[50] Lagoons include: rock pools and gorge pools fed by waterfalls or rivers. This category can be salt or fresh water, including billabongs, spillage of rivers including ponds in parks etc., but does not include fishing ponds.

As the current definitions are not supported by strong evidence or have much meaning in a national or international comparison, a more comprehensive and definitive definition was sought. The definition of a lake, dam and lagoon is not articulated succinctly in any literature in relationship to drowning prevention location classification or in general terms. It appears that waterways merge from lake/dam/lagoon to a creek/river or bay without a definitive boundary. In addition man-made structures are transforming these waterways. Trevathan describes a term he calls liminal zones, transitional areas where dammed reservoirs (including lakes, dams and lagoons) give way to the current of rivers that feed them.[51] The ecological and aesthetic differences between a dammed river and a free-flowing river are somewhat distinct, and understanding the implications of what liminal zones represents is challenging. What impact this has on drowning risk or for prevention is also not defined as the aesthetics changes to these bodies of water (such as visibility from turbulent flow) could have varying implications.

By examining a broader range of literature, a more inclusive definition was sought for each individual location. The following definitions found in the literature include:

Lake: Typically a large body of water within a body of land, separated from the ocean. The term “lake” or “pond” as part of a water body name is arbitrary and not based on any specific naming convention, but for lakes is usually restricted to those water bodies greater than one meter deep when full.[52] In general, lakes tend to be larger and/or deeper than ponds. A lake, by contrast to a pond, has an “aphotic zone,” meaning there is an area deep enough that sunlight can’t reach the bottom.[52] This definition is sometimes problematic when attempting to define lakes in Australia where many lakes are ephemeral (lakes which fill for brief periods).

Dam: A barrier constructed for the retention of water, water containing other substances, fluid waste or tailing. The barrier stops or restricts the flow of water or underground streams.[53] It is important to appreciate however, the distinct hydrological differences present in dams created to restrict flow (e.g. dammed river systems), and those man-made dam water holes (e.g. independent farm/agricultural dam watering holes). Microorganisms in the two environments can vary greatly and could potentially play an added role in drowning fatality (e.g. farming dams, livestock and algae production).[54,55]

Lagoon: A shallow body of water separated from a larger body of water by a barrier (such as islands or reefs) connected, at least intermittently to the larger body of water, by one or more restricted inlets.[56-60] Lagoons can be both coastal and inland in nature, with both having a dynamic ecosystem rich in biodiversity. In literature, a lagoon can also include water bodies of coastal lagoons, coastal lakes, bahiras, intermittently closing and open lakes and lagoons, and limans.[61] In Australia, the term intermittently closed and open lake and lagoons has been developed in an attempt to apply a specific definition to the lagoon environment.[62] This encompass small coastal lagoons and small coastal creeks, with entrances that are mostly closed as well as occasionally closed barrier estuaries with untrained entrances. Little literature could be found defining a lagoon in an inland/noncoastal environment, such as those created by waterfalls and billabongs.

BACKGROUND KEY POINTS

- Inland waterways are a leading location for drowning deaths globally, in high, middle and low income countries
- Limited investigation exists into drowning deaths that occur in lakes, dams and lagoons internationally
- Lake, dam and lagoon drowning deaths are caused by factors such as unsafe use of watercraft (including the non-use of personal flotation devices), lapses in supervision of children, lack of effective barriers between children and water sources, the consumption of alcohol and/or drugs, and cultural differences/language barriers of visitors to the tourist locations
- Although having some interconnecting overarching risk factors, each location will require individual prevention strategies unique to each location
- Effective strategies include appropriate fencing and warning signs where possible, water safety skills, education around drowning risks and the need for supervision around water sources, farm safe play areas, public awareness of the need for effective CPR skills, and education of tourists (including international visitors) to the location in a culturally appropriate manner
- Important to appreciate nature cannot be divided into precise, neat categories and the scientific community needs to accept there will never be a precise definition for these aquatic environments

OBJECTIVES

This study aimed to:

- To determine the prevalence of Australian drowning deaths in inland waterways that are classed as lakes, dams or lagoons, and to identify high-risk populations within this setting
- Identify risk factors for drowning to better inform programs and intervention prevention strategies targeting high-risk populations
- Explore means of improving data collection with the NCIS, particularly relating to the classification of location of inland deaths and identifying risk factors in rural and remote locations

METHODS

All unintentional, drowning deaths in Australian waterways classified as an inland waterway (lake, dam or lagoon) between 1 July 2008 and 30 June 2018 (a period of ten financial years) were included in this report.

Information for this report has been collected from State/Territory Coronial Offices, the National Coronial Information System (NCIS) and media reports. It has been collated and analysed by the Royal Life Saving Society – Australia.

Royal Life Saving uses a media monitoring service (both electronic and print media) during the course of the year to identify drowning deaths in the media. The information is then corroborated with information from the NCIS, police and Royal Life Saving State/Territory Member Organisations before being included in this report.

All care is taken to ensure that the information presented is accurate. Please note that the data extracted from recent financial years may change depending upon the outcomes of ongoing coronial investigations and findings. This report contains information correct as at 29 January 2019. As of this date, 85.5% of cases were closed (i.e. no longer under coronial investigation).

Data excluded from this report include: drowning deaths known to be as a result of suicide, homicide or infanticide, deaths from natural causes, aquatic life fatal injury (shark and crocodile attacks), or hypothermia where identified. Cases where the intent of death is classified as undetermined by a coroner, are included. All information presented relates to drowning deaths or deaths where drowning was a contributing factor or could not be excluded as a factor.

Definitions

Definition of lake, dam and lagoon

Within drowning, no formal definition exists for the classification and distinction between an inland water body for lake, dam and lagoons.[49,50] Classification of the data heavily relied upon the reported name of the location in the police and coroners findings. A bay that did not meet the definition for costal classification (2km radius from the ocean inlet) was reclassified as either a lake, dam or lagoon. Similarly, marinas that were not coastal were also reclassified. It is noted that the categorical definition between the three inland waterway types was not easy to differentiate and at times relied upon the original reporting authority description of the waterway (which at times contradicted the above definition).

The definition that was employed for the purpose of this report for each specific location is as follows:

Lake:
A lake is typically a large body of water within a body of land, separated from the ocean. The term "lake" or "pond" as part of a water body name is arbitrary and not based on any specific naming convention, but for lakes is usually restricted to those water bodies greater than one meter deep when full.[51] In general, lakes tend to be larger and/or deeper than ponds. A lake, by contrast to a pond, has an "aphotic zone," meaning there is an area deep enough that sunlight can't reach the bottom.[52] This definition is sometimes problematic when attempting to define lakes in Australia where many lakes are ephemeral, yet was used for this study.

Dam:
A dam is defined as a barrier constructed for the retention of water, water containing other substances, fluid waste or tailing. The barrier stops or restricts the flow of water or underground streams.[53]

Lagoon:
A shallow body of water separated from a larger body of water by a barrier (such as islands or reefs) connected, at least intermittently to the larger body of water, by one or more restricted inlets.[56-60]

General terms and definitions:

Definitions and terms used in this report are consistent with the Australian Water Safety Strategy 2016-202062 and the Royal Life Saving Society – Australia's National Fatal Drowning Database, and are as follows:

Overseas born: Anyone who fatally drowned during the study period that was born in a country other than Australia, including overseas tourists, international students and those in Australia for working purposes at the time of death.

Country of birth: Extrapolated by individual country of birth. The United Kingdom (U.K.) (country unspecified), and countries within the U.K. – England, Scotland, Wales and Northern Ireland, were treated individually for the overall data analysis. The most current Australian Bureau Statistics (ABS) census data which was used to populate crude rate per 100,000 people living in Australia.

Age groups: Classified as per the Australian Water Safety Strategy to align with key life stages. An extension on the 0-4 year old age group was undertaken, breaking down the age group into 6 month time periods from 0-5 years for analysis.

Remoteness classification: The remoteness classification of the drowning location was defined using the Australian Standard Geographical Classification – Remoteness Area (ASGC-RA) system.

Season of drowning: The season when the death occurred: summer (December to February), autumn (March to May), winter (June to August), spring (September to November).

Time of drowning: The time of drowning was coded into four bands: early morning (12:01am to 6am), morning (6:01am to 12pm). Afternoon (12:01pm to 6pm) and evening (6:01pm to 12am).

Day of the week: day of the week the death occurred.

Activity: The specific primary activity the person was undertaking immediately prior to death, causing the person to be in, on, or near the water.

Blood Alcohol Concentration (BAC): Greater than or equal to 0.05g/mL (0.05 grams of alcohol per 100 millilitres of blood) was considered relevant and contributory to the drowning death, presented as BAC ≥0.05% in the data.

Drugs: Positive pharmaceutical substances were given a classification as either a legal or illicit drug type (either by determining from the drug name or if it was determined a drug was outside of non-therapeutic levels. For the purposes of this report, all prescribed medications were considered to be legal. Illicit drugs were defined as: either illicit drugs, non-therapeutic levels of a legal drug or a combination of illicit and therapeutic drugs.

Swimming ability: Where recorded or mentioned in coroner's or police reports this was included in data analysis. Swimming ability was based on a family member or friends' assessment, not actual ability and could be over or under estimated. Categorised as: 1) Non Swimmer – could not swim 2) Poor Swimmer - weak, poor, not a good or competent swimmer 3) Competent swimmer – competent, average swimmer 4) Strong swimmer – strong, very competent, experienced swimmer.

Visitor Status: The distance between the location of drowning and residential postcode was determined using geographical distance in a straight line (google maps). A distance of less than 100km was considered 'not a visitor', more than 100km but within the same state was 'visitor - intrastate', a different state was 'visitor - interstate' and an overseas residential postcode as 'visitor – overseas'. In cases where the drowning location or residential postcode was unknown, this was entered as 'unknown'.

Socioeconomic Disadvantage: The residential postcode of the person who drowned was coded to the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD), an index which summarises the economic and social conditions of people and households within an area, including both relative advantage and disadvantage measures. The Index is ranked from 1 to 10, with a low score indicating relatively greater disadvantage (e.g. many people with low incomes and many people in unskilled occupations), compared to a high score which indicates a relative lack of disadvantage. For analysis, IRSAD was categorised as low rank (1 to 3), high (8 to 10) and other/unknown.

Supervision: for children aged 0-14 years, was coded as following: Yes (supervision present), No (supervision absent), Yes – with limiting factors, e.g. supervised by siblings or other child, under/over aged 12 years or supervision of child unknown. The type of supervision was defined as: none - child left completely unattended for a period of time; indirect - supervising adult was in the vicinity of the child but not giving their full attention to the task of supervising; direct - supervising adult was giving the child their full attention; and unknown type of supervision.

An attempt at resuscitation: Any documented attempt by a lay first responder or emergency service provider, regardless of the period the victim had been submerged in the water. This decision was made based on a review of literature where survival after prolonged submersion in freshwater has taken place in various lake environments, namely due to the apparent neuroprotective component of hypothermia.[64]

Loss of visibility: A documented loss of visibility of the drowning victim in the water in any of the reports which could be defined as longer than one minute. Loss of visibility was primarily used to distinguish an association between the loss of visibility in the water, and those deaths resulting in a search for the victim's body.

A search for the victim's body: A search conducted for longer than 10 minutes. Although a relatively arbitrary period, evidence in the literature does document various forms of neurodeficits present in drowning victims with submersion greater than 10 minutes.[65] From available literature it was concluded that if water temperature is warmer than six degrees Celsius, survival/resuscitation is extremely unlikely if the victim is submerged longer than 30 minutes.[65-68] In water temperature below 6 degrees Celsius, survival/resuscitation is extremely unlikely if submerged longer than 90 minutes.[66-67]

Work-related incidences: Were coded for the dam location. This coding went beyond whether the NCIS had determined if the death was work-related and resulted in an occupational workplace health and safety investigation. From the literature it was determined that children in rural locations succumb to drowning due to the lapse in direct supervision from their guardians.[8,9,15-18,24,25] Deaths where the guardian was involved in work (e.g. mechanical maintenance of a farm vehicle) while supervising a child and the drowning death took place were included in the coding analysis. As alcohol consumption of parents/guardians is a known risk factor in incomplete supervision, an attempt was made to capture the impact of work-related activities on children in the rural dam environment.

Data analysis

The crude drowning rate was calculated using the ten year Australian population figures for the relevant age groups between June 2009 and June 2018, based on 2011 and 2016 census data from the Australian Bureau of Statistics (ABS).

In most cases, data analysis by State/Territory was reported as a percentage rather than raw numbers for ethical reasons; in some instances numbers were very small and it may be possible for cases to be identified. Reporting percentages also allowed for comparison across States/Territories.

Data were analysed using SPSS Version 24 and descriptive statistics have been utilised to present the results in this report.

RESULTS

Between 1st July 2008 and 30th June 2018 (a period of 10 financial years), 255 people drowned in inland waterways classified as either a lake, dam or lagoon in Australia. This represents 8.9% of all drowning deaths in Australia during this period with a crude drowning rate of 0.11/100,000 population.

Drowning deaths occurred in all years of the study period, with a high of 44 deaths (14.5% of total deaths for 2009-2010 financial year) and a low of 16 deaths (5.9% of total deaths for the 2010-2011 financial year) (Figure 2). The average number of deaths per year was 26 deaths.

When examining the crude drowning rates per 100,000 population, the rate varied across the 10 year period of this study, from a low of 0.07/ 100,000 population in 2010-2011 to a high of 0.21/ 100,000 in 2009-2010.

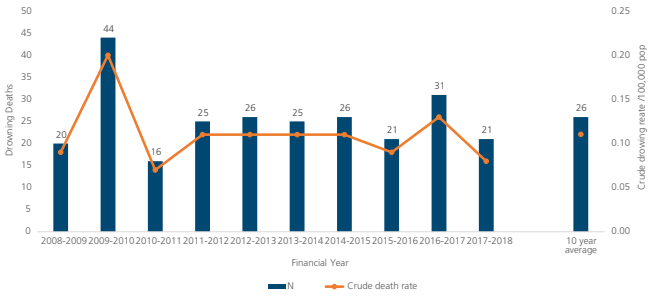


Figure 2: Drowning deaths in lakes, dams and lagoons by financial year and rate per 100,000 population, 2008/09 – 2017/18 (N=255)

Overall, during the 10 year period there were 2875 drowning deaths in Australia, of which lakes, dams and lagoons represent 8.9% (Figure 3).

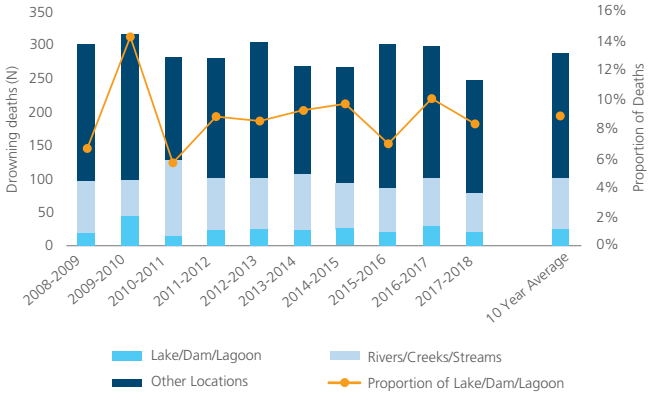


Figure 3: Proportion of drowning deaths by location by financial year, 2008/09 – 2017/18 (N=2875)

Analysis of drowning by demographics

Males were overrepresented in the data, accounting for 87.1% of all lake, dam and lagoon drowning deaths (N=222). Of male deaths, 50.0% occurred in a lake (N=113), 43.2% in a dam (N=96) and 5.9% in a lagoon (N=13). In the female population there was an even distribution between lake and dam drowning deaths, 51.5% (N=17) and 48.5% (N=16) respectively (Figure 4).

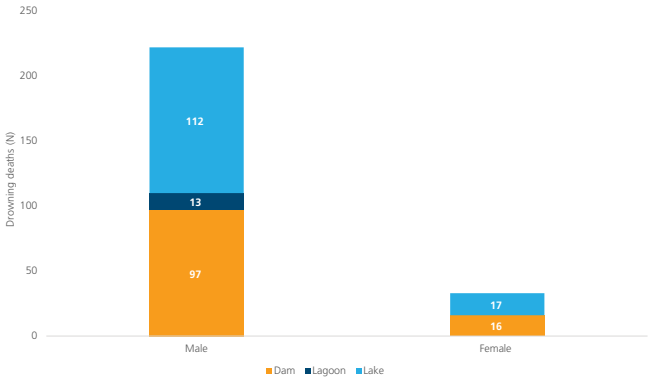


Figure 4: Drowning deaths in lakes, dams and lagoons by sex, 2008/09 – 2017/18 (N=255)

The burden of male drowning was more pronounced when examined by age group and sex (Figure 5). Males accounted for 100% of the drowning deaths among those aged 15-17 years (N=4) and 25-34 years (N=39), closely followed by the 18-24 years age group (95.8%, N=23) and 45-54 years (93.5%, N=29). The male burden was least pronounced in those aged 10-14 years, accounting for 66.7% of all drowning deaths in this age group (N=4).

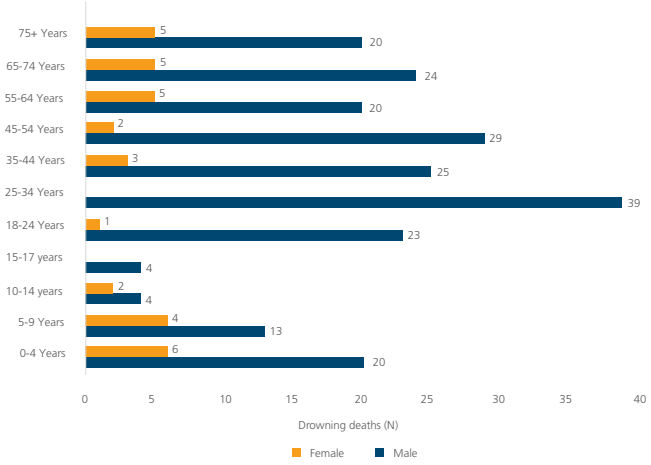


Figure 5: Age-Sex distribution of drowning deaths in lakes, dams and lagoons, 2008/09 – 2017/18 (N=254)

Drowning by age

The largest number of drowning deaths occurred among those aged 25 - 34 years (15.4%, N=39), followed by the 45-54 years (12.2%, N=31). Those aged 15 - 17 years accounted for the lowest number of deaths (1.6%, N=4). (Figure 6) When adjusted for population, the age group with the highest crude drowning rate was those aged 0-4 years (0.18/100,000), followed by the 75 years and over age group (0.17/100,000). Males were dominant in all drowning deaths across all age groups. Several age groups recorded a crude drowning rate for lakes, dams and lagoons greater than the national average crude drowning rate for those locations. The following age groups all recorded a crude drowning rate above the than the national lake, dam and lagoon crude drowning rate of 0.11/ 100,000 population: 0 - 4 years (0.18), 5 - 9 years (0.12), 18 - 24 years (0.16), 25 - 34 years (0.12), 65 - 74 years (0.16) and 75 years plus (0.17) per 100,000 population.

The age distribution changed across the three locations. The 25 - 34 years age group accounted for the greatest number of drowning deaths in lakes (20.2%, N=26) and lagoons (30.8%, N=4) respectively. In dams, children aged 0 - 4 years represented the largest number of drowning deaths (19.6%, N=22), followed by the 65 - 74 years age group (14.3 %, N=16) (Figure 7).

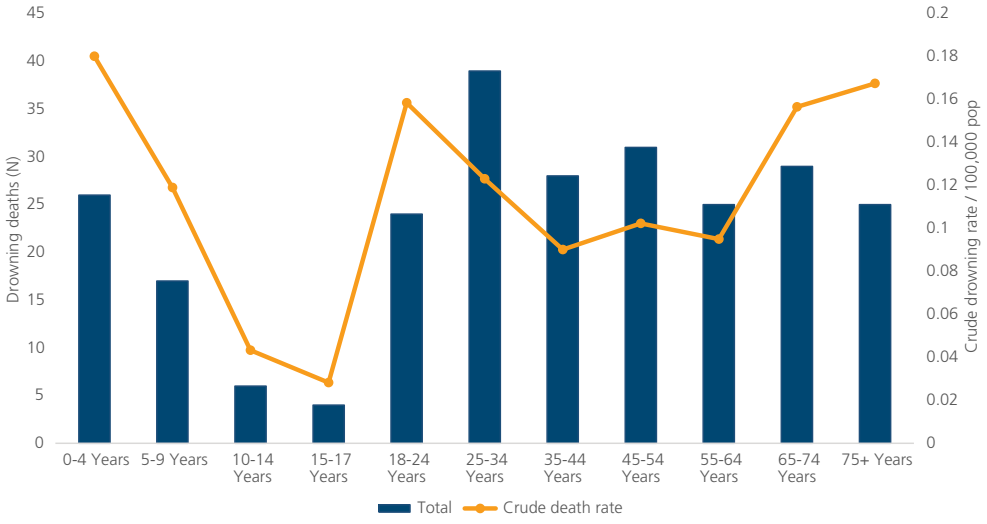


Figure 6: Drowning deaths in lakes, dams and lagoons by age and rate per 100,000 population, 2008/09 – 2017/18 (N=254)

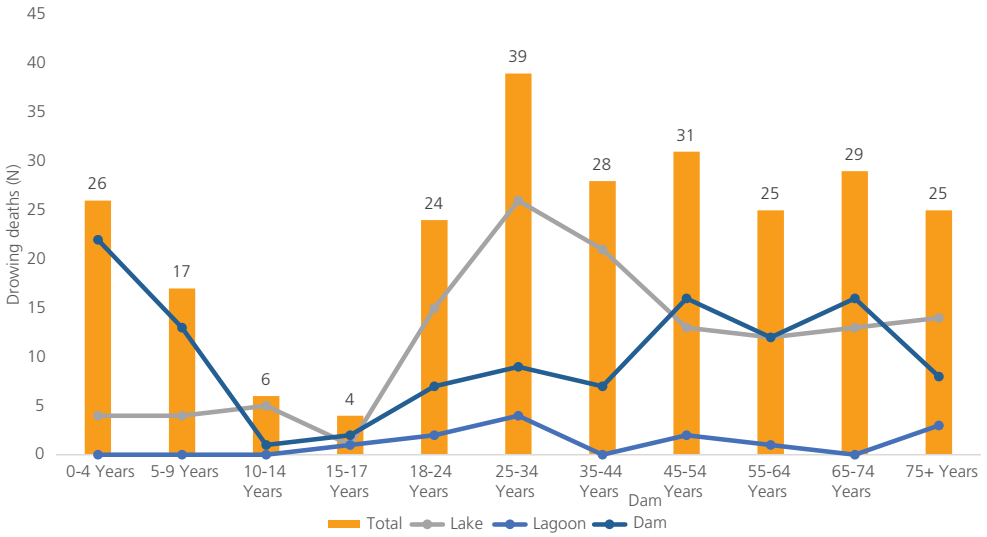


Figure 7: Drowning deaths in lakes, dams and lagoons by age and location, 2008/09 – 2017/18 (N=254)

CASE STUDY: **DROWNING DEATHS IN 0-4 YEARS**

Age was found to be a significant contributory factor to drowning deaths in this study. Ten percent (10.2%, N=26) of all drowning deaths in lakes, dams and lagoon were of children aged 0 - 4 years. Over half of the 0 - 4 years drowning deaths were recorded in Queensland (57.7%). This report found that as rurality of the drowning location increases so did the proportion of drowning deaths among children aged 0 - 4 years.

Males accounted for 76.9% of all drowning deaths in this age group. The risk of drowning appears to be an equal distribution between 1 - 2 years and 3 - 5 years of age, with no drowning deaths occurring among children 12 months and under.

When examined more closely, children aged 12 - 18 months and 18 - 24 months appear to be over-represented in this cohort, representing 19.2% and 23.3% respectively of the drowning deaths in this age (Figure 8). Drowning risk peaks at this age, and could be explained by childhood development where children become more mobile, and a cognitive need to explore their surrounds with limited risk perception takes place. 91.7% occurred under indirect supervision.

The majority of drowning deaths among children aged 0 - 4 years occurred in a dam (76.9%, N=22). Where circumstances were known, only 22.7% of dam cases made mention of child safe play area, a known prevention measure for childhood dam drowning deaths. Nearly three quarters, (72.7%) of drowning deaths that occurred in a dam on a residential or private property recorded that the adult immediately responsible for supervision was working when the drowning took place. Only one child was reported having participated in swimming lessons.

Children in this age group travelled less than 100 meters to the dam during the drowning deaths in 72.7% of the cases (N=16). Distance travelled varied by age of the child (Figure 9) with the smallest distance travelled being 20 meters and the largest distance travelled being 980 meters (child aged 36 months).

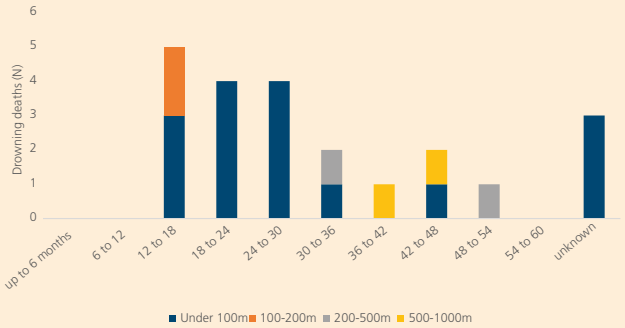


Figure 9: Distance travelled by child at dam location by age in months, 2008/09 – 2017/18 (N=22)

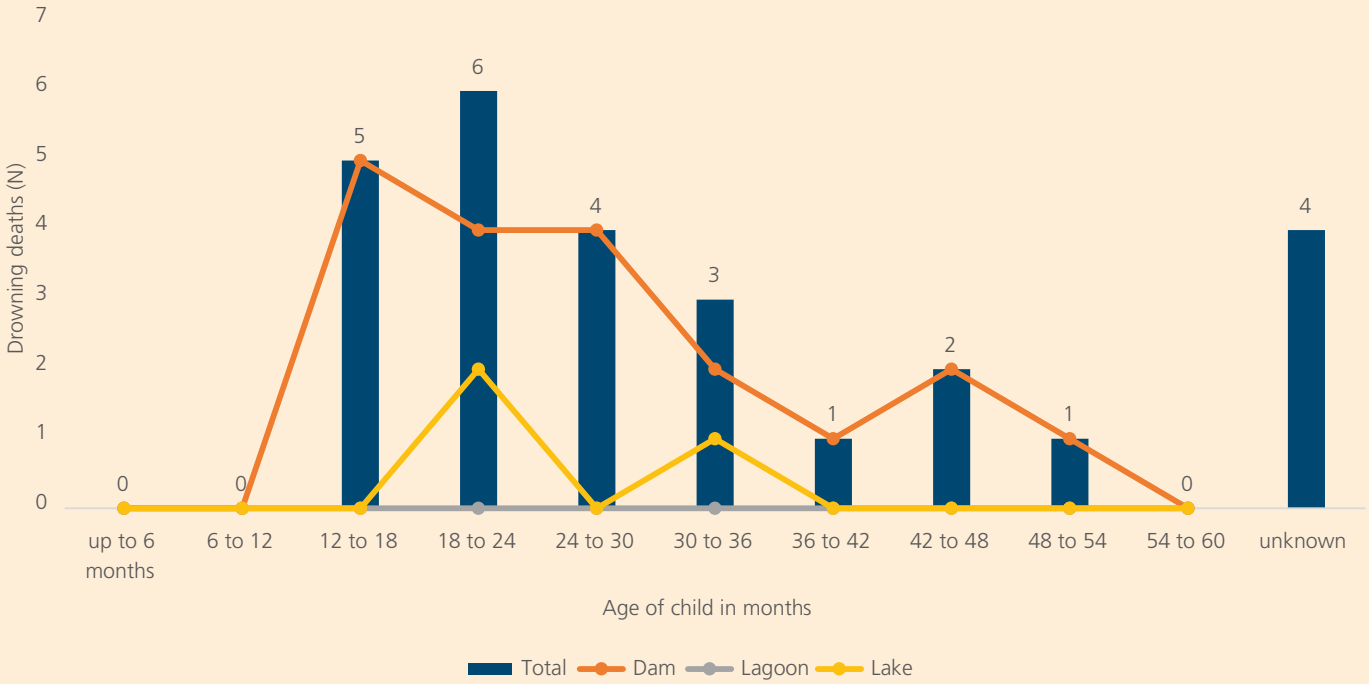


Figure 8: Drowning deaths in lakes, dams and lagoons of children by age in months, 2008/09 – 2017/18 (N=26)

Country of birth

Over half of those who drowned in these locations were born in Australia (52.9%, N=135), with 22.4% born in a country other than Australia (N=57) (Figure 10). The most common countries of birth represented of the overseas born deaths were New Zealand (12.3%, N=7), England (8.8%, N=5) and Germany and Italy (7.0%, N=4 each). The crude drowning rate for overseas born individuals was 0.09/100,000 population compared to the Australian born drowning rate of 0.08. Each location was not equally distributed regarding overseas born crude drowning rate. Lake crude drowning rate for people overseas born of 0.05/ 100,000 population compared to the drowning rate at dams being of 0.03, and lagoons of 0.01/100,000 population of overseas born residents. From the crude rates, along with the total figures displayed (Figure 10), it can be understood that dam locations were not as heavily impacted by ethnicity as compared to lakes.

Aboriginal and Torres Strait Islander Status

Seven percent (7.1%, N=18) identified as Aboriginal, or Torres Strait Islander (Figure 11). The crude drowning rate for Aboriginal and Torres Strait Islander people was 0.28/100,000, four times greater than non-Indigenous Australians (0.07/100,000 population). The higher burden of drowning among Aboriginal and Torres Strait Islander people compared to the rest of the Australian population was consistent across all the locations. Dams recorded the highest number and proportion of fatal drowning among Aboriginal and Torres Strait Islander people, (8.0%, N=9).

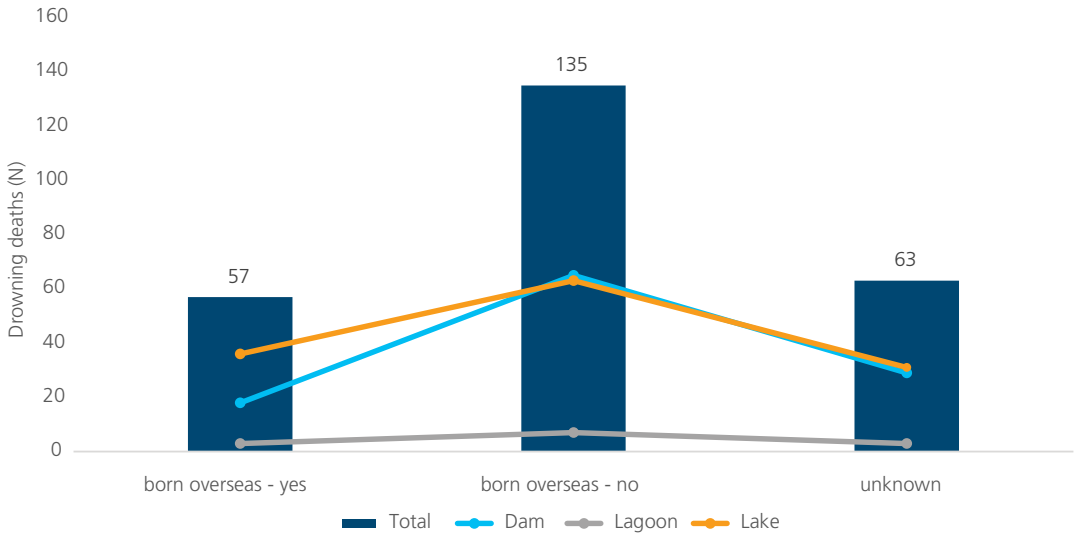


Figure 10: Drowning deaths in lakes, dams and lagoons by country of birth, 2008/09 – 2017/18 (N=255)

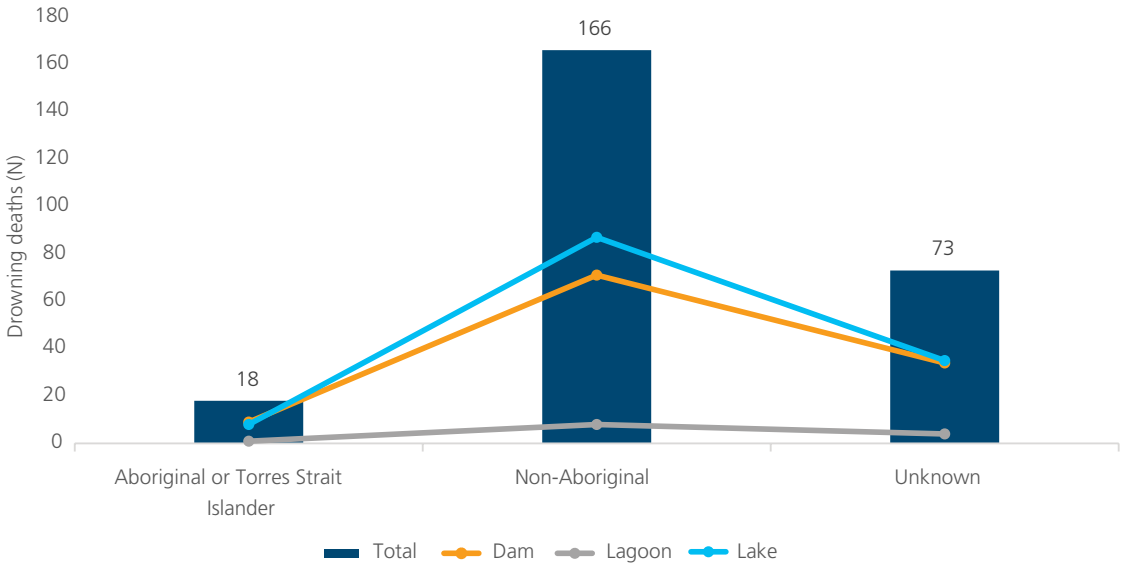


Figure 11: Drowning deaths in lakes, dams and lagoons by Aboriginal and Torres Strait Islander status 2008/09 – 2017/18 (N=255)

When examining Aboriginal and Torres Strait Islander drowning deaths by age distribution, children had the highest proportion of drowning deaths, with older people representing the lowest proportion of drowning deaths (Figure 12). Those aged 45 - 54 years were represented with the highest crude drowning rate, 0.37/100,000 population, compared to 0.05 deaths per non-Indigenous population in the same age group. Children aged 0 - 4 years recorded the next highest with a crude drowning rate of 0.32 deaths/100,000 population, compared to 0.11 non-Indigenous population of that age group. People aged 45 - 54 years represented the age group where the largest variance between crude drowning rates were seen with a variance of 0.32. Age groups which recorded age standardised drowning rates for Aboriginal and Torres Strait Islander population greater than the national average (Aboriginal) drowning death crude rate of 0.28/100,000 population were: 0 - 4 years (0.32), 5 - 9 years (0.32), 35 - 44 years (0.34) and 45 - 54 years (0.37).

When examining the drowning deaths by State/ Territory and Aboriginal and Torres Strait Islander status, the Northern Territory (44.4%), reported the highest proportion, followed by Western Australia (16.0%) and Queensland (10.3%). The Northern Territory recorded the highest drowning death crude rate in lakes, dams and lagoons among the Aboriginal and Torres Strait Islander population, of 0.54 deaths/ 100,000 population (compared to the non-Indigenous crude rate of 0.29). This was followed by Western Australia (0.40 deaths/100,000) and Queensland (0.27 deaths/100,000 population). The largest variance of crude death rates between Aboriginal and Torres Strait Islander population and non-Indigenous populations was in Western Australia (0.32/100,000). Western Australia and the Northern Territory both recorded a drowning death crude rate greater than the national drowning death crude rate for Aboriginal and Torres Strait Islander people (Figure 13).

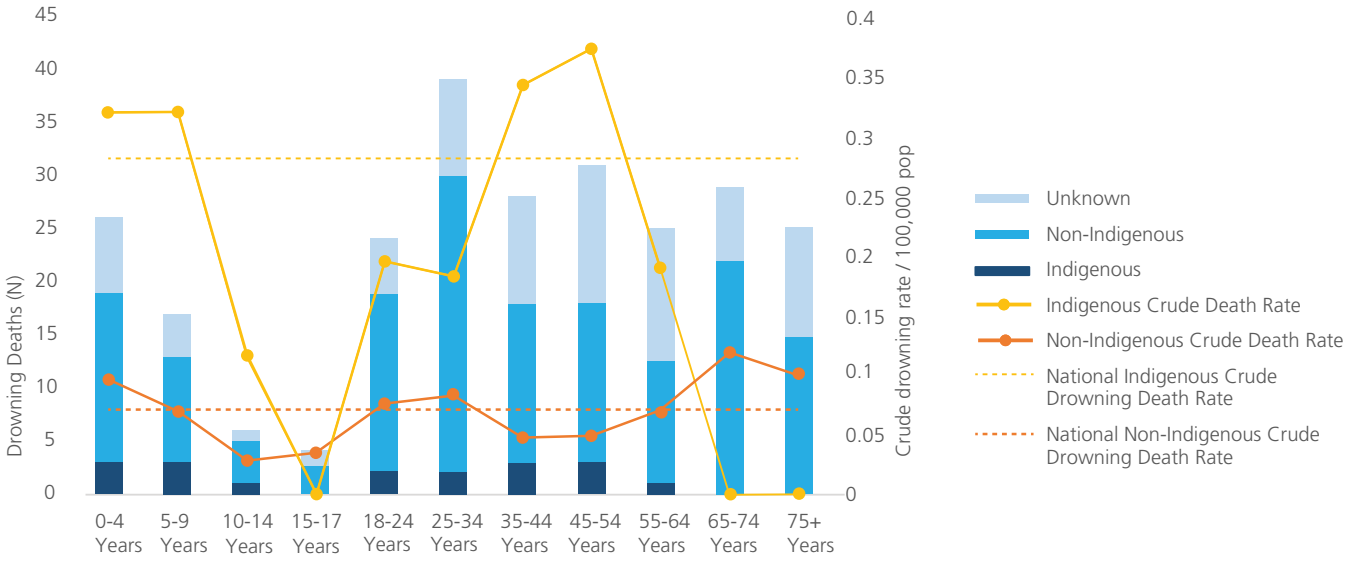


Figure 12: Drowning deaths in lakes, dams and lagoons by Aboriginal and Torres Strait Islander status and age 2008/09 – 2017/18 (N=254)

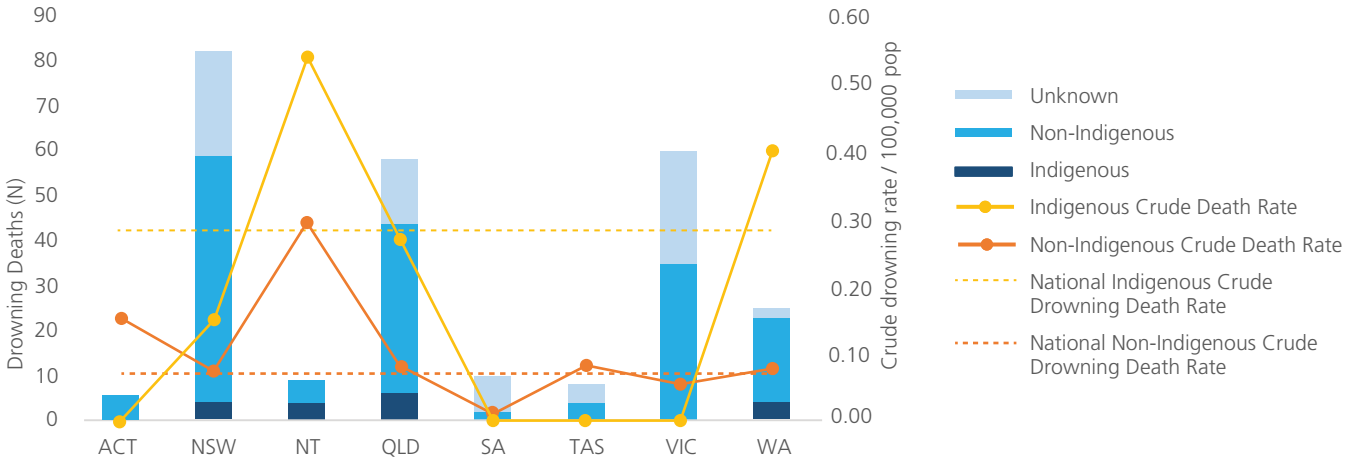


Figure 13: Drowning deaths in lakes, dams and lagoons in Australia by state and crude death rate per 100,000 population, 2008/09 – 2017/18 (N=255)

Socioeconomic status

Over one quarter (29.0%) of those who drowned in the study were known to reside in areas of low socioeconomic advantage (IRSAD). Drowning deaths that occurred in dams recorded the highest proportion of people from low socioeconomic advantage (31.3%), compared to lakes (27.7%) and lagoons (23.1%).

When analysing the IRSAD on the 10 point scale, dams recorded 16.2% (N=18) of people with an IRSAD of 1 (Figure 14), indicating significantly low socioeconomic advantage. Lakes displayed a bimodal presentation, 13.8% (N=18) of people recording an IRSAD of 4 and, 11.5% (N=15) recording an IRSAD of 8, indicating that socioeconomic disadvantage was associated to a lesser extent in lake drowning deaths.

It was found that regardless of location, as rurality increased so did the increase in socioeconomic disadvantage. The same distinction between rurality and State/Territory was also seen. The socioeconomic impact between states/territories varied, with Northern Territory (55.6%), Tasmania (50.0%), South Australia (40.0%), Queensland (37.93%), and NSW (31.7%) registering higher levels of socioeconomic disadvantage than the national average for lake, dam and lagoon deaths (Figure 15).

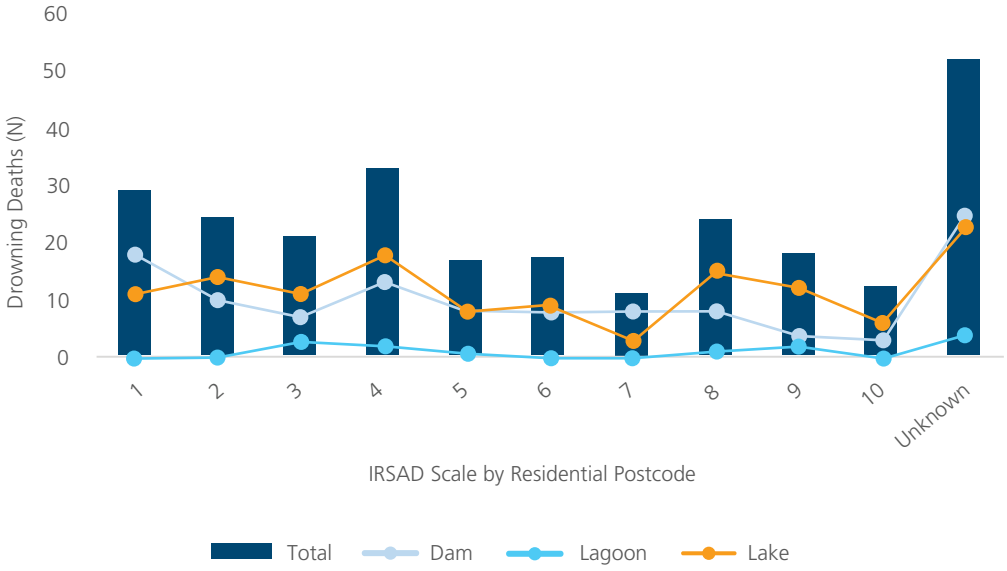


Figure 14: Drowning deaths in lakes, dams and lagoons by IRSAD, 2008/09 – 2017/18 (N=255)

Figure 15: Drowning deaths in lakes, dams and lagoons by socioeconomic status, 2008/09 – 2017/18 (N=255)

Employment

The employment status of the individuals reflects the age distribution across the locations. Employed individuals represented 27.5% of people who drowned in this study (N=70), which was seen uniformly across all three locations. Retired individuals represented 18.4% of the drowning fatalities (N=47), followed by unemployed people (12.2%, N=31), and students (10.6%, N=27). Due to the large incidence of young children experiencing a fatal drowning in the dam, dam employment differed to lakes and lagoons; children not at school were represented more highly at this location (Figure 16). Of the employed individuals who drowned in a dam, self-employed individuals were overrepresented when compared to other locations.

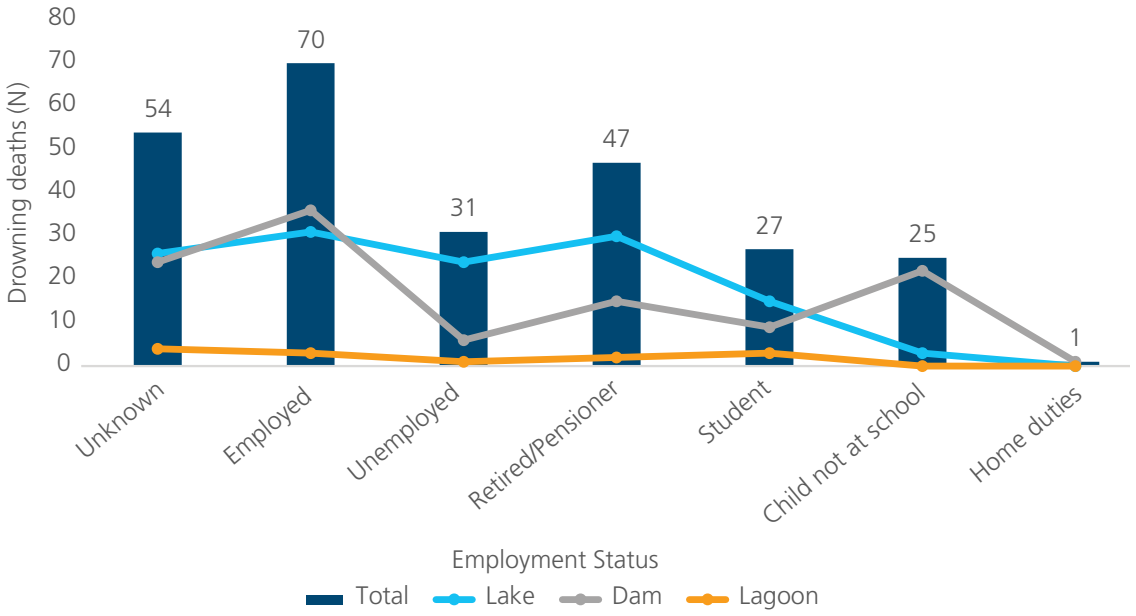
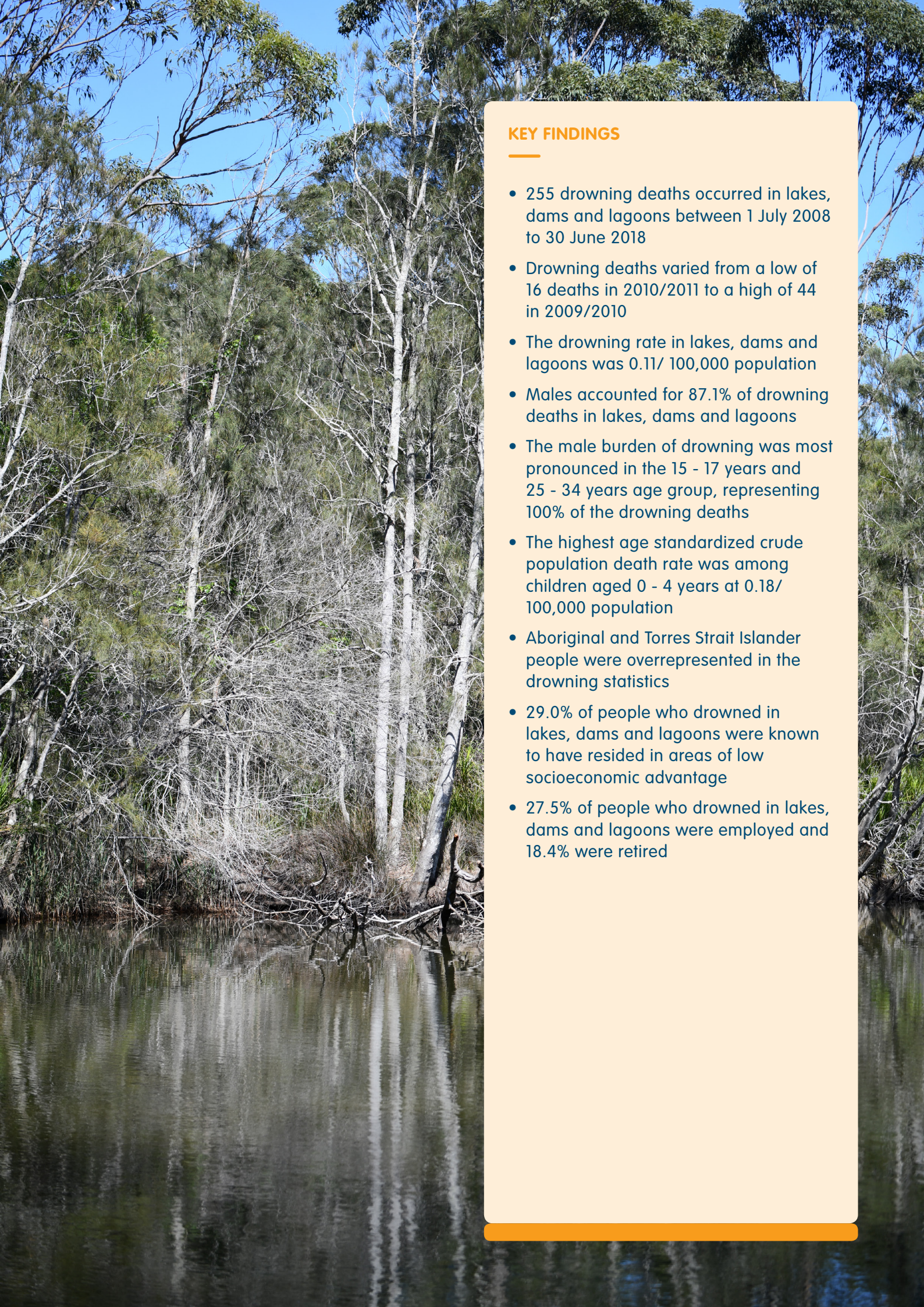


Figure 16: Drowning deaths in lakes, dams and lagoons by employment classification 2008/09 – 2017/18 (N=255)



KEY FINDINGS

- 255 drowning deaths occurred in lakes, dams and lagoons between 1 July 2008 to 30 June 2018
- Drowning deaths varied from a low of 16 deaths in 2010/2011 to a high of 44 in 2009/2010
- The drowning rate in lakes, dams and lagoons was 0.11/ 100,000 population
- Males accounted for 87.1% of drowning deaths in lakes, dams and lagoons
- The male burden of drowning was most pronounced in the 15 - 17 years and 25 - 34 years age group, representing 100% of the drowning deaths
- The highest age standardized crude population death rate was among children aged 0 - 4 years at 0.18/ 100,000 population
- Aboriginal and Torres Strait Islander people were overrepresented in the drowning statistics
- 29.0% of people who drowned in lakes, dams and lagoons were known to have resided in areas of low socioeconomic advantage
- 27.5% of people who drowned in lakes, dams and lagoons were employed and 18.4% were retired

CASE STUDY: **WORK-RELATED DROWNING DEATHS**

Dams were the only location to record work-related drowning deaths. Where working status was known, 32.2% of dam drowning deaths were work-related (or had an association to work-related activities). Males accounted for 89.7% of all work-related drowning deaths. Private or residential dams had a significantly larger proportion of work-related drowning deaths than public access dams, (43.3% vs. 10.0%) (Figure 17).

This could be associated with the main activities being undertaken at these different locations. Of these drowning deaths, 65.5% took place on an agricultural property. When examining only the private or residential dams, 85.7% were based in an agricultural industry. Of the work-related deaths at a dam location, 59.3% occurred when the person was working alone.

When examined by age, people aged 55 years and over accounted for 44.8% of work-related deaths, followed by children aged 0 - 4 years (27.0%) (Figure 18). The most common activities contributing to work-related drowning deaths in dams included: non-aquatic transport such as entering the dam by accident (quadbikes, tractors, helicopters and vehicles), maintenance of water pumps, parents working on machinery while supervising children, and agricultural mustering accidents. The majority of deaths (73.3%) occurred during the day, between the hours of 6:00am and 6:00pm.

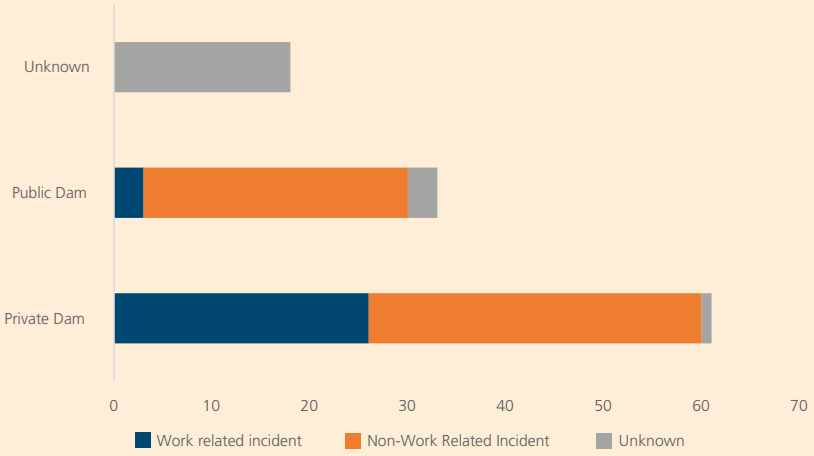


Figure 17: Dam drowning deaths by dam classification and work-related deaths, 2008/09 – 2017/18 (N=112)

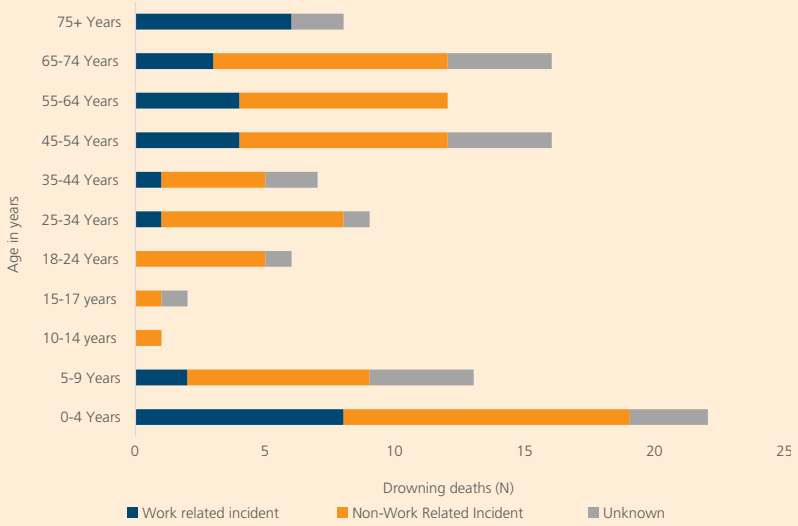


Figure 18: Dam drowning deaths by age and working-related deaths, 2008/09 – 2017/18 (N=112)

Where and when do drowning deaths occur?

Location

Lakes were the leading location for drowning, accounting for 51.0% of deaths (N=130). Dams accounted for the second highest number of deaths (43.9%, N=112), followed by lagoons (5.1%, N=13). (Figure 19)

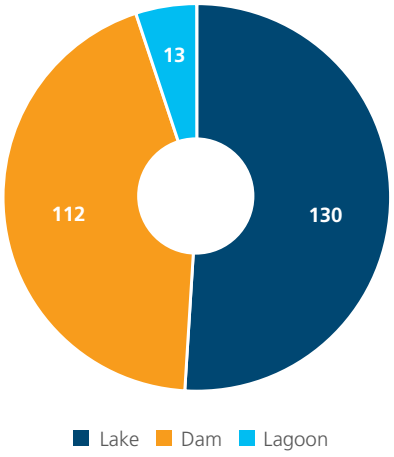


Figure 19: Drowning deaths in lakes, dams and lagoons, 2008/09 – 2017/18 (N=255)

Of the 112 dam drowning deaths, 61 (64.9%) took place in a dam located on a private or residential piece of land, 33 dams were open to public access. The dam classification was unable to be determined in 18 cases (Figure 20). Agricultural or farm locations represented 38.1% of all drowning deaths that occurred in a dam. When only examining the private or residential dams, 68.9% of these deaths were identified as agricultural industry related.

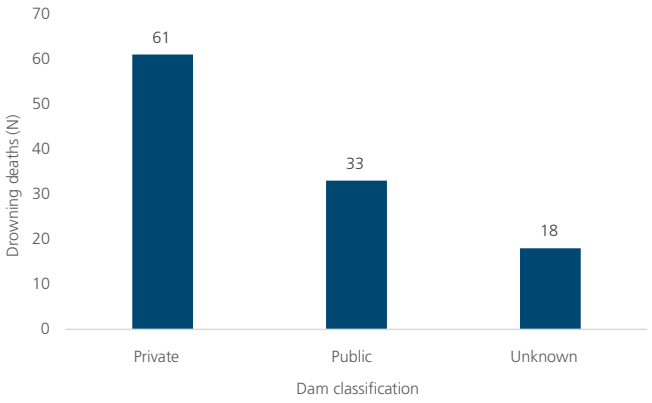


Figure 20: Dam drowning deaths by private/residential or public land, 2008/09 – 2017/18 (N=112)

Over the ten year analysis, there were several lakes, dams and lagoons that recorded multiple drowning deaths. With respect to the frequency of drowning death by all locations, residential bodies of water represented the highest burden of drowning deaths (27.8%). When examining only lakes, Lake Macquarie experienced the highest burden of drowning deaths across all locations with six deaths (Table 1).

Rank	Body of Water Name	State/ Territory	Number of drowning deaths*
1	Lake Macquarie	NSW	6 (4.6%)
2	Lake Eildon	Victoria	5 (3.8%)
3	Lake Hume	NSW	4 (3.1%)
=	St George Basin	NSW	4 (3.1%)
=	Lake Wivenhoe	Queensland	4 (3.1%)
4	Lake Burley Griffin	ACT	3 (2.3%)
=	Tuggerah Lake	NSW	3 (2.3%)
=	Lake Kununurra	Western Australia	3 (2.3%)

*% of all lake drowning deaths

Table 1: Lake drowning black spots by frequency of drowning deaths and State/Territory location (N=130)

When examined by State/Territory and total drowning death during the study period, ACT recorded the highest proportion of drowning deaths in lakes, dams and lagoons (26.1%), followed by Victoria (15.1%). South Australia, recorded the lowest proportion (6.5%) (Figure 21).

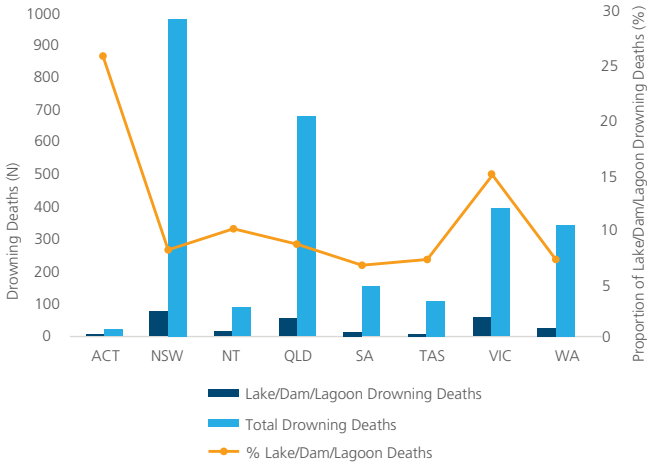


Figure 21: Proportion of drowning deaths occurring in lakes, dams and lagoons by State/Territory, 2008/09 – 2017/18 (N=2781)

When analysing only the proportion of lake, dam and lagoon drowning deaths, 31% occurred in NSW, followed by Victoria (24%), and Queensland (23%).

The Northern Territory had the highest overall crude death rate (0.41/100,000), followed by the ACT and Tasmania (0.16/100,000). The lowest crude death rate was seen in South Australia (0.06/100,000).

Crude drowning rates varied when analysed by location and State/Territory. The national lake crude drowning rate was 0.06/100,000 population, of which the ACT (0.16), Northern Territory (0.18) and Tasmania (0.08) all recorded higher crude drowning rates. The national crude drowning rate for dams was 0.05/100,000 population. Northern Territory (0.18), Queensland (0.08) and Tasmania (0.06) all recorded increased rates compared to the national average. The Northern Territory (0.05) and Tasmania (0.02) were the only states that recorded a crude drowning rate greater than national drowning death rate for lagoons of 0.01/100,000 population (Figure 22).

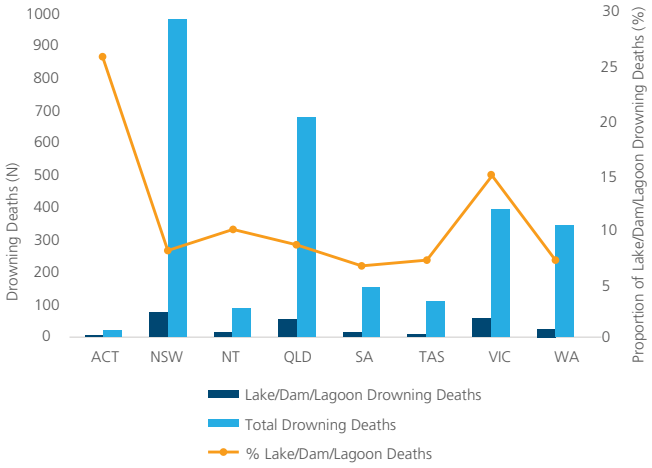


Figure 22: Crude drowning deaths rates in lakes, dams and lagoons by State/Territory per 100,000 population, 2008/09 – 2017/18 (N=255)

Remoteness

When analysed by remoteness, 59.7% of drowning deaths occurred in major cities (N=62) and inner regional areas (N=89), and 11.5% occurred in remote (N=15) or very remote (N=14) locations. When the crude drowning rate was applied to the population a positive correlation was seen between remoteness and number of drowning deaths. As rurality increases, so did the crude drowning rate in lakes, dams and lagoons (Figure 23).

Remote and very remote locations had a drowning rate of 0.51 and 0.75/100,000 population respectively, compared to major cities (0.04/100,000 population) and inner regional areas (0.22/100,000 population). Drowning rates in remote (12.6 times higher) and very remote locations (18.8 times greater) were both significantly greater than the national drowning rate. Major cities were the only classification to record a drowning rate lower than the national lake, dam and lagoon drowning rate, with inner regional (1.9 times higher), outer regional (3.4 times higher), remote (4.6 times higher) and very remote (6.8 times higher) than the national average crude drowning rate for lakes, dams and lagoons.

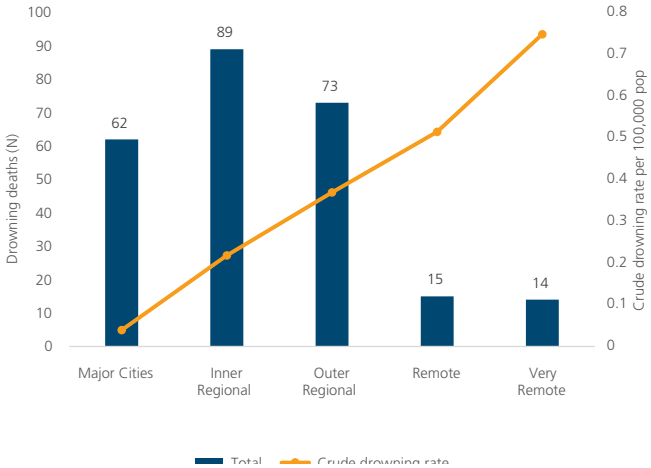


Figure 23: Drowning deaths in lakes, dams and lagoons by remoteness classification of drowning deaths and crude death rate per 100,000 population, 2008/09 – 2017/18 (N=253)

When examining remoteness by Aboriginal and Torres Strait Islanders status, a similar trend was seen. Major cities reported a drowning rate among Aboriginal and Torres Strait Islander population of 0.07/100,000 (compared to 0.03 non-Indigenous population), and very remote locations recorded an Indigenous drowning rate of 0.63/100,000 Aboriginal and Torres Strait Islander population (compared to 0.66 non-Indigenous population). There were no Aboriginal and Torres Strait Islander drowning deaths recorded in remote locations.

Outer regional represented the area with the greatest difference between Aboriginal and Torres Strait Islander (0.37/100,000 population) and non-Indigenous crude drowning rates (0.23/100,000) in lakes, dams and lagoons. Outer regional and very remote locations were the only locations to record a higher crude drowning rate for the Aboriginal and Torres Strait Islander population.

Visitor Status

When analysing by visitor status (yes or no), across the three locations, lagoons recorded the highest proportion of visitor drowning deaths (62.5%) compared to any other location. Dams recorded the highest proportion of non-visitor drowning deaths (87.5%). This could be reflected by the number of drowning deaths that took place at a private or residential dam.

When analysing remoteness by visitor status (yes or no), it was found that as the location moves from major cities to outer regional areas, the percentage of visitor drowning deaths increased, to a high of 48.9% in outer regional locations (Figure 24).

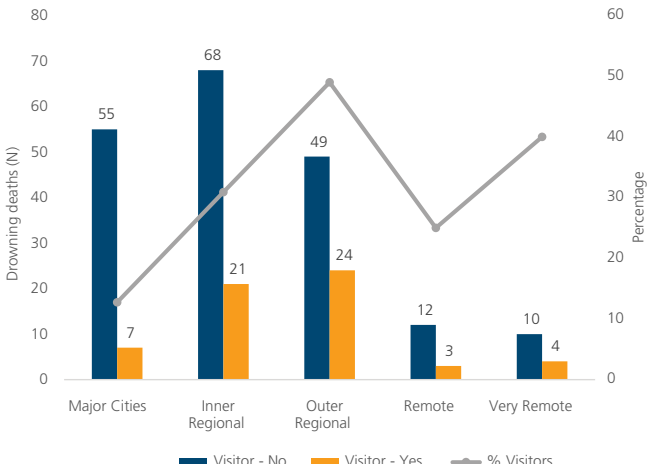


Figure 24: Drowning deaths in lakes, dams and lagoons by remoteness classification of drowning deaths and visitor status, 2008/09 – 2017/18 (N=253)

KEY FINDINGS

- Over half of all drowning deaths in this study occurred in a lake (51.0%), and 43.9% occurred in a dam
- The majority of dam drowning deaths took place on private or a residential piece of land (54.0%)
- Lake Macquarie recorded the highest burden of drowning deaths across all locations
- The Northern Territory recorded the highest crude drowning rate of 0.41 deaths/100,000 population followed by the ACT and Tasmania (0.16/100,000 each)
- South Australia recorded the lowest crude drowning rate of 0.06/100,000 population
- 59.7% of drowning deaths occurred in major cities or inner regional areas
- As rurality increased, so did the crude drowning rate, with remote and very remote having a rate of 0.51/100,000 and 0.75/100,000
- Lagoons recorded the highest proportion of visitor drowning deaths (87.5%)
- Drowning deaths in dams had a non-visitor population of 82.3%, influenced by the number of private or residential drowning deaths
- The percentage of visitor drowning deaths increased from major cities to outer regional areas

Time of Drowning Deaths

Season

Drowning deaths occurred all year round, with the highest proportion occurring in summer (36.5%, N=93), followed by spring (22.8%, N=58) (Figure 25). When analysed by location, there was variance between seasons. Drowning deaths in dams featured more highly in autumn and winter, whereas drowning in lakes and lagoons was more common in summer and spring.

During summer, the activities most commonly undertaken prior to drowning were swimming and recreating (28.0%), followed by a fall (24.7%). Of people who drowned during a rescue event, 75.0% occurred in summer. During winter, the most common activity prior to drowning was a fall (27.1%), followed by boating (18.8%) and using watercraft (14.6%).

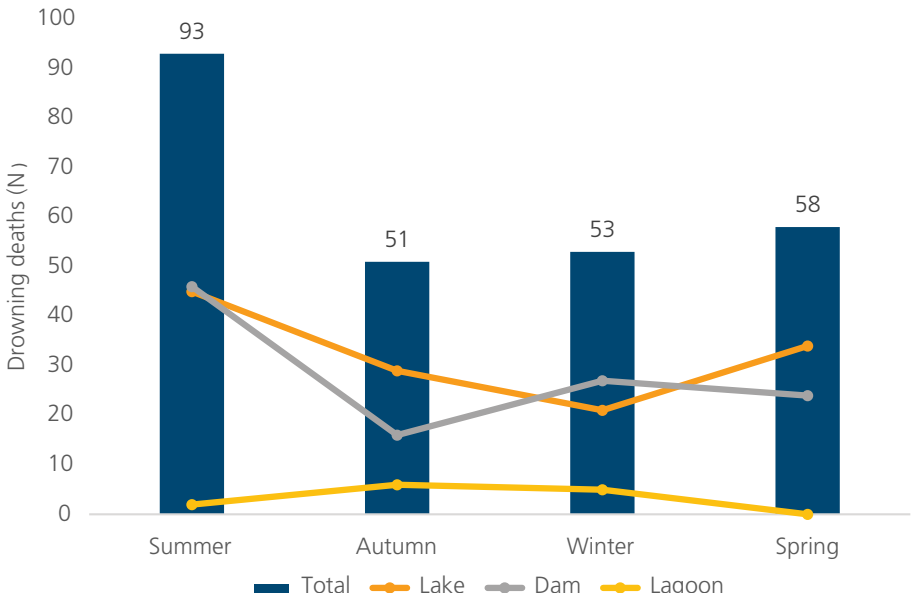


Figure 25: Drowning deaths in lakes, dams and lagoons by season, 2008/09 – 2017/18 (N=255)

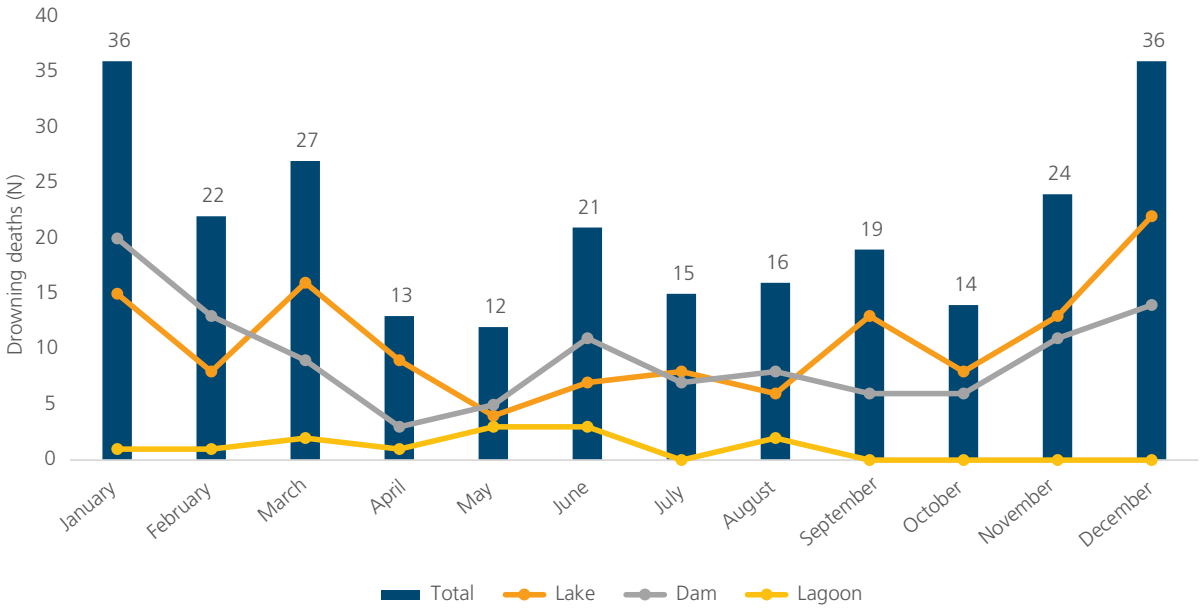


Figure 26: Drowning deaths in lakes, dams and lagoons by month, 2008/09 – 2017/18 (N=255)

Month

Aligning with the seasonal trends for drowning, the highest number of deaths occurred equally in January and December (14.1% each). The lowest number of deaths occurred in May (4.7%) and April (5.1%) (Figure 26). When broken down by location, there was variance between month distributions. Over the study period, the highest incidence of drowning deaths per month in a lake, dam and lagoon was seven (Figure 27).

Day of Week

More people drowned on weekends than weekdays, with Sunday accounting for 22.0% (N=56) and Saturdays accounting for 15.3% (N=39) of total deaths. The lowest number of deaths occurred on Monday (9.0%, N=23) and Tuesday (9.8%, N=35) (Figure 28). This trend of drowning deaths was seen consistently across all locations.

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
2008-2009	1	2	2	2	1	1	3	1	2	0	1	4
2009-2010	2	3	2	2	4	5	6	7	6	3	1	3
2010-2011	1	1	0	0	2	1	2	3	3	0	1	2
2011-2012	3	2	2	4	0	5	3	2	2	0	1	1
2012-2013	2	2	5	2	1	3	2	2	2	1	3	1
2013-2014	0	0	1	1	3	6	2	2	2	5	0	3
2014-2015	1	1	1	3	5	2	5	0	3	1	2	2
2015-2016	4	2	2	0	4	2	4	0	1	0	1	1
2016-2017	0	0	4	0	2	7	4	4	5	3	0	2
2017-2018	1	3	0	0	2	4	5	1	1	0	2	2

Figure 27: Drowning deaths in lakes, dams and lagoons by financial year and month, 2008/09 – 2017/18 (N=255)

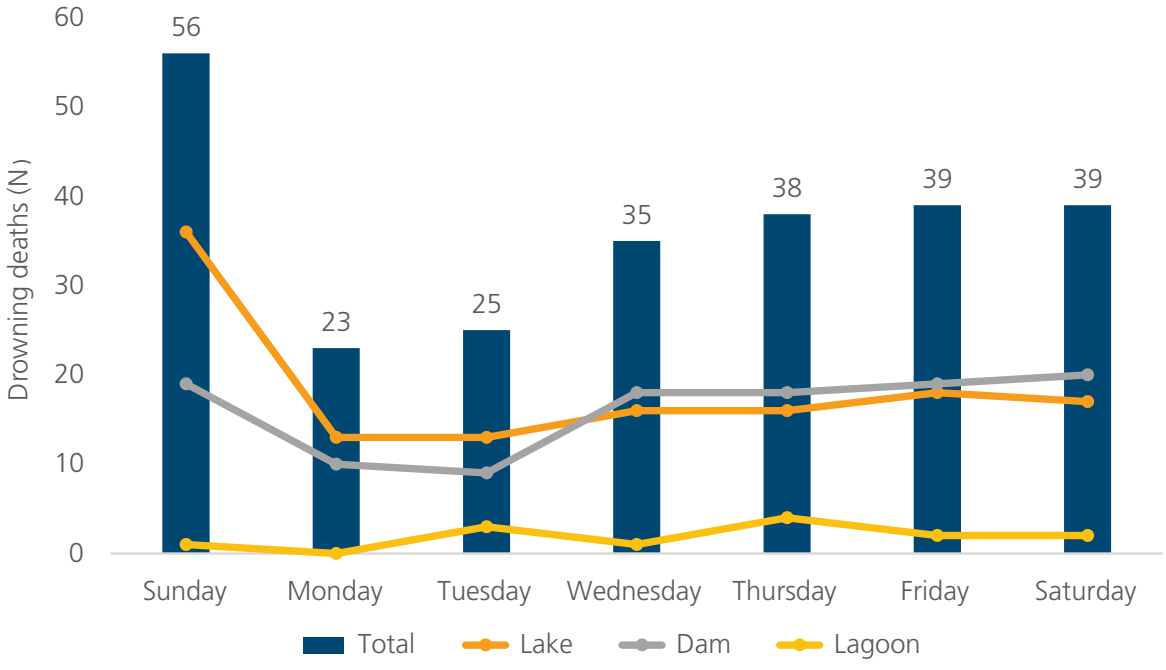


Figure 28: Drowning deaths in lakes, dams and lagoons by day of week, 2008/09 – 2017/18 (N=255)

Time of day

Almost half (47.8%, N=122) of deaths occurred in the afternoon (12:01pm and 6.00pm). A similar proportion of people drowned in the morning (12.01am to 6.00am) (22.4%, N=57) as the evening (6:01pm – 12:00am) (19.6%, N=50). A further 5.1% (N=13) of drowning deaths occurred in the hours of the early morning (12:01am – 6:00am). The time of drowning was unknown in 5.1% of cases (Figure 29). This distribution was seen across all locations.

In the early morning, the leading activities prior to drowning was swimming and recreating (30.8%) and non-aquatic transport deaths (23.1%), and in the morning hours were a fall (21.1%) and non-aquatic transport (15.8%). A similar scenario was seen during the afternoon, with swimming and recreating and a fall each accounting for 23.8% of drowning deaths. During the evening, swimming and recreating (24.0%) and fall (22.0%) were the most common activities. (Figure 30).

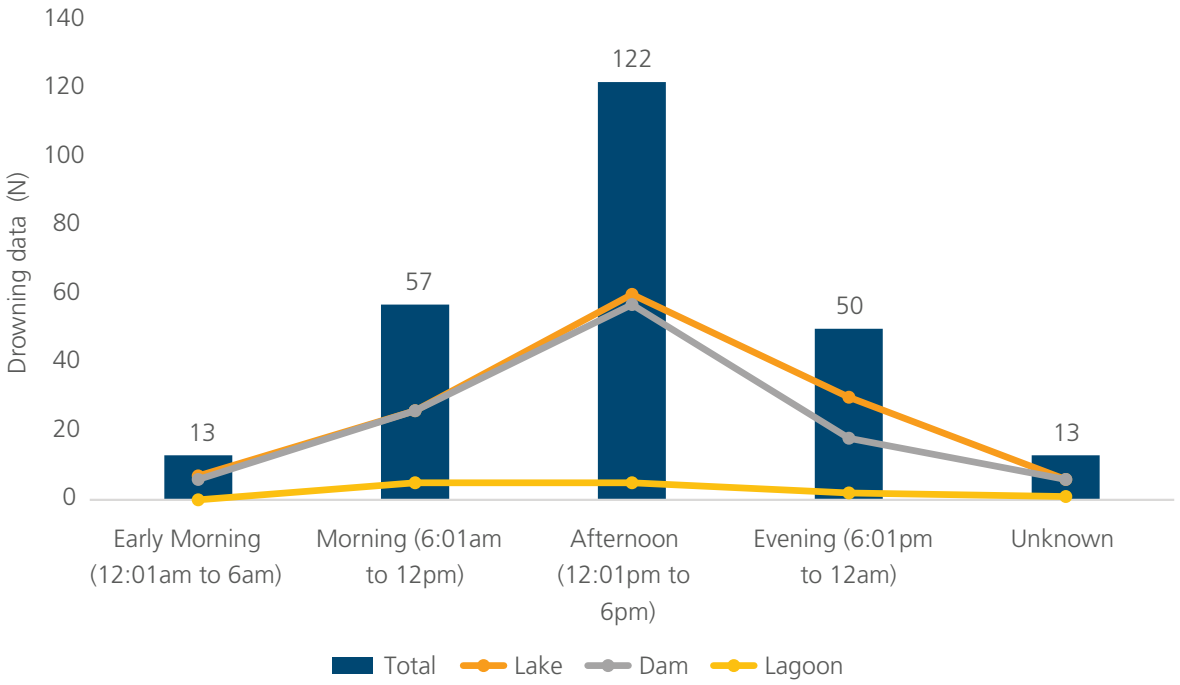


Figure 29: Drowning deaths in lakes, dams and lagoons by time of drowning, 2008/09 – 2017/18 (N=255)

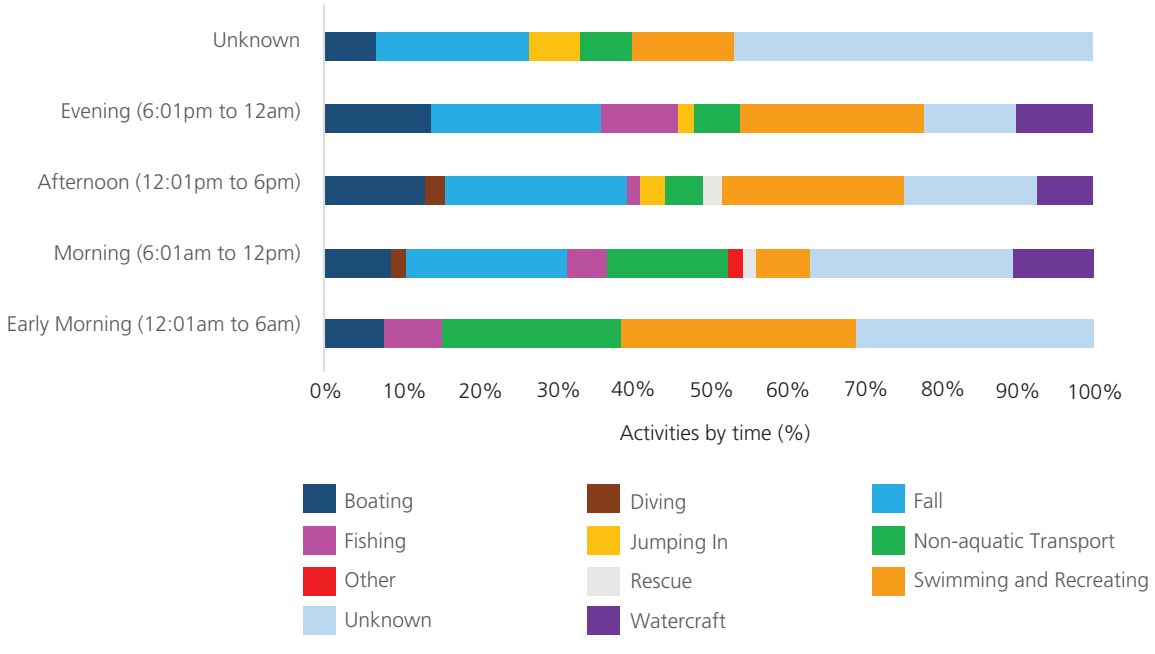
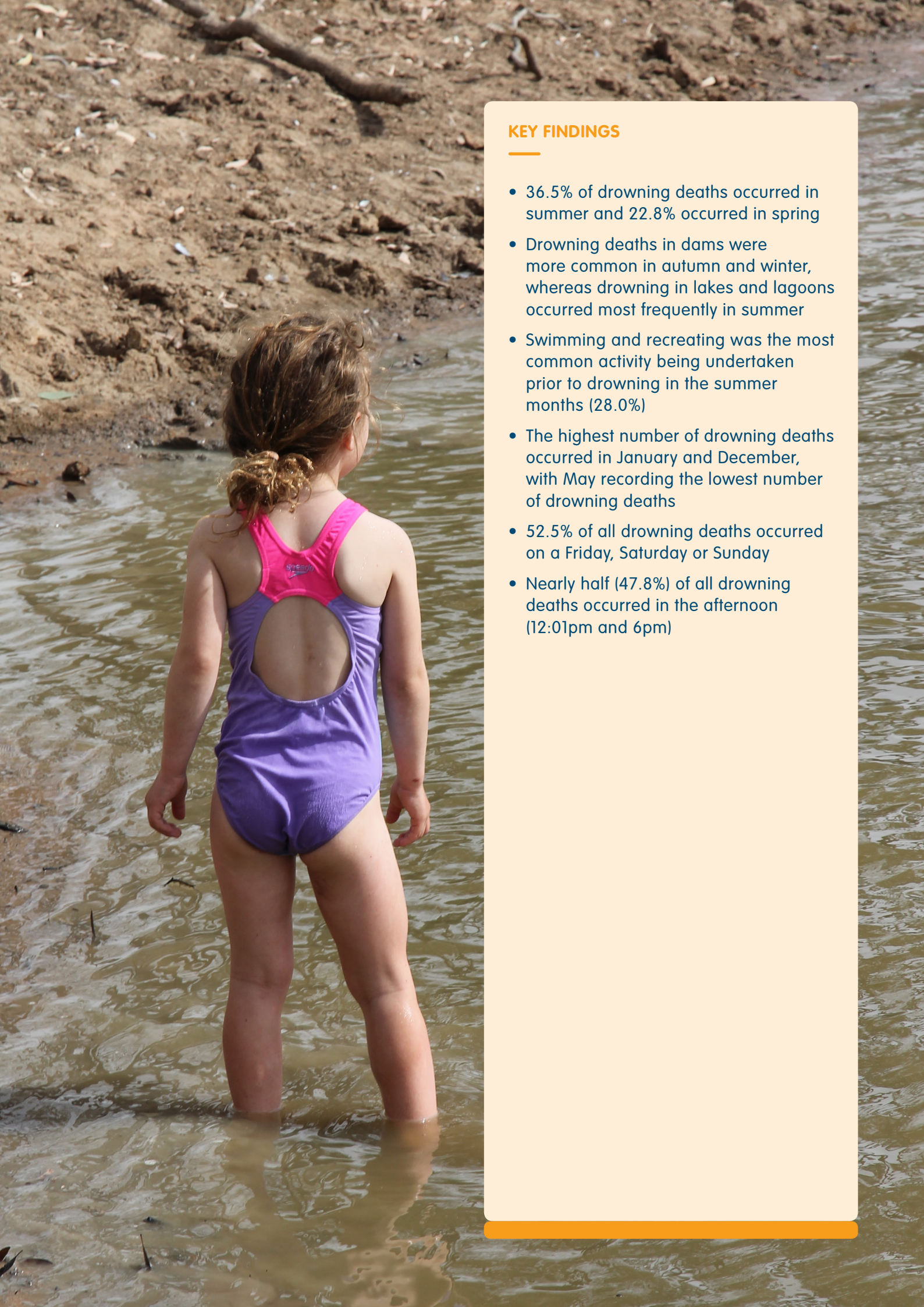


Figure 30: Drowning deaths in lakes, dams and lagoons by time of drowning, 2008/09 – 2017/18 (N=255)



KEY FINDINGS

- 36.5% of drowning deaths occurred in summer and 22.8% occurred in spring
- Drowning deaths in dams were more common in autumn and winter, whereas drowning in lakes and lagoons occurred most frequently in summer
- Swimming and recreating was the most common activity being undertaken prior to drowning in the summer months (28.0%)
- The highest number of drowning deaths occurred in January and December, with May recording the lowest number of drowning deaths
- 52.5% of all drowning deaths occurred on a Friday, Saturday or Sunday
- Nearly half (47.8%) of all drowning deaths occurred in the afternoon (12:01pm and 6pm)

Activity

This study found that a diverse range of activities were being undertaken across the three locations. Drowning deaths most frequently occurred as a result of a fall (21.7%, N=55), followed by swimming and recreating (20.4%, N=52) and boating (11.8%, N=30) (Figure 31). When analysed by sex and activity, swimming and recreating was the most common activity for males (20.7%) and second most common for females (18.2%). The leading cause for females was a fall into the water (33.3%), which was the second most common for men (19.8%).

Activity prior to drowning was unknown in approximately 20.4% of drowning deaths, which indicates that there are more people undertaking aquatic activities alone than at river locations (18.0%) which can increase their risk of drowning. This may also highlight the remote nature of some of the lake, dam and lagoon locations and a potential lack of witnesses to a number of drowning deaths. The large number of open cases, would also impact this finding.

When comparing the activities between the three locations, there was some variance in activity. In lakes, the most common activity was swimming and recreating (27.7%) followed by boating (19.2%), and a fall (10.0%). In contrast, at dams, falls represented 36.6% of all deaths, followed by non-aquatic transport (14.2%) and swimming and recreating (12.5%). Both lakes and dams had a high number of deaths with unknown activity recorded (16.2% and 25.0% respectively).

Differences were evident when analysed by activity and age group (Table 2). All drowning deaths in children aged 0 - 4 years were attributed to a fall. The distribution of activity and age group can be seen in Table 2. Older age groups related mainly to recreating activities or risk-taking behaviour. These activity-age distribution was uniform across all locations.

KEY FINDINGS

- Falls were the most common activity prior to drowning (21.7%), followed by swimming and recreating (20.4%) and boating (11.8%)
- For males, the most common activities were swimming and recreating (20.7%), and a fall (19.8%)
- For females, the most common activities were a fall (33.3%), and swimming and recreating (18.2%)
- In lakes, the most common activities prior to drowning were swimming and recreating (27.1%) and boating (19.2%)
- In dams, the most common activities prior to drowning was a fall (36.6%), and non-aquatic transport (14.2%)
- Falls represented 100% of drowning deaths among children aged 0 - 4 years

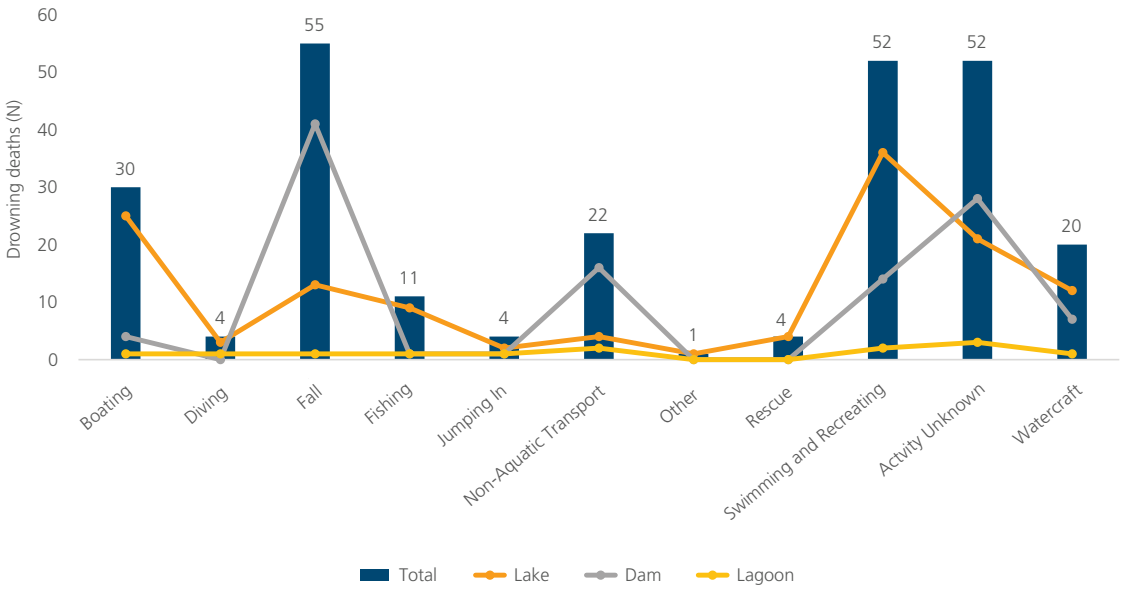


Figure 31: Drowning deaths in lakes, dams and lagoons by activity, 2008/09 – 2017/18 (N=255)

Table 2: Lead activity prior to drowning in lakes, dams and lagoon by age group, 2008/09 – 2017/18

Rank	0-4 Years	5-9 Years	10-14 Years	15-17 Years	18-24 Years	25-34 Years	35-44 Years	45-54 Years	55-64 Years	65-74 Years	75 + Years	Total
1	Fall	Swimming and Recreating	Swimming and Recreating	Swimming and Recreating	Swimming and Recreating	Swimming and Recreating	Watercraft	Swimming and Recreating	Unknown	Unknown	Fall	Fall
2		Fall	Boating	Non-Aquatic	Boating	Boating	Swimming and Recreating	Unknown	Watercraft	Fall	Unknown	Swimming and Recreating
3		Unknown	Rescue	Fishing	Non-Aquatic	Watercraft	Boating	Boating	Fall	Non-Aquatic	Non-Aquatic	Unknown
4		Watercraft			Unknown	Fall	Fall	Non-Aquatic	Boating	Boating	Fishing	Boating
5					Watercraft	Fishing	Unknown	Diving	Swimming and Recreating	Fishing	Boating	Non-Aquatic
6					Jumped In	Jumped In	Non-Aquatic	Fall	Non-Aquatic	Swimming and Recreating		Watercraft
7					Fall	Non-Aquatic	Rescue	Watercraft	Other			Fishing
8						Rescue	Diving	Rescue				Jumped In
9						Diving						Rescue
10												Diving
11												Other

CASE STUDY: **PERSON ALONE DURING THE DROWNING INCIDENT**

A total of 107 (41.9%) drowning deaths occurred when the person was alone. With the unknown cases removed, there was an equal split of people alone compared to people not alone (N=107).

The distribution did not vary across location: lakes 43.4%, dams 40.7% and lagoons 38.5% recording the person as being alone at the time of drowning (Figure 32). Males were more likely to be alone at the time of death compared to females (40.9% males compared to 48.5% females). In cases where the person was recorded to be alone was seen to impact attempted CPR rates, 21.1% of people alone had CPR administered compared to 44.8% of people not alone.

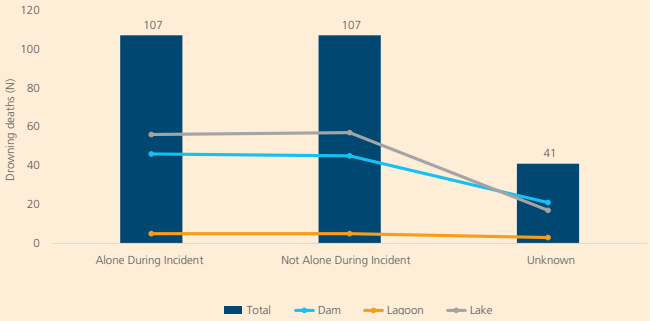


Figure 32: Drowning deaths in lakes, dams and lagoons of people found to be alone during drowning event, 2008/09 – 2017/18 (N=255)

The largest proportion of individuals being alone at the time of death were reported in Tasmania (62.5%) and Victoria (50.8%). The states/territories that recorded the lowest proportion of people alone were South Australia (30.0%) and Queensland (31.0%).

This study found that as remoteness increased (from major cities towards very remote areas), there was a negative correlation in the proportion of people found to be alone, for example, the proportion of people alone decreased as rurality increased. The highest proportion of people alone during a drowning death was in the major cities (58.3%) and the lowest in very remote locations (33.3%) (Figure 33).

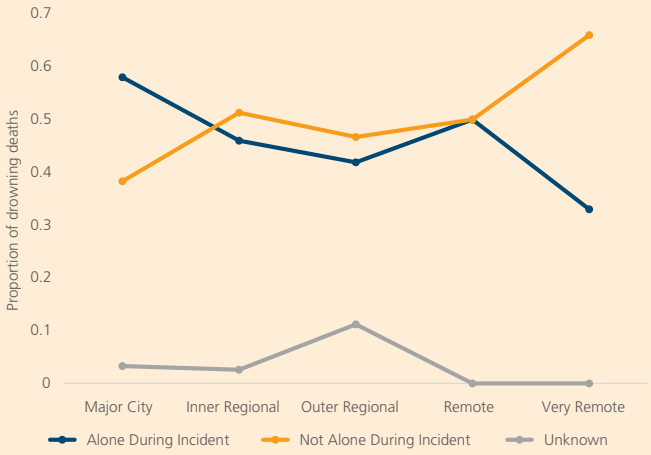


Figure 33: Drowning deaths in lakes, dams and lagoons of people found to be alone during drowning event and remoteness, 2008/09 – 2017/18 (N=225)

The likelihood of someone being alone when they drowned impacted by age, which reflects both the activities being undertaken and the supervision aspect involved in children. Older people who drowned were more likely to be alone; 80.0% of people aged 75 years and over, 80.0% of those aged 55 - 64 years and 65.0% of those aged 65 -7 4 years. Age groups found to be least likely alone were those aged 25 – 34 years (23.1%) and 15 - 17 years (25.0%). Almost one third (30.8%) of children aged 0-4 years were found to be alone at the time of death. (Figure 34)

Activity also appeared to have an effect on the distribution of people alone. Fishing and non-aquatic transport drowning deaths had the highest proportion of people found to be alone (81.8% and 68.1% respectively). Swimming and recreating was the least likely activity for someone was found alone (9.8%).

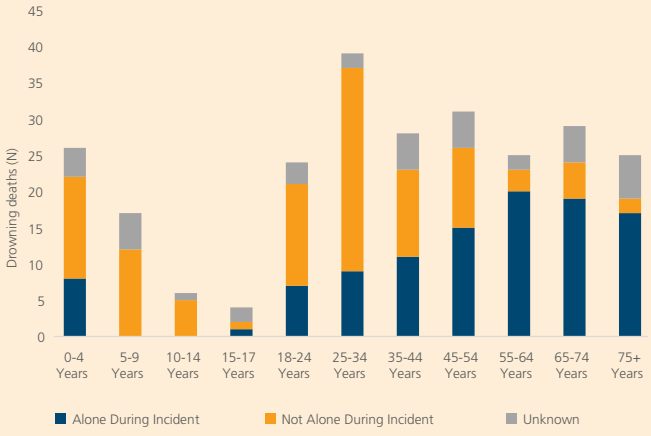


Figure 34: Drowning deaths in lakes, dams and lagoons of people found to be alone during drowning event and age, 2008/09 – 2017/18 (N=254)

Risk Factors

Alcohol and Drugs

Alcohol was known to be involved in 30.6% (N=78) of all drowning deaths in this study. The recorded blood alcohol concentration (BAC) levels ranged from 0.0 g/L to 0.4 g/L. In 58 cases alcohol involvement was unknown, suggesting the association between drowning events and alcohol may be larger than currently estimated (Figure 35).

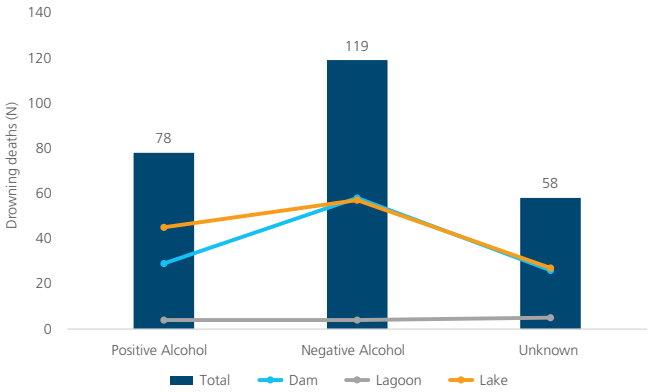


Figure 35: Drowning deaths in lakes, dams and lagoons by positive alcohol reading, 2008/09 – 2017/18 (N=255)

The involvement of alcohol was seen across all three locations, with 34.9% of lake drowning deaths, 30.8% of lagoon and 25.7% of dam deaths recorded a positive alcohol reading. Dams recorded the lowest level of alcohol readings.

Of the 78 cases known to involve alcohol, 92.3% were male. The highest proportion of alcohol-related drowning deaths was found in the 25 - 34 years age group (20.5%), followed by those aged 18 - 24 years (17.9%) and 45 - 54 years (16.7%).

Over half (55.6%) of all Aboriginal and Torres Strait Islander cases had a positive alcohol reading, compared to 28.2% of all non-Indigenous cases (Figure 36).

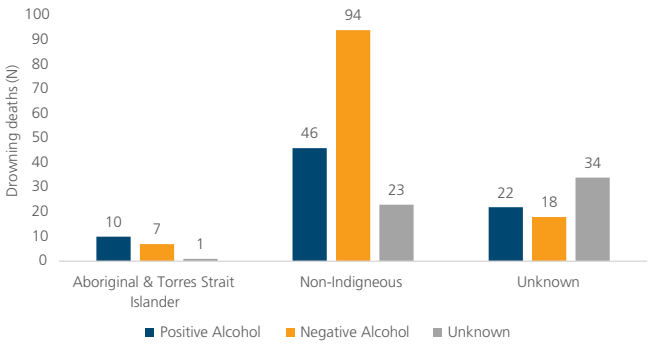


Figure 36: Drowning deaths in lakes, dams and lagoons by positive alcohol toxicology and Aboriginal and Torres Strait Islander status, 2008/09 – 2017/18 (N=255)

When examining alcohol involvement in each State/Territory, the Northern Territory recorded the highest proportion of alcohol-related drowning deaths (77.8%), followed by the ACT (50.0%) and Western Australia (37.5%). The states/territories differed significantly in regards to the proportion of unknown alcohol records, which could significantly impact the proportion seen per state. The states/territories that recorded the lowest number of alcohol unknown cases were Western Australia (4.2%) and Northern Territory (11.1%). Care must be taken when interpreting these findings to the high number of alcohol unknown cases, as this may not accurately reflect the true nature of alcohol-related drowning deaths.

When season of drowning and known alcohol involvement were analysed, alcohol related drowning deaths were evenly spread between seasons, with spring showing the highest proportion of alcohol-related drowning deaths (36.2%), followed by autumn (35.3%) and winter (30.2%). Summer recorded the least (24.7%).

Swimming and recreating recorded the highest proportion of alcohol related deaths (51.0%), followed by boating (43.3%). A fall into water accounted for the lowest proportion of alcohol-related deaths (11.0%).

Drowning deaths where alcohol was judged to be a contributory factor

A BAC equal to or higher than 0.05g/L (BAC ≥0.05%) (the legal limit for operating a motor vehicle) was deemed to be a contributory factor in a drowning death. Alcohol was deemed to be a contributory factor in 74.0% of cases where alcohol was known to be involved. This distribution was consistently seen across all three locations; lakes 77.8%, dams 69.0% and lagoons 75.0% respectively (Figure 37).

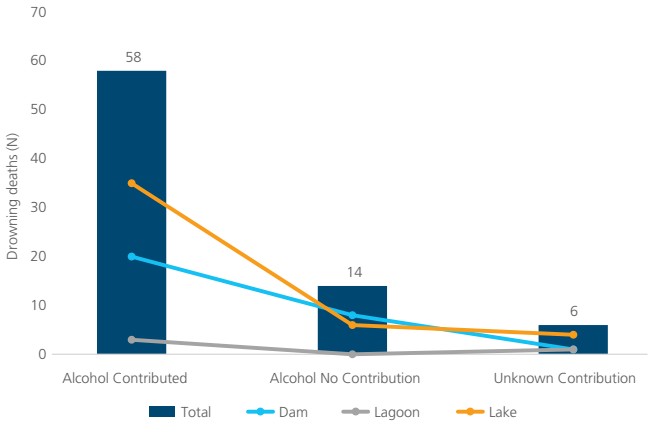


Figure 37: Drowning deaths in lakes, dams and lagoons by contributory factor of positive alcohol toxicology, 2008/09 – 2017/18 (N=78)

Where alcohol was deemed to be a contributory factor for, males accounted for 94.8% of cases. Alcohol was more likely to be a contributory factor in people aged 18 - 24 years (92.9% of deaths in this age group involved alcohol), followed by the 45 - 54 and 35 - 44 years age group, 84.6% and 72.7% respectively.

When analysed by State/Territory, Western Australia had the largest proportion of drowning deaths where alcohol was deemed a contributory factor, with 100% of all alcohol-related drowning deaths recording a BAC ≥0.05g/L. This was followed by Northern Territory (85.7%) and NSW (79.1%). No deaths in Tasmania recorded alcohol as a contributory factor. South Australia (33.3%) recorded the lowest proportion of alcohol-related deaths considered a contributory factor to the drowning.

When analysing alcohol-related cases by activity, 41.1% of swimming and recreating, 33.3% of boating cases and 22.7% of non-aquatic transport cases involving alcohol recorded a BAC ≥0.05g/L.

Of cases where alcohol was considered to be a contributing factor to drowning, 41.4% registered an alcohol reading above 0.2g/L or above, four times the legal driving limit. The highest BAC recorded was a reading of 0.4g/L, which is eight times the legal limit.

Drug related drowning deaths

When examining the contribution of pharmaceutical substances (both legal and illicit drugs), 82 cases (32.2%) were known to have a positive reading to drugs (Figure 38). As with reporting alcohol involvement in drowning deaths, the presence of drugs was unknown in 30.2% of cases. The proportion of positive drug readings was similar across all three locations, lakes (35.7%), dams (28.3%) and lagoons (30.8%).

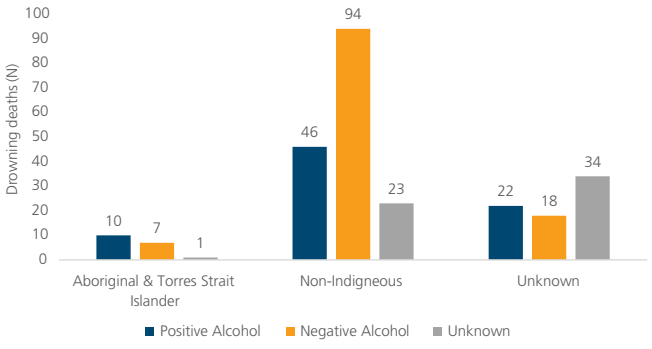


Figure 38: Drowning deaths in lakes, dams and lagoons by positive drug readings, 2008/09 – 2017/18 (N=255)

Of female drowning deaths, 36.4% were known to have a positive reading for a drug, and 31.5% of all male drowning deaths. This distribution pattern was seen across all locations. When comparing between males and females for total cases known to have recorded positive for drugs, 85.4% were male, while females represented 14.6% of total drug-related cases.

The known presence of a pharmaceutical substance accounted for 48.0% of all drowning deaths in the 75 years and older age group, 41.3% of both the 65 - 74 and 2 5- 34 years age groups. The highest proportion of deaths where drugs were known to be a contributory factor in the drowning death was the 45 - 54 and 55 - 64 years age groups, followed by those aged 25 - 34 years (43.8%).

When analysing presence of drugs by State/Territory, Northern Territory recorded the highest proportion of drowning deaths with a positive drug reading (66.7%), followed by Victoria (36.0%).

Of all the Aboriginal and Torres Strait Islander cases, 33.3% (N=6) had a positive blood toxicology to a pharmaceutical substance, compared to 38.0% (N=64) of all non-Indigenous cases (Figure 39). This was a reverse correlation to that seen with Indigenous status and alcohol.

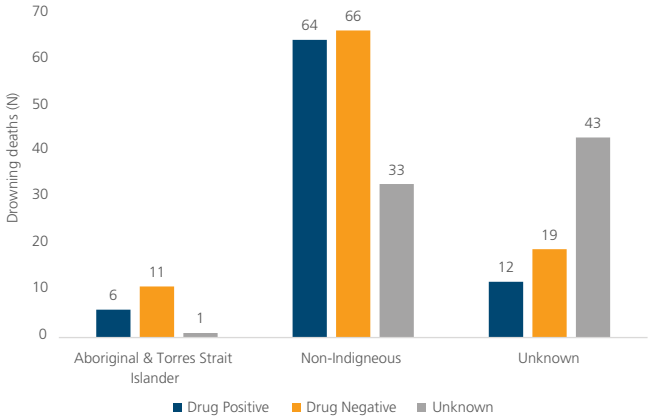


Figure 39: Drowning deaths in lakes, dams and lagoons by positive drug reading and Aboriginal & Torres Strait Islander status, 2008/09 – 2017/18 (N=255)

When analysing the presence of positive drug readings with activity, 75.0% of people who jumped in 54.5% of non-aquatic transport and 54.5% of fishing drowning deaths were found to have positive toxicology to a drug substance.

Comparison between legal and illicit drug toxicology
Of the 82 cases that returned a positive drug toxicology, 44.0% of the cases involved an illicit drug (Figure 40). The distribution was uniform across all three locations.

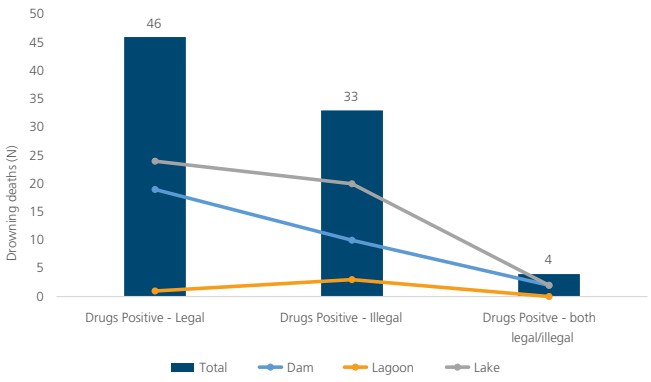


Figure 40: Drowning deaths in lakes, dams and lagoons by presence of illicit drugs, 2008/09 – 2017/18 (N=80)

Males accounted for all drowning deaths known to involve illicit drugs. Of drowning deaths known to involve illicit drugs, those aged 25-34 years represented the highest proportion (35.1%), followed by those aged 18 - 24 years (18.9%) and 35 - 4 years (16.2%). The bias towards males was significantly less prominent when examining drowning deaths involving legal drugs (i.e. medication). Females accounted for 31.4% of legal drug-related drowning deaths. As people aged, a shift between illicit and legal drugs occurred, with those aged 65 years and over recording a higher proportion drowning deaths involving legal drugs.

South Australia recorded the highest percentage of illicit drug-related drowning deaths, with 100% of all drug-related drowning deaths involving an illicit substance. This was followed by both Queensland and the Northern Territory (66.7% each).

In Aboriginal and Torres Strait Islander cases where toxicology was positive for drugs, 83.3% contained an illicit substance, compared to 40.9% of non-Indigenous cases (Figure 41).

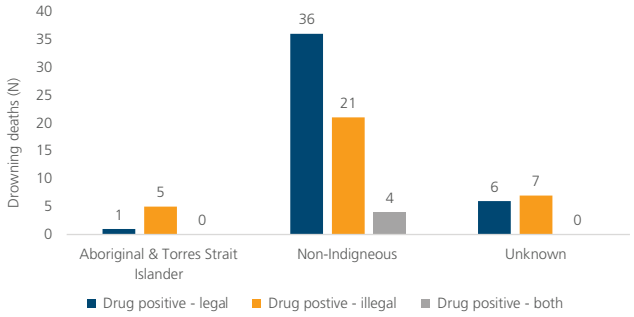


Figure 41: Drowning deaths in lakes, dams and lagoons by illicit positive pharmaceutical toxicology screening, 2008/09 – 2017/18 (N=80)

All drug-related drowning that occurred when diving, jumping in and using watercraft involved illicit drugs, and 88.9% of boating drowning deaths, and 56.3% of swimming and recreating drowning deaths.

The most common illicit drug identified in lake, dam and lagoon drowning deaths was cannabis, equating to 84.8% of all deaths where illegal drugs were present, followed by amphetamines (21.0%). There were a wide variety of legal pharmaceutical substances identified in the known drug related drowning deaths in this study. Commonly occurring pharmaceutical substances were mainly of a therapeutic nature and were of the drug classifications anti-depressants, anti-convulsants, analgesics and narcotic medications including opioids, and cardiovascular agents such as anti-hypertensives and anti-arrhythmic agents.

Alcohol and drugs combined

Ten percent (10.6%, N=27) of cases were known to involve both drugs and alcohol. Of these cases, 55.6% involved illicit substances. The most common activities being undertaken whilst under the influence of both alcohol and any type of drug was non-aquatic transport (18.5%), followed by swimming and recreating (14.8%), and boating, a fall and fishing, (11.1% each of the drug and alcohol-related deaths).

KEY FINDINGS

- Alcohol was known to be involved in 30.6% of drowning deaths
- 92.3% of alcohol-related deaths were male
- The 18-24 years age group accounted for the highest proportion of drowning deaths involving alcohol (20.5%)
- 55.6% of all Aboriginal and Torres Strait Islander cases reported a positive alcohol reading, compared to 28.2% of non-Indigenous cases
- Northern Territory recorded the highest proportion of alcohol-related drowning deaths (77.8%), followed by the ACT (50.0%)
- 74.0% of alcohol-related cases recorded a BAC ≥0.05%
- Western Australia reported 100% of all alcohol-related drowning deaths recording a BAC level ≥0.05g/L
- 41.1% of drowning deaths where alcohol was deemed to be contributing factor reported a BAC ≥0.02g/L, four times above the legal limit
- Drugs were known to be present in 32.2% of drowning deaths
- 45.1% were known to involve illicit drugs, males accounted for all of these drowning deaths
- The 25-34 years age group accounted for the highest proportion of drowning deaths involving illicit drugs (35.1%)
- South Australia recorded the highest percentage of illicit drug-related drowning deaths, 100% of all drug-related drowning deaths
- The most commonly detected illicit drug was cannabis
- 10.6% of all lakes, dams and lagoons drowning deaths were known to involve both drugs and alcohol

Pre-existing medical conditions

Related to the use of legal drug substances, is the association between pre-existing medical conditions and drowning deaths. This study found that 96 cases (37.6%) were found to have a pre-existing medical condition. The distribution was similar across lake and dam locations, with an increase in no pre-existing medical condition cases seen in the lagoon location (Figure 42).

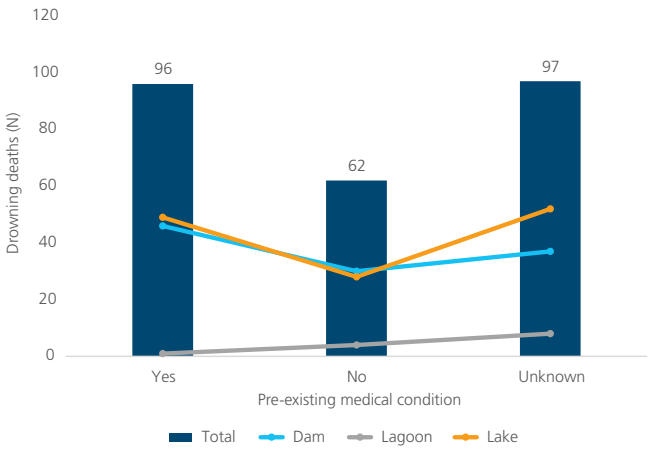


Figure 42: Drowning deaths in lakes, dams and lagoons by pre-existing medical condition, 2008/09 – 2017/18 (N=255)

When examining pre-existing medical condition by sex, 39.4% of females were known to have a pre-existing medical condition, compared to 37.4% of males.

Pre-existing medical conditions were more common among those aged 55 years and over, as this population as a whole has a higher prevalence of pre-existing medical conditions. The 65 - 74 years age group was most represented, with 79.3% of this age group recording a pre-existing medical condition, followed by those aged 75 years and older, and the 55 - 64 years age group (both 64.0%). Over one-third (35.3%) of children aged 5 - 9 years were found to have a pre-existing medical condition. The majority of these cases were congenital health conditions ranging from cardiovascular conditions to neuro-cognitive disorders such as autism.

Drowning deaths involving a pre-existing medical condition were more likely to occur in the Northern Territory; 66.7% of those who drowned were known to have a pre-existing medical condition, followed by Tasmania (50.0%), and Victoria (47.5%). South Australia had the lowest proportion of cases that recorded pre-existing medical condition (10.0% of all cases). This was followed by the ACT (16.7%) and Queensland (27.5%).

Nearly a quarter (22.2%) of Aboriginal and Torres Strait Islander cases were known to have a pre-existing medical condition. This is significantly lower than the known medical conditions in the non-Indigenous population (41.7%).

When examining drowning deaths by activity, fishing was the activity with largest proportion of cases with pre-existing medical conditions, accounting for 54.5% of all fishing deaths. A fall (41.8%) and swimming and recreating (39.6%) also recorded a higher proportion of people with pre-existing medical conditions than other activity categories.

Commonly occurring types of pre-existing medical conditions included: cardiovascular conditions such ischemic heart disease and arrhythmias, neurological conditions such as epilepsy, neurodegenerative and cognitive conditions such as dementia and Alzheimer's and the consequences of alcoholism. This was very constant across all three inland waterways.

KEY FINDINGS

- 96 people (37.6%) were found to have a pre-existing medical condition
- People aged 65 - 74 years were most likely to record a pre-existing medical condition (79.3%)
- The Northern Territory (66.7%) and Tasmania (50.0%) recorded the highest proportion of cases with known pre-existing medical conditions
- 39.4% of females who drowned had a pre-exiting medical condition, compared to 37.4% of males
- Commonly occurring medical conditions included: cardiac conditions such ischemic heart disease and arrhythmias, epilepsy, dementia and Alzheimer's and the consequences of alcoholism

Lifejacket use

When analysed by activity, 12.0% of all people participating in watercraft and boating activities were known to be wearing a lifejacket. Of those that occurred in a dam, a lower response of unknown lifejacket users and a higher response of no life jacket use was recorded compared to lakes and lagoons. These results indicate that watercraft and boating activities associated with a lake are more likely to be associated with lifejacket use than the same activities at a dam. Lifejacket usage was also examined in the population who were rock fishing (N=11), with no deaths recording the use of a lifejacket, however 90.1% of the cases recorded this variable as unknown.

Lifejacket use was examined in people participating in boating activities immediately prior to death, with four cases reporting lifejacket use at the time of death (13.3%) (Figure 43). Across the three locations, all recorded lifejacket use took place at a lake, with no lifejacket use recorded for boating at a dam or lagoon.

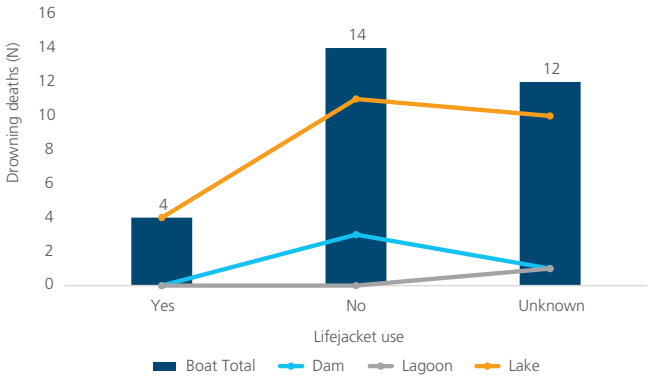


Figure 43: Drowning deaths in lakes, dams and lagoons by lifejacket use in boating activities, 2008/09 – 2017/18 (N=30)

Lifejacket use was examined in people participating in watercraft activities immediately prior to death, with two cases reporting lifejacket use at the time of death (10.0%) (Figure 44). Similarly to boating, all lifejacket usage was reported at a lake location.

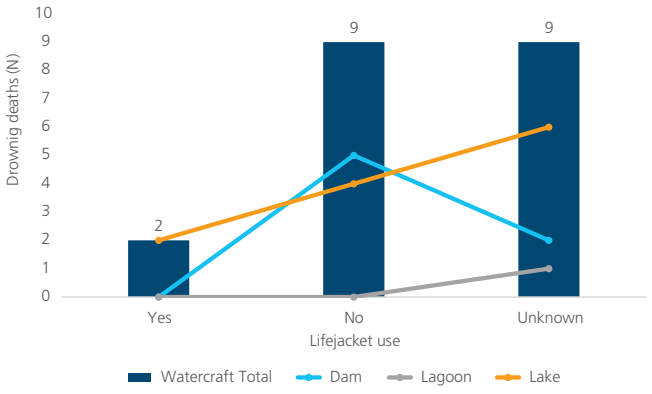


Figure 44: Drowning deaths in lakes, dams and lagoons by lifejacket use in watercraft activities, 2008/09 – 2017/18 (N=20)

Swimming ability

Swimming ability was recorded in 31.0% of the cases. Of those, 49.4% were recorded as non-swimmers and 21.5% recorded as a poor swimmer (Figure 45). The distribution of swimming ability was consistent across all three locations, with non-swimmers and poor swimmers heavily recorded in the data (Figure 46).

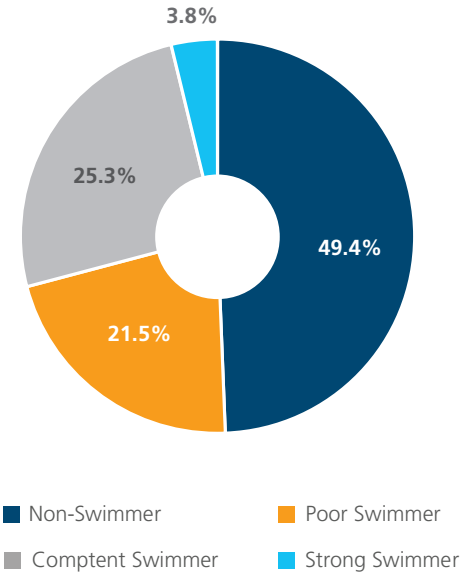


Figure 45: Drowning deaths in lakes, dams and lagoons by swimming ability (where known), 2008/09 – 2017/18 (N=79)

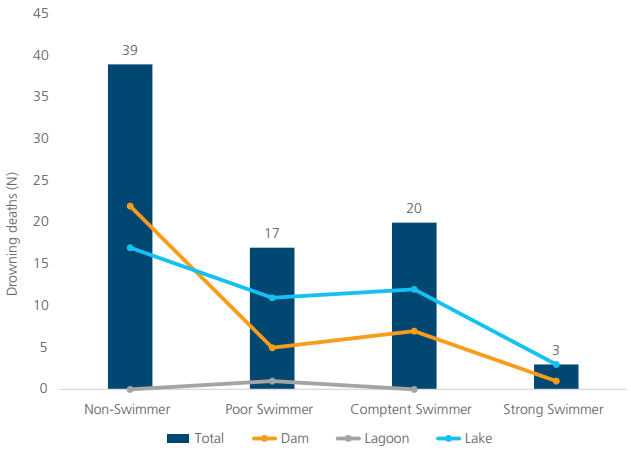


Figure 46: Drowning deaths in lakes, dams and lagoons by swimming ability (where known), 2008/09 – 2017/18 (N=79)

Of the 79 cases were swimming ability was known, males represented 59.5% of people who were non-swimmers or poor swimmers. The proportion of swimming ability between sex was consistent with non-swimmers representing 48.5% of males and 50.0% of females. No females were recorded having a strong swimming ability. The distribution of swimming ability varied between age groups. The non-swimmers followed a bimodal distribution with children aged 0 - 4 years heavily overrepresented, as well as people aged 65 years and older (Figure 47).

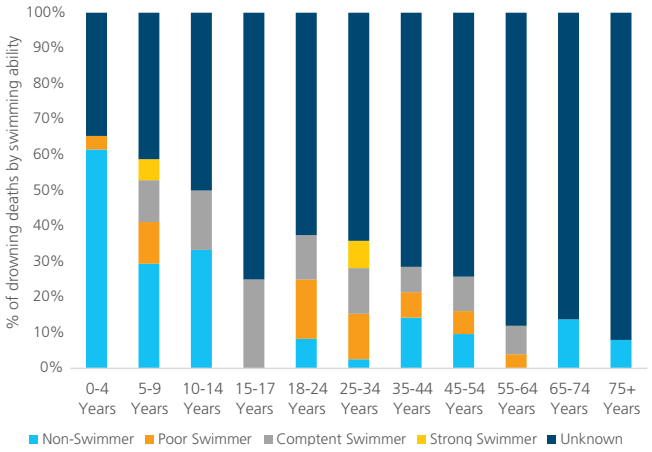


Figure 47: Drowning deaths in lakes, dams and lagoons by swimming ability by age groups, 2008/09 – 2017/18 (N=255)

When examining swimming ability by State/Territory, swimming ability varied greatly, as did the proportion of swimming ability known. Queensland was over-represented in non-swimmers with 29.4% of all cases recorded as non-swimmers (56.7% of all known swimming ability cases). When analysing proportion of non-swimmers and poor swimmers by State/Territory, Queensland was overrepresented with 41.4% of total drowning cases being identified as either a non-swimmer or poor swimmer. (Figure 48) When removing the unknown swimming ability cases, NSW had the greatest proportion of non-swimmers and poor swimmers (81.25%), followed by Queensland (80.0%) and Western Australia (66.7%).

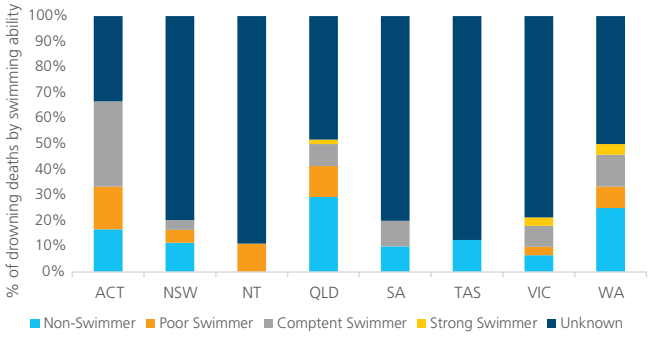


Figure 48: Drowning deaths in lakes, dams and lagoons by swimming ability and State/Territory, 2008/09 - 2017/18(N=255)

When examined by remoteness of the drowning location, swimming ability distribution generally did not change, with non-swimmers and poor swimmers overrepresented in all locations. Interestingly non-swimmers were the majority everywhere other than very remote locations, where poor swimmers recorded the highest distribution in the known cases. No strong swimmer cases were recorded in a remote or very remote locations.

The role of swimming ability and activity was also examined. Non-swimmers and poor swimmers were overrepresented in drowning deaths that occurred due to a fall (100% of cases where swimming ability was known) and boating (83.3%) (Figure 49). Swimming ability appears to have played a lesser role in deaths that occurred due to diving, 100% of cases where swimming ability was known were recorded as either being a competent or strong swimmer. There was an equal distribution seen between non-swimmers and poor swimmers vs competent swimmers and strong swimmers where swimming ability was known in watercraft activities (57.14%), swimming and recreating (56.7%) and fishing (50.0%).

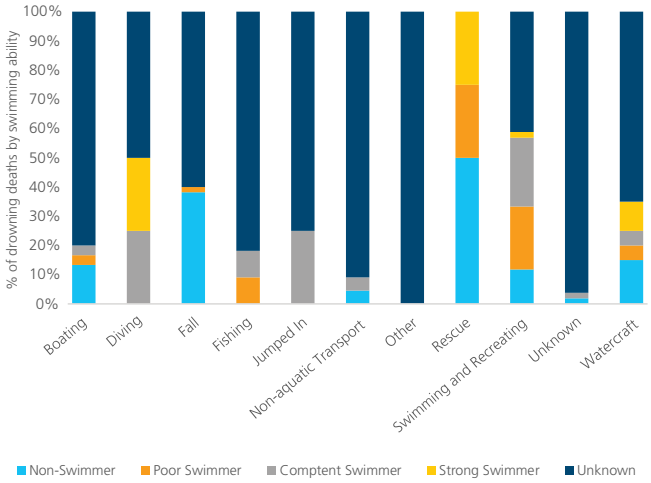


Figure 49: Drowning deaths in lakes, dams and lagoons in Australia by swimming ability and activity, 2008/09 - 2017/18 (N=255)

KEY FINDINGS

- 12.0% of all people participating in watercraft and boating activities were known to be wearing a lifejacket
- No lifejacket use was recorded in the dam location
- No lifejacket usage was seen in the rock fishing cases
- Of known swimming ability, 70.9% of cases were recorded as poor or non-swimmers
- Where swimming ability was known, non-swimmers and poor swimmers were overrepresented in deaths that occurred due to a fall (100%) and boating (83.3%)

Other Risk Factors

From analysis of the fatal drowning cases in all lakes, dams and lagoons, apart from the usual identified risk factors for drowning, there were several other factors that either influenced the occurrence or the outcome of the drowning deaths in a lake, dams and or lagoon.

Flooding Related

A total of five (2.0%) drowning deaths were known to be flood-related across the study period. Males accounted for 100% of all flood-related drowning deaths. The majority of the flood-related deaths occurred in lakes (60.0%), and 40.0% in dams. It should be mentioned that during 2009-2010, high levels of flooding occurred across much of Queensland and NSW which may have contributed to the high prevalence of drowning deaths during this period.

Overall, people aged 65 years and over experienced the highest recorded number of flood-related drowning deaths (60.0%, N=3) of all flood-related drowning deaths. Both NSW and Victoria recorded the highest proportion of drowning deaths (40.0%), with Queensland recording the remaining 20.0% across the study period. The largest proportion of flood-related drowning deaths occurred in regions considered major cities or outer regional areas (40.0%), with the remaining deaths occurring in remote areas (20.0%).

The majority of drowning deaths that took place in flooded areas were as a result of non-aquatic transport (40.0%), for example driving a car home across a flooded water crossing and being swept away due to the force of the water. Swimming and recreating, fishing and boating all represented the remaining deaths equally with 20.0% each.

When examining other possible associations with flood-related drowning events, 40.0% of the flood related drowning cases tested positive to some form of drug in their bloodstream and 60.0% had a positive alcohol reading.

Multiple Fatality events

In this study, 11 cases (4.3%) were multiple fatalities where more than one person drowned during the same incident. Multiple fatality events most frequently occurred when swimming and recreating (36.4%) or boating (27.3%). Of the multiple deaths fatalities, 72.7% were male, and 18.2% were affected by alcohol. A positive drug reading in the bloodstream was found in 18.2% of multiple fatality events. Multiple fatality events represented 3.4% of all drowning deaths in dams, and 5.4% in lakes.

KEY FINDINGS

- 2.0% of all lake, dam and lagoon drowning deaths were known to be flood-related
- Men accounted for all flood-related drowning deaths
- 60.0% were of people aged 65 years or over
- 40.0% occurred as a result of non-aquatic transport
- 4.3% of drowning deaths were known to be a multiple fatality event
- 72.7% of multiple fatality drowning deaths were male
- 36.4% of multiple fatality events occurred while swimming and recreating

Attempted Cardiopulmonary Resuscitation (CPR) Administration

In 23.9% (N=61) of drowning deaths in lakes, dams and lagoons, CPR was delivered. The distribution of CPR varied across locations, with dam locations recording the highest attempt of CPR (31.9%), followed by lakes (18.6%) and lagoons (7.7%). (Figure 50)

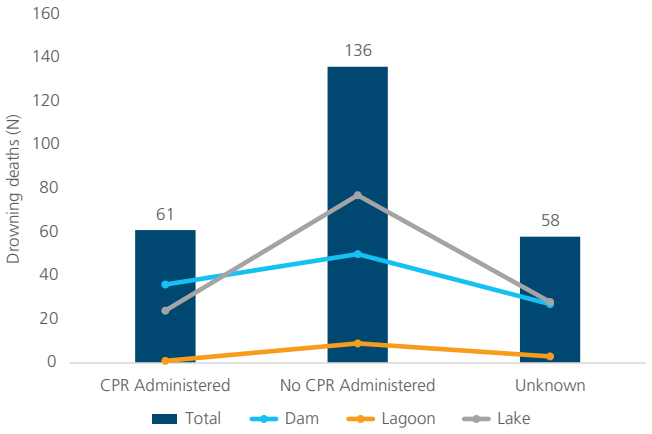


Figure 50: Drowning deaths in lakes, dams and lagoons by attempted CPR, 2008/09 - 2017/18 (N=255)

When examining CPR administration rates by State/Territory, the highest CPR administration rates were recorded in the Northern Territory (55.5%) and Queensland (41.4%) (Figure 51). The lowest attempted CPR administration rates were recorded in South Australia (10.0%) and NSW (12.5%).

When analysed by remoteness, it was found that as remoteness increased (moved from major cities towards very remote areas), so did the attempted administration of CPR. The highest attempted CPR rate was seen in very remote areas (41.7%) and the lowest seen in major cities (23.3%).

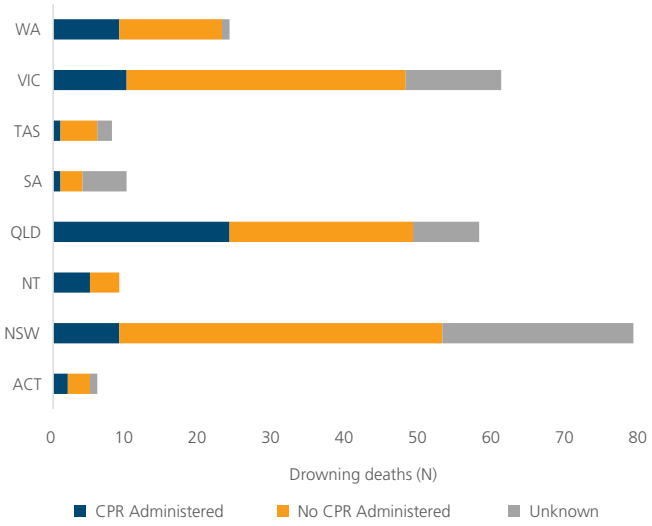


Figure 51: Drowning deaths in lakes, dams and lagoons by attempted CPR and State/Territory, 2008/09 - 2017/18 (N=255)

The attempted administration of CPR varied across all age groups, reflecting age groups more likely to be swimming or undertaking activities alone in, on or around the water. Drowning deaths involving children were more likely to have CPR administered, with children aged 0 - 4 years having CPR attempted in 61.5% of all cases, and children 5 - 9 years 52.9% of the time. Age groups that reflected the lowest rates of CPR were those aged 18 - 24 years (8.3%), 75 years and over (8.0%), and 55 - 64 years (8.0%) (Figure 52).

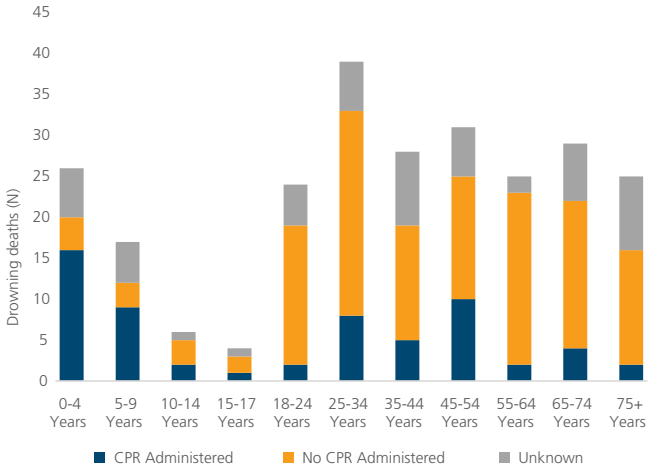


Figure 52: Drowning deaths in lakes, dams and lagoons by attempted CPR and age, 2008/09 - 2017/18 (N=254)

Activity also appeared to have an effect on the distribution of attempted CPR. An attempted rescue resulted in the highest attempted CPR administration with 75.0% of all cases. This was followed by swimming and recreating (43.1%) and a fall (36.4%). 100.0% of diving and fishing drowning deaths recorded no attempts of CPR. Drowning deaths when using watercraft and boating also recorded low rates of attempted CPR (15.0% and 13.0% respectively).

From the available data in this study, in all cases where a body was retrieved (with no search for the body taking place), CPR was attempted. A bystander commenced CPR until emergency services arrived. CPR rates were reflective of a search for a victim's body in most drowning scenarios.

CASE STUDY: **LOSS OF VISIBILITY OF THE PERSON**

There was a total of 107 drowning deaths in lakes, dams and lagoons where the person was known to be with others during the incident. Of these cases, 92 deaths resulted in a loss of visibility of the person in the water during the incident (36.1% of total cases).

The distribution did not vary across location greatly, with dams recording a loss of visibility of the person in 86.7% of cases, 85.9% at lakes and 80.0% at lagoons. Of male drowning deaths, 90.1% resulted in a loss of visibility, compared to 83.3% of female deaths. The loss of visibility was also seen to impact attempted CPR rates, with CPR administered in only 43.5% of cases (compared to 100% of cases where visibility was not impacted). From the 92 deaths that resulted in a loss of visibility, 95.7% ended with a search for the victim's body.

When examining cases where visibility of the person was lost during the event by State/Territory, the states that recorded the highest proportion of loss of visibility were South Australia (50.0%) and Queensland (48.3%) (Figure 53). Tasmania recorded the lowest proportion of cases where visibility of the person was lost during the incident (12.5%).

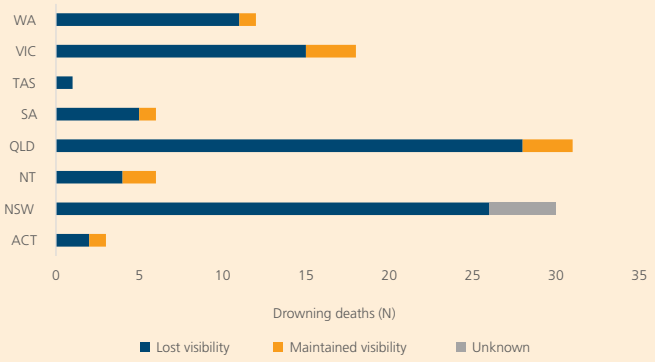


Figure 53: Drowning deaths in lakes, dams and lagoons by loss of visibility during drowning event and State/Territory, 2008/09 - 2017/18 (N=107)

The distribution of the loss of visibility of the person during the drowning event was impacted by age. Lost visibility of the person during the drowning event was most likely among drowning deaths involving children (0 - 17 years) whereas drowning incidents involving people aged 65 years and over were least likely to have lost visibility of the body during the drowning event, 50.0% of people aged 75 years and over, and 60.0% the 65 - 74 years age group (Figure 54).

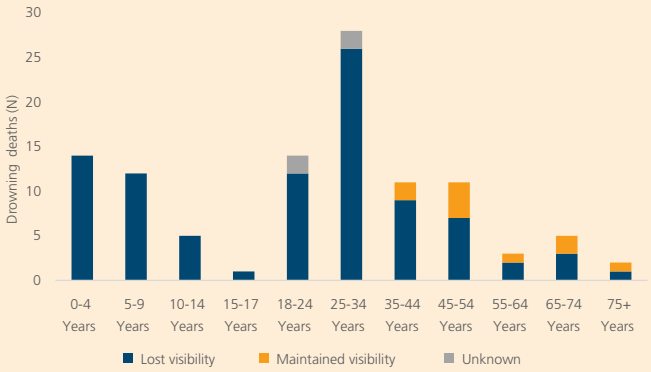


Figure 54: Drowning deaths in lakes, dams and lagoons by loss of visibility during drowning event and age, 2008/09 - 2017/18 (N=107)

When analysed by remoteness, there was no trend found between location remoteness and loss of visibility during the drowning incident. Outer regional areas recorded a high of 93.1%, and very remote areas recording the lowest proportion of cases (75.0%) that lost visibility of the person in the water.

Activity immediately prior to death also appeared to have an effect on the distribution of people where visibility was lost during the drowning event (Figure 55). Non-aquatic transport (50.0%) and boating activity (66.7%) recorded the lowest proportion of drowning deaths where visibility was lost, compared to most other activities that recorded 100.00% of lost visibility (diving, a fall into the water, fishing, jumping in and a rescue).

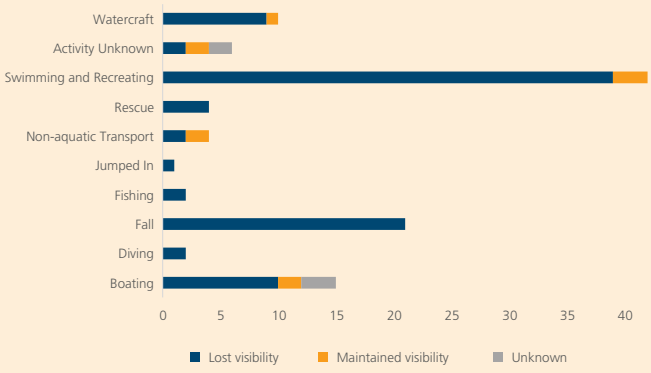


Figure 55: Drowning deaths in lakes, dams and lagoons by loss of visibility of the person in the water and activity, 2008/09 - 2017/18 (N=107)

CASE STUDY: **SEARCH FOR BODY AND RETRIEVAL**

A total of 160 (84.2%) of drowning deaths recorded in lakes, dams and lagoons resulted in a search for the person. The distribution did not vary across location greatly, lakes recorded a search in 86.1% of the known cases, dams 88.9% and lagoons 70.0% (Figure 56).

There were no differences between search rates in private or residential dams and public access dams, with private dam drowning deaths resulting in a search rate of 88.6% and public access dams 89.2%. Search time ranged from 10 minutes to over three weeks. The mean search time for all deaths requiring a search was between 12 and 24 hours. When analysed by sex, 87.4% of male deaths resulted in a search for victim, compared to 80.8% of female deaths.

A search for the person had an impact on CPR rates. A search resulted in CPR administration in 30.2% of cases (compared to when no search was required 62.5%). A positive alcohol reading was present in 38.9% of cases resulting in a search and 40.5% of cases recorded positive for drugs.

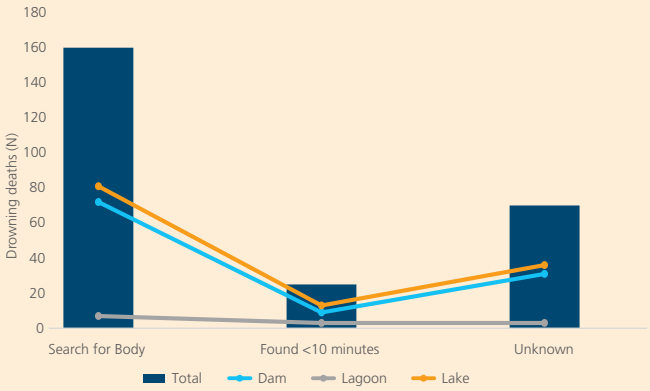


Figure 56: Drowning deaths in lakes, dams and lagoons by drowning event that resulted in a search for the victim, 2008/09 - 2017/18 (N=255)

Drownings deaths which resulted in a search for the person was impacted by age. Drowning deaths involving children were most likely to result in a search, with 100.0% of children 0 - 17 years ending in search. Age groups that recorded the lowest proportion of searches were among those aged 65 - 74 years (61.1%) and 45- 54 years (68.1%) (Figure 57).

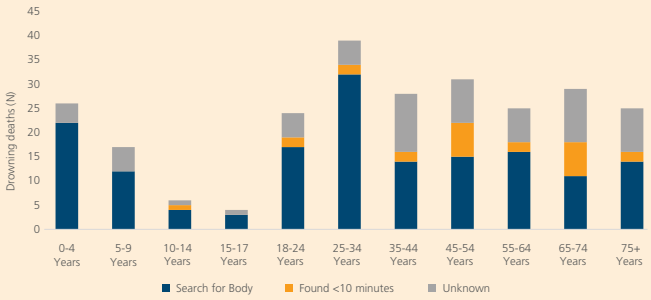


Figure 57: Drowning deaths in lakes, dams and lagoons by drowning event that resulted in a search for the victim by age group, 2008/09 - 2017/18 (N=254)

Where known, South Australia recorded the greatest proportion of search and rescue attempts with 88.9%, followed by NSW (87.8%) and Queensland (87.5%) (Figure 58). The Northern Territory recorded the lowest proportion of search and rescue attempts (66.7%). These results are a similar distribution to cases where visibility of the person was lost during the drowning event.

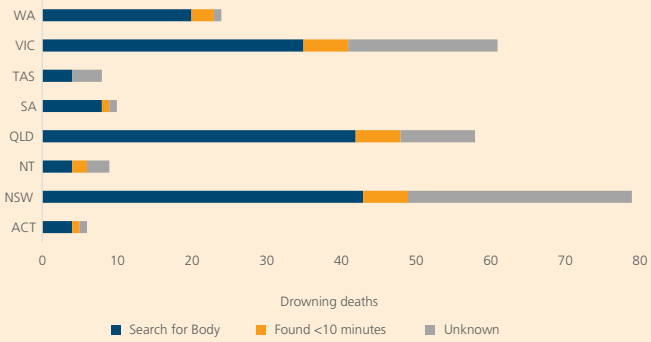


Figure 58: Drowning deaths in lakes, dams and lagoons by drowning event that resulted in a search for the victim, 2008/09 - 2017/18 (N=255)

When analysed by remoteness, no trend was found between location remoteness and search for the person. Remote areas recorded a high of 78.7%, and very remote areas recorded the lowest proportion (66.7%).

Activity immediately prior to death also appeared to have an effect on the distribution of people where a drowning death resulted in a search. Deaths involving diving recorded a search rate of 100.0%, followed by a fall (97.4%), and swimming and recreating (89.4%). Activities that recorded the lowest proportion of search attempts were jumping in (66.7%) and rescue attempts (75.0%).

Australian Capital Territory 2008/09 – 2017/18

6

Drowning deaths occurred in a lake

0.16

Deaths per 100,000 people

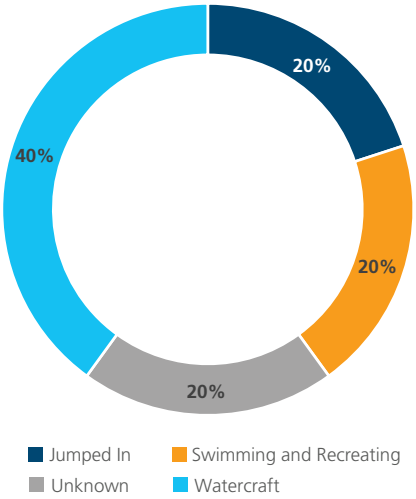
Who

100%

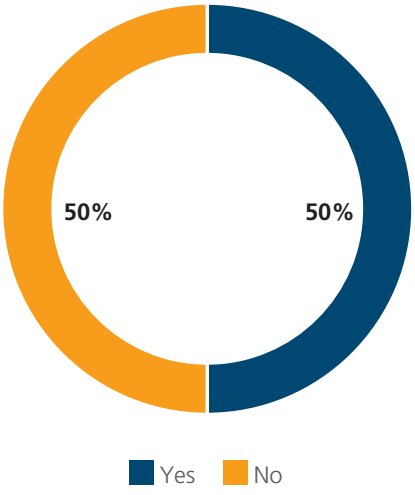
100% 18 – 74 years of age

50% born overseas

Activity



Risk Factors – Alcohol present



Circumstances (where known)

50% Were alone at the time of death

33% Visibility of the person was lost during the incident

66% A search was conducted

New South Wales 2008/09 – 2017/18

79

Drowning deaths occurred in a lake, dam or lagoon

0.11

Deaths per 100,000 people

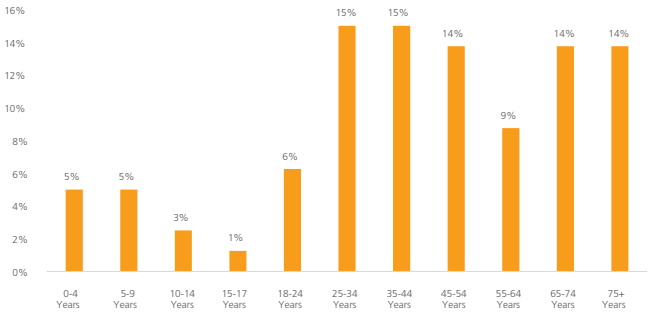
Who

91% **9%**

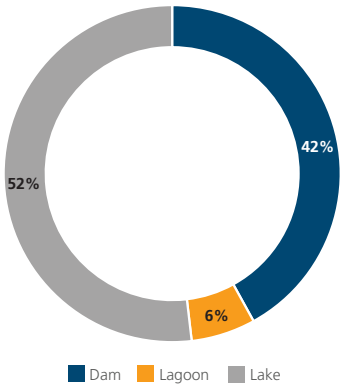
7% Aboriginal or Torres Strait Islander

16% born overseas

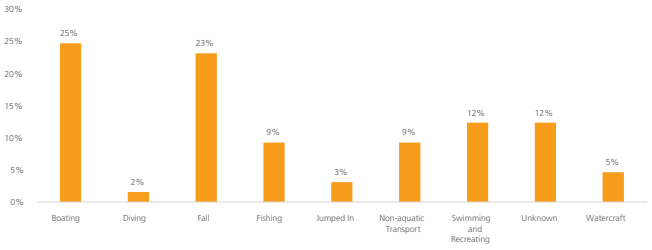
Age breakdown



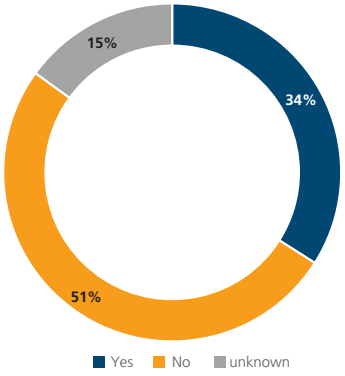
Environment



Activity



Risk Factors – Alcohol present



Circumstances (where known)

41% Were alone at the time of death

33% Visibility of the person was lost during the incident

54% A search was conducted

Northern Territory 2008/09 – 2017/18

9

Drowning deaths occurred in a lake, dam or lagoon

0.41

Deaths per 100,000 people

Who

89%

11%

44% Aboriginal or Torres Strait Islander

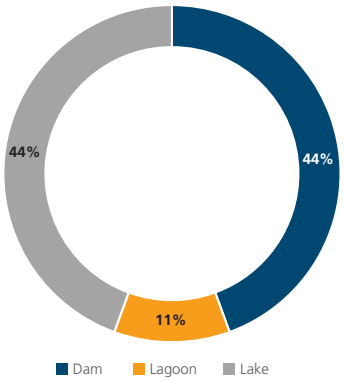
33% born overseas

Age breakdown

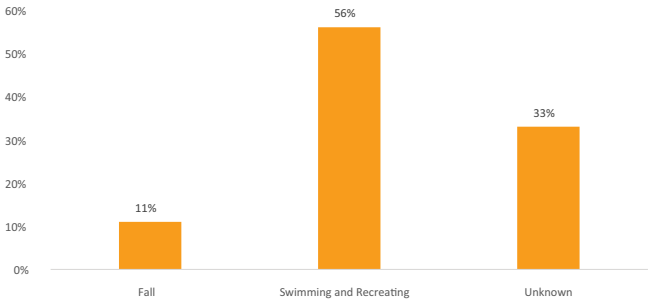
100%

18 – 64 years of age

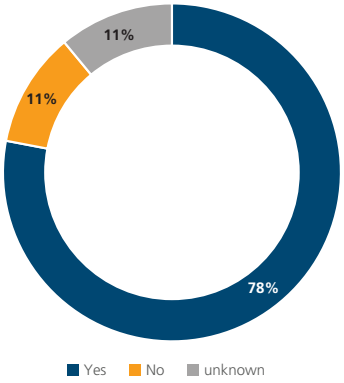
Environment



Activity



Risk Factors – Alcohol present



Circumstances (where known)

33% Were alone at the time of death

44% Visibility of the person was lost during the incident

44% A search was conducted

Queensland 2008/09 – 2017/18

58

Drowning deaths occurred in a lake, dam or lagoon

0.13

Deaths per 100,000 people

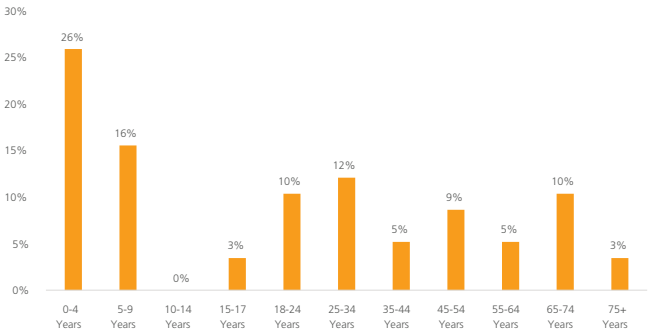
Who

79% **21%**

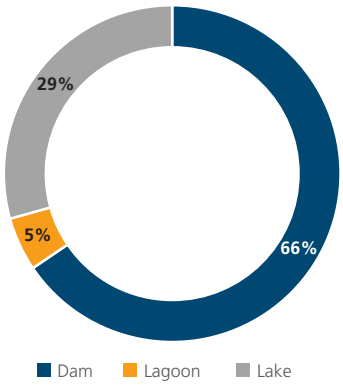
14% Aboriginal or Torres Strait Islander

28% born overseas

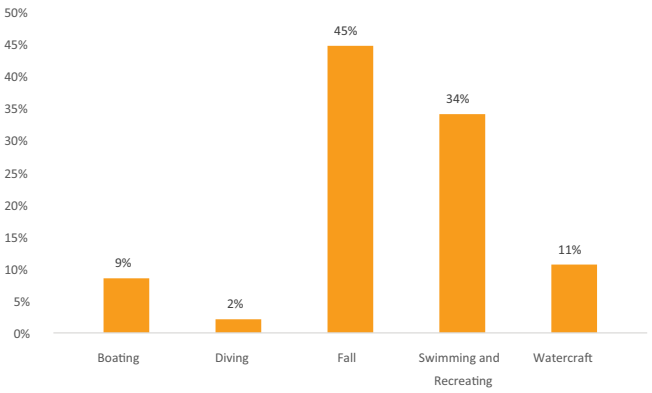
Age breakdown



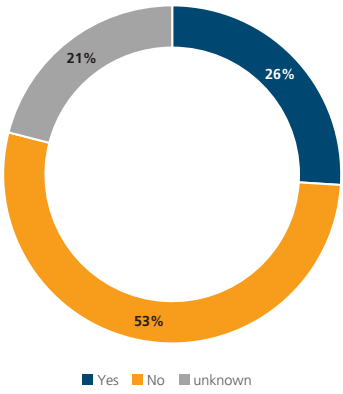
Environment



Activity



Risk Factors – Alcohol present



Circumstances (where known)

31% Were alone at the time of death

48% Visibility of the person was lost during the incident

72% A search was conducted

South Australia 2008/09 – 2017/18

10

Drowning deaths occurred in a lake, dam or lagoon

0.06

Deaths per 100,000 people

Who

80% **20%**

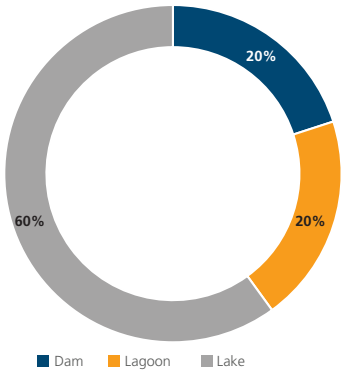
10% born overseas

Age breakdown

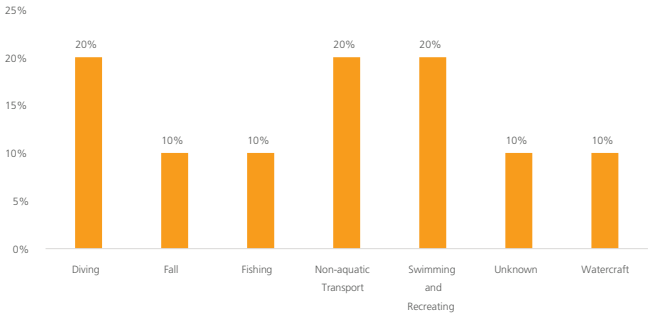
70%

18 – 64 years of age

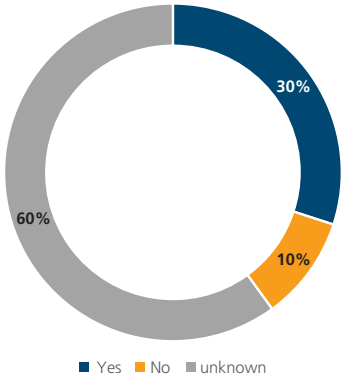
Environment



Activity



Risk Factors – Alcohol present



Circumstances (where known)

30% Were alone at the time of death

50% Visibility of the person was lost during the incident

80% A search was conducted

Tasmania 2008/09 – 2017/18

8

Drowning deaths occurred in a lake, dam or lagoon

0.16

Deaths per 100,000 people

Who

100%

25% born overseas

Age breakdown

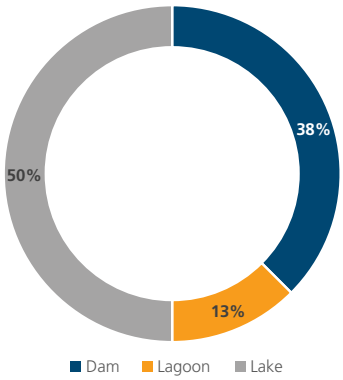
50%

25-54 years

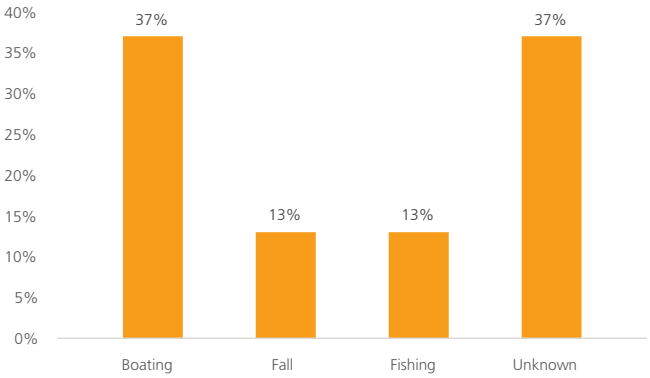
50%

65 years+

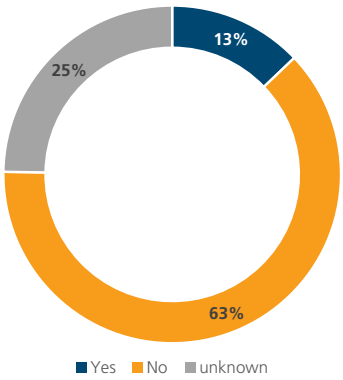
Environment



Activity



Risk Factors – Alcohol present



Circumstances (where known)

63% Were alone at the time of death

12% Visibility of the person was lost during the incident

50% A search was conducted

Victoria 2008/09 – 2017/18

61

Drowning deaths occurred in a lake, dam or lagoon

0.11

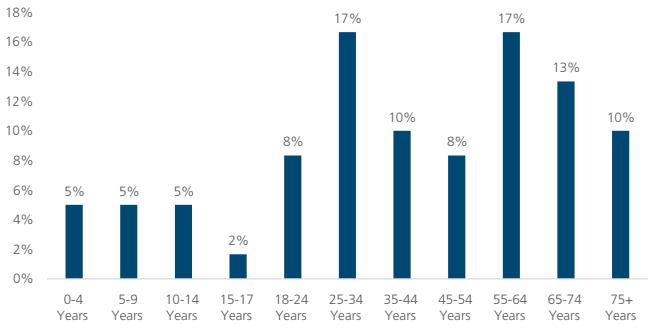
Deaths per 100,000 people

Who

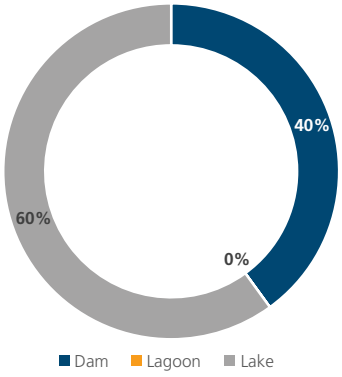
85% **15%**

18% born overseas

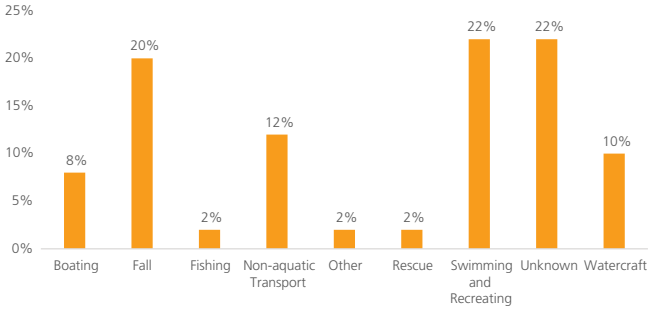
Age breakdown



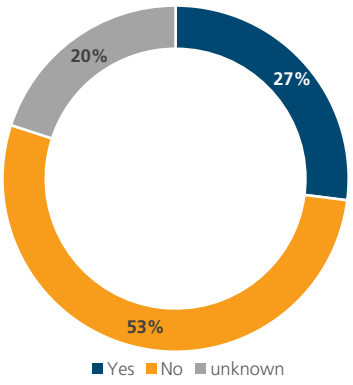
Environment



Activity



Risk Factors – Alcohol present



Circumstances (where known)

51% Were alone at the time of death

25% Visibility of the person was lost during the incident

57% A search was conducted

Western Australia 2008/09 – 2017/18

24

Drowning deaths occurred in a lake, dam or lagoon

0.10

Deaths per 100,000 people

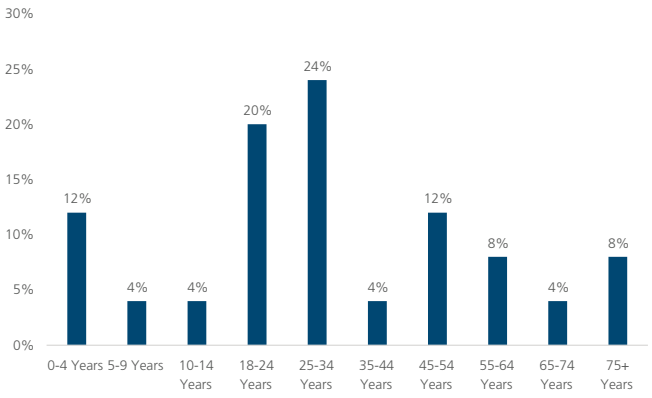
Who

92% **8%**

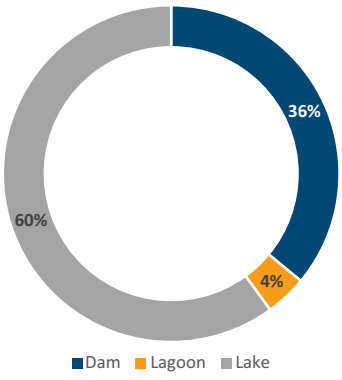
17% Aboriginal or Torres Strait Islander

36% born overseas

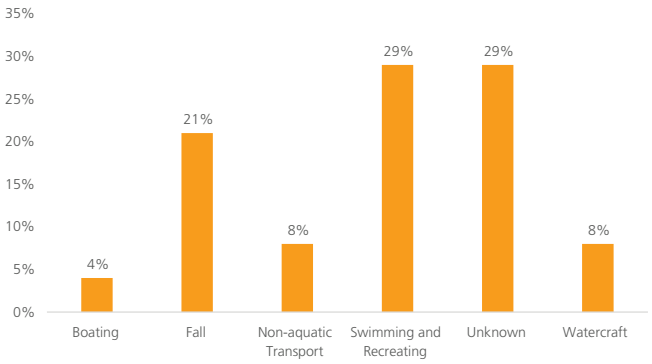
Age breakdown



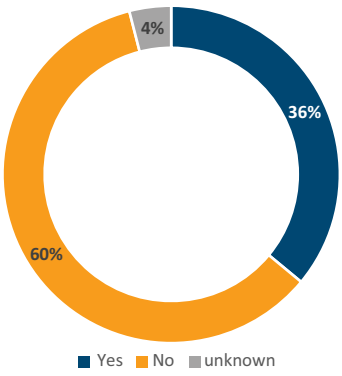
Environment



Activity



Risk Factors – Alcohol present



Circumstances (where known)

50% Were alone at the time of death

46% Visibility of the person was lost during the incident

83% A search was conducted

DISCUSSION

Inland waterways (rivers, creeks, streams, lakes, dams and lagoons) continue to be the aquatic location with the highest number of drowning deaths in Australia, with 1020 drowning deaths (35.5% of all drowning deaths) recorded over the 10 year period of this study. Analysis of data collected on the scale and nature of the drowning deaths in lakes, dams and lagoons provides the opportunity to identify risk factors and contribute to evidence based drowning prevention strategies for the given environment.

This study provides evidence for the need for further investigation into lake, dam and lagoon environments in their own right, highlighting themes worthy of future focus and further research. The study also provides evidence towards the initiation or the development of prevention strategies specifically for lakes, dams and lagoons, appreciating the interconnecting theme of risk factors related to drowning deaths in all inland waterways.

Like most other locations, the significant burden of males in overall drowning statistics is mirrored in lakes, dams and lagoons. Males accounted for 87.1% of all drowning deaths experience in Australian lakes, dams and lagoons over the 10 year period of this study. That burden is most pronounced in the 15 - 17 years and 25 - 34 years age groups, where males accounted for 100% of the drowning deaths. Males were more likely to drown in lakes, dams and lagoons as a result of intentionally diving or jumping into the water. Males were also significantly more likely than women to drown whilst undertaking activities such as boating and watercraft use.

Alcohol consumption is a clear contributor to increased drowning risk.[69-71] Like that seen in rivers, alcohol in drowning deaths in lakes, dams and lagoons continue to be a concerning issue, with 30.6% of all lake, dam and lagoon deaths recording a positive BAC reading. In this study, alcohol was more prevalent across all age groups, compared to previously reported statistics of alcohol–related drowning deaths recorded in river locations.[44] The male population was significantly overrepresented in the readings, with young adults 25-34 years the most common offenders. Drowning deaths involving alcohol were more likely to have occurred at public recreation areas like lakes and lagoons compared to private or residential dam locations. There was also a significant increase in positive BAC readings among Aboriginal and Torres Strait Islander drowning deaths population compared to non-Indigenous. Alcohol was commonly associated with swimming and recreating in the lake environment, as well as boating and watercraft use. The involvement of alcohol in non-aquatic transport accidents is also of concern.

Where alcohol was detected, 74.4% of cases exceeded a BAC reading of ≥0.05%, the legal alcohol driving limit. Alcohol is a well-documented risk factor for drowning and there is current evidence it also decreases the effectiveness of cardiopulmonary resuscitation (CPR).[72-74]

Therefore, successful lake, dam and lagoon drowning prevention strategies must communicate the risks of undertaking aquatic activity whilst under the influence of alcohol and highlight the extreme dangers associated with excessive alcohol consumption. Broad public awareness campaigns should be implemented. From these results, it is concerning that a number of drowning deaths occur in isolation from witnesses and the ingestion of both alcohol and/or drugs has a contributory effect on a large proportion of drowning death in these locations. Drowning deaths that result from non-aquatic transport, boating and watercraft whilst under the influence of alcohol and/or drugs remain a concern. With the increased number of cases where alcohol involvement is unknown, similarly for positive drug analysis, the above results could underrepresent the current situation. This warrants improvement in data collection processes for these related variables. Royal Life Saving will continue to work with the National Coronial Information System (NCIS), State/Territory Coronial Offices and the Police to enhance toxicological reporting. Better data will ultimately enhance our understanding of the true contribution of alcohol and drugs in river drowning deaths in Australia.

Similar to the current prevention strategies recommended in river drowning prevention research,[45,46,70] the enforcement of, and public awareness of State/Territory legislation around the operation of boats and 0watercraft while under the influence of alcohol needs to be continued to be explored. A move towards a national stance on the legislation would be beneficial. Education and awareness of non-aquatic transport related drowning deaths also needs to take place, with public awareness around the operation of motor vehicles and the potential of an aquatic fatality, something not often commonly associated in the public.

The use of lifejackets was highlighted in this study, with only 12% of watercraft and boating fatalities known to be wearing a lifejacket. All recorded cases of lifejacket use took place at the lake location, with no lifejacket use recorded at dams. The public perceptions of personal flotation device usage on private/agricultural dams should be explored further. Flotation devices not only allow for assistance in buoyancy during a drowning incident, but play a role in stability and assist in search and rescue.

A number of the drowning deaths in lakes, dams and lagoons, appear to coincide with people undertaking aquatic activities alone (42% total). Undertaking such activities alone can increase the risk of drowning, and should be advised against, especially in a remote or isolated setting. Of the proportion of drownings that occurred where people were not undertaking aquatic activities alone, 86% of cases experienced a loss of visibility during the drowning event. In the lakes, dams and lagoons environment, simply undertaking aquatic activities together is not an appropriate message. Messages should be focused on providing an increase of visibility at all times when recreating together (e.g. fluorescent swimwear, light wrist bands, and wearing a lifejacket).

Pre-existing medical conditions have varying impacts and associations with a person's risk of drowning when undertaking aquatic activity or recreating in close proximity to water, especially those that severely impact ones quality of life. Further research into the role of pre-existing medical conditions and drowning risk is needed to examine the true impact, whether it be the medical condition itself or as a result of medication associated with the condition.

When creating specific campaigns for these environments it must be appreciated that the age distribution of drowning deaths between locations varies. Children under the age of five and people 65 years and older, are overrepresented in the total drowning deaths in the lake, dam and lagoon environment. This could be attributed to swimming ability, lapses in supervision, and known medical conditions.

When examining the locations independently, young adult males are overrepresented in drowning deaths at lakes. This could be explained by the reflection of the risk-taking behaviours highlighted throughout the study. Swimmers in this environment must co-exist with boaters, water skiers and other recreational watercraft users, as well as be exposed to unexpected drop-offs into deep water, seaweed and other marine life, reeds and dangerous objects buried in the sand including discarded fish hooks. Water conditions, especially visibility, can be unpredictable and strong currents can be fatal for even experienced swimmers. Hypothermia is also a real threat to swimmers in some lake environments, as water temperature is known to be lower even in summer weather. Poor mobile network coverage and the absence of rescue equipment such as lifebuoys can also complicate rescue efforts when swimmers get into difficulty.

The lake environment also had a higher prevalence of visitors or tourists represented in the drowning deaths in this study. Drowning prevention efforts aimed at the lake environment need to encompass not only the local constituents but the tourist population who frequent these locations, including international visitors. Language barriers, different cultural attitudes to water safety and an increase in risk-taking behaviour by visitors in unfamiliar locations need to be taken into account when developing prevention measures. Prevention measures for the lake environment should include the importance of adequately supervising children during travel, such as camping at a lake environment.

Dam locations also were heavily impacted by drowning deaths among children aged 0 - 4 years, as well as those aged 65 years and over. There was an ongoing theme of work-related injuries in the agricultural dam location. Little investigation has been undertaken into workplace health and safety regulations to prevent farm/agricultural related drowning deaths. From previous studies, safe play areas on farms, to prevent dam drowning deaths has been highlighted.[18,25] The findings of this study warrants further investigation into drowning prevention strategies in dams

Despite national campaigns aimed at preventing drowning of young children, drowning deaths are still occurring in the 0 - 4 years population. Further investigation into the protective nature of swimming ability in this cohort may be of benefit given the difficulty in providing barriers to these large aquatic environments. Continued promotion of the child safe play areas should continue, as well as the importance of prolonged resuscitation in children.[25, 26] Investigation into the provision of rescue equipment, or access to defibrillators on isolated properties containing dams is warranted.

It should be mentioned there was a high prevalence of drowning deaths during 2009-2010 period, which recorded levels of flooding across much of Queensland and NSW. It is possible that the drowning deaths during this time were not directly due to the flood activity, however the flood itself led to the filling of ephemeral lakes or dams (that were previously dry), increasing access and risk to drowning in these areas. This however was not captured in the data due to coding definitions. No information was available at the time of this study to examine the impact of flood and/or drought played on the incidence and prevalence of lake, dam and lagoon drowning deaths. Flooding and natural disaster related drowning deaths will continue to be an issue in Australia and prevention in lakes, dams and lagoons during extreme weather needs to remain a focus, similar to rivers. Prevention strategies should focus on education of people around the dangers of flood-waters, particularly when using non-aquatic transport. Further education into the change of driving conditions in flooded waters needs to take priority, and the interaction that alcohol and drugs can play in these changed conditions.

Given the stoic nature of most rural and remote residents and the ideologies instilled over generations, utilisation of local resources is important in the construction and implementation of public health campaigns and programs. Cultural appropriateness and personal relatability is critical for success. As a substantial attributed burden to the dam drowning death crude rates is from children aged 0 - 4 years, access to and affordability of swimming and water safety education should be investigated. Targeting school-age children in these communities is neglecting a high-risk constituent of the at risk population. This also disregards the school-age children who attend distance education, who have limited access to school swimming instruction during the school term and rely on non-school funded programs such as private swim schools and swimming clubs in their local communities. With strong relationships previously established, advocacy through these channels could be worthwhile.

It is also important to note that lake, dam and lagoon crude drowning death rates increased with rurality of the drowning location, with very remote locations recording a crude death rate 18 times greater than major city locations. Rural and remote settings present unique obstacles for drowning prevention delivery. Delivery of programs in rural and remote settings need to be investigated, with risk-factors and access to delivery opportunities somewhat similar to low-income countries. Primary prevention strategies that work in metropolitan areas are not always successful or translate well to rural locations. There is evidence for supporting the implementation of strategies including the promotion of child safe play areas and targeted public awareness campaigns for rural and regional aquatic environments, noting the challenges with delivery of programs to dispersed and small populations.

First aid and CPR skills for lay first responders also remain vital. Teaching rural adults water safety awareness and the importance of active supervision is key. Swimming and water safety lessons for rural children and parents are not only a delivery portal for drowning prevention but a major place for social interaction due to geographical isolation. Action is required around research and delivery of targeted prevention campaigns in rural areas, with drowning prevention strategies tailored to specific age groups in these rural areas. Utilisation of current resources in these rural and remote communities is also vital, for both the sustainability of programs and buy-in from local residents.

This change in CPR administration rates might be contributed to both location of deaths (lake, dam and lagoon), and other factors such as the person swimming, visibility, search time and remoteness of locations, not reflecting changes between states/territories (relating to availability of CPR education) as such. Therefore, increased responder time is an important aspect in rural and remote fatal injuries, especially given the remote locations of lakes, dams and lagoons. Like most other potentially fatal injuries, response time is critical in remote locations.[78-79] There is an avenue for advocacy, the value of modern telecommunications and skilled telephone triage training for emergency service providers for rural and remote Australia. Access to telecommunication in these areas is vital as there has been a well-documented association between early intervention and treatment with positive prognosis of the drowning victim.[26,65-68] Education of the lay first responder (i.e. community CPR training) should continue as the uptake in rural and remote is positive. Further promotion of this is an urban setting, especially those who frequent remote swimming areas, should also be considered.

Drowning rates of the Aboriginal and Torres Strait Islander population were four times higher than drowning rates among the general Australian population. With many Aboriginal and Torres Strait Islander people living in isolated communities, and the identification of key contributing factors of alcohol, swimming ability and undertaking aquatic activities alone, there is a need for culturally appropriate strategies to be developed to prevent drowning deaths among Aboriginal and Torres Strait Islander communities.

A detailed analysis of population data helps guide advocacy for future drowning prevention strategies. Our experience of successful injury prevention strategies indicates that a reduction in burden is best achieved through specific targeted interventions using the four-portal approach to aquatic deaths of education, improved design (e.g. of environments, safety barriers and safety equipment), legislation and rescue–resuscitation.[47] Although there is a benefit of a national prevention strategy, some State/Territory variations would be beneficial. The majority of states/territories had a strong prevalence of lake drowning deaths, apart from Queensland, which was overrepresented in drowning deaths occurring in dams. Age differentiation and targeting programs to specific high-risk groups should also be adopted on a state-by-state basis.

An important consideration in the funding of lake, dam and lagoon drowning prevention is the significant cost that search and rescue play in the recovery of drowning victims in this environment, with a high percentage of the deaths resulting in a search for the victim's body. These costs are not only tangible (such as the economic cost of the search), but intangible costs must also be considered (such as pain and the psychological impact on the families of those involved, and the loss of economic income to society).

LIMITATIONS

A number of cases within this report were open, meaning the case was still under investigation (N=37, 14.5%). As such, a number of variables remain unknown until the case is closed following completion of any coronial investigation. It should be noted that there may be a higher number of unknown variables among cases in regional and remote locations or more recent years where a larger proportion of cases may still be under investigation. This may alter the result findings for several variables that were heavily impacted by 'unknown' findings.

Amongst cases which were closed, records were incomplete with some cases still missing information, either because the information was unknown or it was not made available electronically. In such cases, variables were entered as 'unknown', again limiting the completeness of the data. Access to toxicology and autopsy reports specifically were not always available in all cases, thus impacting on the understanding of the involvement of alcohol and/or drugs may have played in the drowning deaths. Data on BAC levels was unknown in 22.4% of cases. Similarly, drug toxicology was unknown in 29.8% of all cases.

Endogenous alcohol production can increase the BAC of drowning victims following submersion and confound epidemiological studies, regarding the role of alcohol.[74-76] The lapse in reliable information on the time between death and the autopsy/toxicology testing may lead to an inaccurate report of BAC in some victims in this dataset due to decomposition, artificially inflating the results. Toxicology and autopsy reports, where possible, were examined and in most circumstances made reference to possible inflation of BAC due to decomposition, these findings were noted as non-relevant.

Cases where the coroner has made an open finding were included. This may overestimate the number of unintentional fatal drowning deaths in lakes, dams and lagoons as some cases were classified as "undetermined intent" or "still under investigation" within the NCIS database. However, this information is also cross-checked and correlated with media and other reports so it is assumed the numbers should not change significantly.

A key limiting factor in making a comparison between locations or inclusion of drowning deaths in this report was the definition of a lake, dam and lagoon. The definition made comparison between locations and any contribution factors specific to locations difficult. This should be interpreted with caution as the definition in aquatic natural environments can never be precise and does not allow it to fit neatly into categories.

Adding to the difficulty in determining water classification was in part due to the classification by the National Coronial System. Locations included in this study generally fell into four categories: area of still water (farm dam, pond/pool of water, natural ice), stream of water (river/creek/stream, brook/trickle of water, canal), large area of water (lake, sea/ocean, bay, public dam/reservoir, estuary) and marsh/swamp (bog, mire and wetland). As noted no specific NCIS coding was given to lagoons. Police reports and title given to the body of water also did not always correlate to coding in the NCIS database. The non-classification of lagoons in the NCIS database could account for the small number of lagoon classifications in the study, where lagoons were mainly bays not associated with ocean/harbour classification.

Calculations for crude fatal drowning rates by population, of remoteness classification used an average from three years 2006, 2011, and 2016 (Australian Census years) for population and drowning data for the financial years from 2008/2009 to 2017/2018. The rates produced may not be as accurate as if the population data was available for each of the years of the drowning data.

There is limited exposure data available for drowning generally, specifically a lack of exposure information relating to lakes, dams and lagoons. Therefore, relative risk in this study was calculated including only unintentional drowning deaths in a lake, dam or lagoon and does not take into account the total exposed population or the unintentional non-fatal drowning cases. The exclusion of non-fatal drowning, underreports the true burden of lake, dam and lagoon drownings to Australia.

One fifth (20%) of cases in this study had an unknown Indigenous status. Where Indigenous status was unknown, for the purpose of calculating crude death rates, the unknown group were not included in the analysis, in an attempt to not underestimate the Indigenous population within the drowning deaths in this study.

It is known that drought has played a significant role in the Australian landscape during the 10 year period featured in this study. As such, many dams, especially on residential or private properties may be empty or no longer a prominent feature on the property. This decrease in water supply at these locations may have skewed the results and led to underreported data in these rural or agricultural locations, or any other closed water system that relies on heavy rainfall for its existence. At the time of reporting, no data was available on the drought declaration in relation to post codes of drowning deaths and the change in rainfall over time. Further investigation into the correlation between drowning incidence and these factors could prove valuable for a true estimation of burden.

Although the study has limitations, there are numerous strengths produced by the study. The specific ten year period that was chosen for the study (omitting the current years drowning data 2018/2019) minimised the number of cases still under coronial investigation, strengthening the data presented. It also allowed for a current picture of the issue to be displayed by selecting the most current data possible.

The study utilised the National Drowning Database, held by Royal Life Saving Society - Australia. The database utilizes a collaboration of State/Territory Coronial Offices, the National Coronial Information System (NCIS) and media reports. This allows for a holistic, comprehensive picture to be presented in relation to each drowning death, strengthening the identification of individual and unique risk factors.

There are few studies that have examined lake, dam and lagoon waterways in isolation of inland waterway systems for drowning prevalence and risk factors. While location specific risk factors and prevention strategies have been established for rivers and inland streams, there has not been sufficient research conducted to understand if the prevention strategies are transferable to the lake, dam and lagoon environment or to inform the development of effective prevention strategies for lake, dam and lagoon inland waterways in their own right. This study highlights the need for further investigation into lake, dam and lagoon drowning deaths, with the emerging complex nature of drowning events, as well as highlighting the challenges faced and translating effective preventative actions into population based strategies. A detailed analysis of population data, like this study provides, aims to help guide advocacy for future drowning prevention strategies in the lake, dam and lagoon environment.

CONCLUSION

Previous studies have highlighted the sustained high numbers of drowning deaths experienced in rivers across Australia, with limited investigation into other inland waterways. This report demonstrates that over the past 10 years, a similar sustained trend can be seen in lakes, dams and lagoons. Further effort is needed to reduce drowning statistics in these locations and translate a community oriented understanding of the risks associated with activities at these aquatic locations.

While an analysis of the scale and nature of the lakes, dams and lagoons drowning deaths is an important first step in determining trends and informing prevention strategies, a need to increase our understanding of the users of these locations and our understanding of, and attitudes towards, the unique hazards and risks that the lakes, dams and lagoons present. Further work is also needed to not only understand the recreational and usage patterns of lakes, dams and lagoons, but an examination into work-related deaths must also take place.

Differentiating between rivers and lakes, dams and lagoon deaths is an important hurdle in the prevention process. While the locations share many similarities, there are common trends unique to the lake, dam or lagoon individual setting, especially emerging trends between private/residential waterbodies in comparison to public access bodies of water. Further investigation differentiating between these two environments would be warranted.

This research highlights the need for holistic, multi-strategy approach to drowning prevention in inland waterways, with specific delivery to each location (lakes, dams and lagoons), due to the variation in drowning age and activity across the different locations. Children under 4 years of age and those aged 65 and over were overrepresented in most locations, as were males 18 - 34 years in the lake environment.

The cases examined identify patterns of behaviour by both adults and children that contribute to the deaths unique to each location – lake, dam and lagoon. Drowning prevention measures in these locations, especially those in remote areas, need to go beyond the realm of current drowning advocacy strategies. The results highlight the issue of visibility during a drowning incident in the these locations and support the implementation of strategies such as the promotion of child safe play areas and targeted public awareness campaigns for these unique aquatic environments.

These findings demonstrate:

- An increased risk at dams on agricultural farm locations.
- Supervision of children and the need for child safe play areas for children on rural properties with access to inland waterways.
- Need and importance of CPR training to improve drowning outcomes, particularly in remote locations.
- A heightened risk of drowning in regional and remote areas, highlighting the need for strategies such as modern telecommunications and skilled telephone triage training for emergency service providers.
- The lack of swimming ability and the need for swimming and water safety programs in regional and remote locations.
- The need to raise awareness within the agricultural industry to the risk of drowning on rural properties, specifically with dam locations.

Primary prevention strategies that work in metropolitan areas are not always successful or translate well to rural locations where a large proportion of lakes, dams and lagoon drowning deaths take place. Action is required around research and delivery of targeted prevention campaigns in rural areas, with drowning prevention strategies tailored to specific age groups in these rural areas. Utilisation of current resources in these rural and remote communities is also vital, for both the sustainability of programs and buy-in from local residents.

It is important to appreciate the complex socioeconomic and demographic factors in rural and remote areas, and the challenges faced translating these into effective preventative actions like learn to swim programs, community education programs, or policy documents. There is unfortunately no one strategy that will prevent all rural and remote drowning deaths in the lake, dam or lagoon environment, therefore a wide variety of strategies targeting a range of age groups, aquatic locations, and activities will be required to reduce drowning deaths in this marginalised high-risk population.

Royal Life Saving is well placed to expand upon the findings of this report and implement its recommendations. As a water safety and drowning prevention organisation, we are committed to developing and implementing evidence based strategies to achieve a significant reduction in inland waterway drowning deaths in Australia.

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