Risky business: a 15-year analysis of fatal coastal drowning of young male adults in Australia

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ABSTRACT

Introduction Drowning is a leading cause of unintentional death, especially for males. In Australian coastal waters, young male adults account for 25% of the burden of male drowning. This study aims to describe young male coastal drowning deaths and to examine the prevalence of risk factors, especially alcohol and drugs.

Methods Characteristics of unintentional fatal drowning involving males (15–34 years) were compared with other adults (15 years and older). Data were sourced from the National Coronial Information System (Australia) and Surf Life Saving incident reports (2004/2005–2018/2019). Relative risk was calculated and χ^2 tests of independence were performed ($p<0.05$). Blood alcohol and drug concentrations were analysed with permutational analyses of variance.

Results Young males drowned more while jumping (9.85 times), swimming/wading (1.41 times), at rock/cliff locations (1.42 times) and on public holidays (1.8 times). Young males drowned less while boating (0.81 times), scuba diving (2.08 times), offshore (1.56 times) or due to medical factors (3.7 times). Young males drowned more (1.68 times) after consuming illicit drugs (amphetamines 2.26 times; cannabis 2.25 times) and less with prescription drugs (benzodiazepines 2.6 times; opiates 4.1 times; antidepressants 7.7 times). Blood serum concentrations of cannabis were higher in young males, while amphetamine and alcohol were lower.

Discussion Unsafe behaviours alongside certain activities or locations create deadly combinations of risk factors. A relationship between age, activity, attitude and affluence is proposed, where young males drown more in affordable activities with fewer regulations. Our results support multilevel strategies (spanning life stages) to reduce young male coastal drowning.

INTRODUCTION

Drowning is a preventable problem in which males are continually overrepresented in the estimated 372 000 drowning deaths per year.[1] The male burden differs across age groups, with younger males accounting for a significant proportion of drowning deaths globally,[2–4] such that Moran[5] suggests that drowning prevention interventions targeting young males are needed worldwide. This pattern is also true in Australia, where the burden of male drowning is most pronounced in the adolescent and early adult years (aged between 15 and 34 years old).[6 7] This increased risk of drowning in younger males is attributed to greater participation in aquatic activities (and therefore increased exposure), inflated confidence levels that do not reflect actual abilities, for example, water competence, and social determinants (ie, peer pressure).[5 8 9] This period of adolescence and early adulthood is also recognised as a time where the likelihood to engage in risk-taking behaviours increases (ie, participating in aquatic activities under the influence of drugs and or alcohol, and disregarding safety messaging).[5 10] The significant loss of young males and their contribution to society is certain to have ramifications for present and future generations.

Australia is an island continent with an extensive coastline that is a popular location for Australians and international visitors. The coast, and aquatic recreation, is embedded within Australian culture, which is unsurprising with 85% of the population residing within 50 km of the coast. Coastal environments are dynamic with many associated risks and hazards that need to be considered, with coastal natural waters (especially off beaches, rocks and offshore seas) most commonly involved in Australian drowning deaths.[11–13] Too often, people visiting the coast do not recognise or choose to ignore associated risks and hazards, resulting in an average of 112 unintentional coastal drowning deaths each year.[14] Since 2004, younger males (15–34 years of age) account for one in four coastal drowning deaths and therefore remain a priority for coastal safety agencies. Recognition and a greater understanding of circumstances specific to this high-risk population may enable more specific preventative approaches.

While there is an increasing body of research into risk factors, behaviours and attitudes of males and drowning,[5 15 16] there is a paucity of research exploring the characteristics of drowning deaths of younger males in coastal environments. This study primarily aimed to describe the epidemiology of coastal drowning deaths involving young males in Australia compared with other adults. A parallel aim was to explore the prevalence of potential risk factors in these events, with a focus on the use of alcohol and drugs. This research will extend our understanding of coastal drowning deaths of younger males and is intended to guide the development and design of future effective, targeted educational messaging to prevent these tragedies.

METHOD

Data were collected from the National Coronial Information System (including coroner's findings, police, autopsy and toxicology reports), media reports and SLSA's SurfGuard Incident Report Database. All coastal water drowning deaths in Australia (up to 12 nautical miles) that occurred between 1 July 2004 and 30 June 2019 were included in the

Table 1 Variable categorisation and definitions

Variable		Definition
Age/Gender category		
Young males		Young males (males aged 15–34)
Other adults		Other adults (females aged 15–34, all adults 35+)
Medical/Injury		Whether the patient had a medical condition or injury contribute to death, as ruled by the coroner
Medical	Injury	
Medical and injury	None	
Activity	PWC	Activity patient was participating in when incident occurred
Attempting a rescue	Rock fishing	
Boating	Scuba diving	
Drug-taking activities	Snorkelling	
Fall	Swimming/Wading	
Jump	Watercraft	
Land-based fishing	Unknown	
Non-aquatic transport	Other	
Location	Coastal pool	Coastal location type where incident occurred
Bay	Port/Marina	
Beach	River/Creek	
Jetty	Rock/Cliff	
Offshore	Other	
Time of day		Time of day the incident occurred
Morning (6:01–12:00)	Evening (18:01–0:00)	
Afternoon (12:01–18:00)	Night (0:01–6:00)	
Public holiday		Whether the incident occurred on a national public holiday
Yes		
No		
Patrolled location		Whether the incident occurred at a location patrolled by volunteer lifesavers/paid lifeguards. Australia currently has 321 Surf Life Saving clubs nationally.[14]
Yes		
No		
Distance to Surf Life Saving Services		Distance from incident location to nearest Surf Life Saving club as a proxy for trained life-saving services (lifeguards/lifesavers)
<1 km		
1–5 km		
>5 km		
Toxicology		Whether alcohol and/or drugs contributed to death, as ruled by the coroner
Alcohol		
Drugs		
Alcohol and drugs		
Drug group concentration		When a drug was determined to contribute to a death, the percentage concentration above therapeutic or toxic thresholds
Cannabis		
Amphetamines		
Benzodiazepines/Hypnotics		
Opioids		
Antidepressants		
Toxicological drug ratio		Ratio of the quantity of drug present in blood serum to the quantity required to impact drowning (either toxic quantity or physiological quantity)
Blood alcohol concentration		Blood alcohol concentration (g/100 mL of blood)

PWC, Personal Watercraft, e.g. jetskis.

analysis. Incidents were categorised across multiple variables (see table 1). Drowning death incidents involving children under the age of 15, intentional incidents (suicide and homicide) and those that occurred greater than 12 nautical miles offshore or in non-coastal areas (eg, rivers, swimming pools) were excluded from analyses. Also excluded from analyses were unknown values, including five cases where the victim could not be classed into any age group or classified as either 'Young male' or 'Other adult'.

Patient toxicology was collated from coronial toxicological analyses and was coded as 'alcohol' if blood alcohol content exceeded 0.05 g/100 mL (the legal driving limit in Australia); 'drugs' if any drugs (illicit, prescription, over-the-counter) were detected and ruled to contribute to the death by the coroner,

Table 2 Factors contributing to drowning of young males and other adults

	Young males n (%)	Other adults n (%)	Total (N)	Relative risk (95% CI, lower to upper)	P value
Drowning deaths	378 (27.5)	996 (72.5)	1374*		
Medical	31 (8.2)	294 (29.5)	326	0.27 (0.19 to 0.39)	**<0.001*** **
Injury	36 (9.5)	110 (11.0)	146	0.85 (0.59 to 1.21)	0.38
None	311 (82.7)	592 (59.4)	903		

***p<0.001.
*Totals that exceed others presented elsewhere in this paper indicate both medical and injuries contributed to incident.

reached toxic thresholds or physiological concentrations that could impair decision-making. These thresholds were determined from multiple sources including toxicological, forensic and coronial reports as well as relevant literature (online supplemental table 1).

It was not appropriate or possible to involve patients in the design, conduct or reporting of this research.

Statistical analyses

Statistical analyses were conducted in R (R V.3.6.1) and RStudio (V.1.2.5019). Relative risk (RR) ratios comparing young males with other adults were calculated for categorical variables using the package *epitools*. For all RR ratios, the reference group is 'other adults'; hence, a RR ratio >1 means that this variable was more common in young male incidents and vice versa (<1 more likely in other adults). Blood alcohol concentration (BAC) and the quantity of drug present were analysed with permutational analyses of variance using the package lmperm.

RESULTS

Between 1 July 2004 and 30 June 2019, there were 476 young male (0.99/100 000 population) and 1172 other adult (0.51/100 000 population) coastal and ocean drowning deaths. This equates to one in four drowning deaths occurring on our coasts are young males. Young males were 3.7 times less likely to drown than other adults due to precipitating medical factors (table 2). Figure 1 shows the average mortality rate of young males by age, and highlights the dramatic increase observed at 18–19 years old, which is largely sustained through to 34 years old. The average rate from 15 to 17 is 0.38 per 100 000 population, while the average rate almost tripled for 18–34 years is 1.08 per 100 000 population, 2.85 times more likely to drown than males aged 15–17 years old.

Significant results found that young males were 9.85 times more likely to drown while jumping, 1.41 times more likely while swimming or wading, 0.81 times less likely to drown while boating and 2.08 times less likely to drown while scuba diving than other adults (table 3). Young males were 1.42 times more likely to drown at rocks or cliff locations and 1.56 times less likely to drown offshore (table 3). Young males were 1.39 times less likely to drown in the morning but 1.15 times more likely to drown in the afternoon and were 1.8 times more likely to drown on a public holiday than other adults (table 3). There were no differences detected for other activities, other location categories, distance to the nearest life-saving service or for whether the location was ever patrolled or not.

Alcohol and drugs

The risk of drowning under the influence did not differ between young males and other adults (table 4). However, young males were 1.68 times more likely to drown under the influence of illicit drugs (table 4), in particular amphetamines (2.26 times) and cannabis (2.25 times; table 4), than other adults. Young males were 2.44 times less likely to drown under the influence of or affected by prescription drugs such as benzodiazepines/

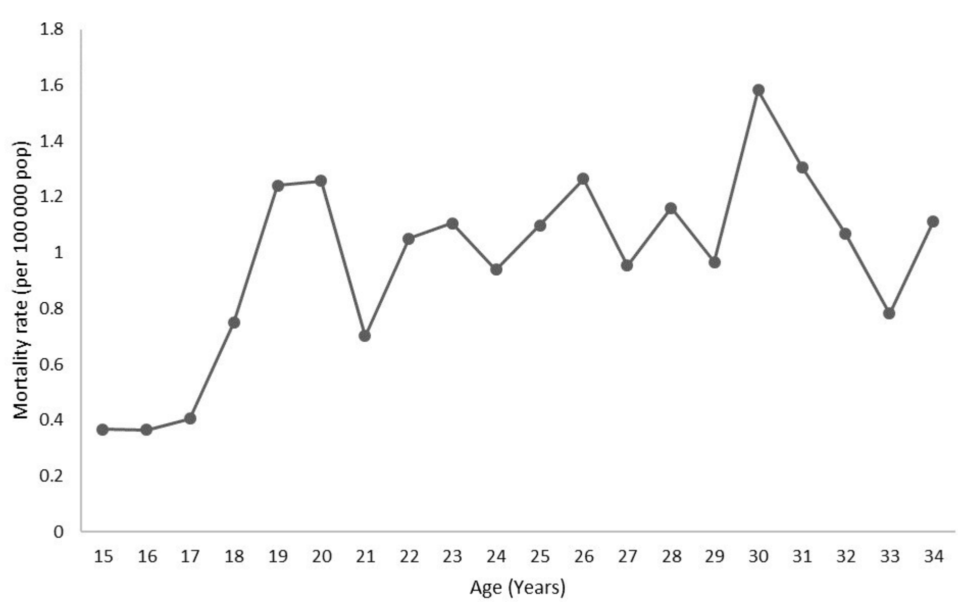

Figure 1 Average mortality rate by age per 100 000 population (1 July 2004–30 June 2019) for coastal drowning deaths involving young males aged 15–34 years.

Table 3 Epidemiological summary and analyses of drowning deaths involving young males compared with other adults (1 July 2004–30 June 2019)

Drowning risk	Young Males n (%)	Other Adults n (%)	Total n	Relative risk (95% CI, lower to upper)	P value
Mean annual drowning deaths	32 (29.1)	78 (70.9)	110	1.97 (1.31 to 2.98)	**<0.002****
Mean adult population (millions)	3.20 (17.2)	15.39 (82.8)	18.59		
Activity (n)	476 (28.9)	1172 (71.1)	1648		
Attempting a rescue	22 (4.6)	38 (3.2)	63	1.42 (0.85 to 2.37)	0.19
Boating	68 (14.3)	303 (25.9)	391	**0.55 (0.43 to 0.71)**	**<0.001*****
Fall	30 (6.3)	48 (4.1)	82	1.53 (0.98 to 2.39)	0.07
Jump	16 (3.4)	NP	20	**9.81 (2.87 to 33.5)**	**<0.001*****
Land-based fishing	NP	14 (1.2)	18	0.49 (0.14 to 1.7)	0.42
Non-aquatic transport	5 (1.1)	12 (1)	17	0.94 (0.34 to 2.68)	1
PWC	NP	12 (1)	14	0.37 (0.09 to 1.68)	0.41
Rock fishing	51 (10.7)	130 (11.1)	182	0.96 (0.71 to 1.31)	0.97
Scuba diving	11 (2.3)	57 (4.9)	68	**0.48 (0.25 to 0.89)**	**0.02***
Snorkelling	40 (8.4)	70 (6.0)	110	1.4 (0.96 to 2.04)	0.082
Swimming/Wading	170 (35.7)	296 (25.3)	492	**1.41 (1.21 to 1.65)**	**<0.001*****
Watercraft	35 (7.4)	85 (7.3)	122	1.01 (0.70 to 1.49)	0.92
Other	7 (1.5)	13 (1.1)	22	*	
Unknown	14 (2.9)	91 (7.8)	105	*	
Location (n)	476 (28.9)	1172 (71.1)	1648		
Bay	28 (5.9)	95 (8.1)	128	0.72 (0.48 to 1.09)	0.12
Beach	228 (47.9)	516 (44.0)	772	1.09 (0.97 to 1.22)	0.16
Jetty	10 (2.1)	24 (2.0)	37	1.02 (0.49 to 2.12)	1
Offshore	69 (14.5)	265 (22.6)	337	**0.64 (0.50 to 0.82)**	**<0.001*****
Coastal pool	NP	7 (0.6)	10	0.92 (0.24 to 3.54)	1
Port/Marina	7 (1.5)	34 (2.9)	41	0.506 (0.23 to 1.13)	0.11
River/Creek	NP	11 (0.9)	16	0.61 (0.17 to 2.2)	0.77
Rock/Cliff	126 (26.5)	218 (18.6)	362	**1.42 (1.17 to 1.72)**	**<0.001*****
Other	NP	NP	4	*	
Time of day (n)	407 (29.4)	979 (70.6)	1386		
Night (00:01–06:00)	41 (10.1)	100 (10.2)	141	0.98 (0.70 to 1.39)	1
Morning(06:00–12:00)	99 (24.3)	333 (34.0)	432	0.72 (0.59 to 0.87)	**<0.001*****
Afternoon (12:01–18:00)	213 (52.3)	445 (45.5)	658	1.15 (1.03 to 1.29)	**0.021***
Evening (18:01–00:00)	54 (13.3)	101 (10.3)	155	1.29 (0.94 to 1.75)	0.13
Patrolled location (n)	450 (29.7)	1063 (70.3)	1513		
Yes	144 (32.0)	300 (28.2)	444	1.13 (0.96 to 1.34)	0.16
No	306 (68.0)	763 (71.8)	1069		
Distance to Surf Life Saving Services (n)	431 (28.9)	1061 (71.1)	1492		
<1 km	130 (30.2)	284 (26.8)	414	1.12 (0.94 to 1.34)	0.2
1–5 km	103 (23.9)	240 (22.6)	343	1.05 (0.86 to 1.29)	0.63
>5 km	198 (45.9)	537 (50.6)	735	0.91 (0.81 to 1.02)	0.11
Public holiday	408 (28.5)	974 (68.0)	1433		
Yes	43 (10.5)	57 (5.9)	100	1.8 (1.23 to 2.62)	**0.003****
No	365 (89.5)	917 (94.1)	1333		

*p<0.05, **p<0.01, ***p<0.001.
NP, not presented in line with ethics requirements (cohorts<5 may be identifiable); PWC, Personal Watercraft, e.g. jetskis.

sedatives (2.6 times), opiates (4.1 times) or antidepressants (7.7 times) when compared with other adults (table 4).

The average BAC for young males who fatally drowned while under the influence of alcohol was 0.17, and while three times greater than the legal limit (0.05 g of alcohol per 100 mL blood), was significantly lower than the mean 0.2 BAC for other adults (table 5). However, the average blood serum concentration for cannabis was significantly higher for young males than other adults, while other adults had, on average, a higher amphetamine concentration ratio (table 5). There were no differences between the concentration ratios for opiates, antidepressants and benzodiazepines/sedatives (table 5).

DISCUSSION

Drowning is a leading cause of unintentional fatalities,[1] and since 2004, Australia has recorded an average of 112 coastal drowning deaths each year.[14] Young males (aged between 15 and 34 years old) comprise a significant proportion of this burden, accounting for a quarter of Australian coastal drowning deaths—a trend that is reflected internationally.[2] This study is the first epidemiological

Table 4 Contribution of drugs and alcohol in drowning deaths of young males compared with other adults

	Young males n (%)	Other adults n (%)	Total	Relative risk (95% CI, lower to upper)	P value
Alcohol and drugs					
Alcohol total†	64 (13.1)	137 (11.3)	201	1.18 (0.9 to 1.55)	0.23
Drugs total†	51 (10.4)	129 (10.9)	180	1 (0.74 to 1.35)	1
None	306 (62.4)	800 (66.1)	1163		
Unknown	69 (14.1)	144 (11.9)	215		
Total	490 (27.9)‡	1210 (68.8)‡	1759‡		
Class of drugs					
Illicit drugs	43 (10.6)	61 (6.0)	104	1.68 (1.16 to 2.44)	**0.007****
Prescription drugs	12 (3.0)	78 (7.7)	90	0.41 (0.22 to 0.74)	**0.0013****
None	349 (86.4)	877 (86.3)	1226		
Total	404 (28.5)	1016 (71.5)	1420		
Drugs types: Contributing to death					
Amphetamine					
Yes	17 (3.6)	19 (1.6)	36	2.26 (1.18 to 4.3)	**0.015***
No	459 (96.4)	1153 (98.4)	1612		
Total	476 (28.9)	1172 (71.1)	1648		
Cannabis					
Yes	32 (6.7)	36 (3.1)	68	2.25 (1.41 to 3.56)	**<0.001*****
No	444 (93.3)	1136 (96.9)	1580		
Total	476 (28.9)	1172 (71.1)	1648		
Benzodiazepines/Sedatives					
Yes	7 (1.5)	46 (3.9)	53	0.38 (0.17 to 0.84)	**<0.012***
No	469 (98.5)	1126 (96.1)	1595		
Total	476 (28.9)	1172 (71.1)	1648		
Opiates					
Yes	NP	31 (2.6)	34	0.24 (0.073 to 0.77)	**0.011***
No	473 (99.4)	1141 (97.4)	1614		
Total	476 (28.9)	1172 (71.1)	1648		
Antidepressants					
Yes	NP	19 (1.6)	20	0.13 (0.017 to 0.94)	**0.021***
No	475 (99.8)	1153 (98.4)	1628		
Total	476 (28.9)	1172 (71.1)	1648		

*p<0.05, **p<0.01, ***p<0.001.
†Include cases with drugs and alcohol contributing to death.
‡Totals that exceed others presented elsewhere in this paper indicate both alcohol and drugs contributed to incident.
NP, not presented in line with ethics requirements.

analysis describing key characteristics of young male coastal drowning deaths in Australia (but see Hamilton and Schmidt[17]). Our results emphasise the complexity of drowning prevention when behaviours are the deadliest risk factor.

Characteristics of young male coastal drowning deaths in Australia

The high risk associated with young males and drowning is widely thought to reflect exposure to aquatic locations due to participation, lack of knowledge and a tendency to be careless or to take unnecessary risks through misguided or irrational thought processes.[5 10 16 18 19] Testosterone may also contribute to or exacerbate these attitudes, and therefore increase the risk of drowning, especially during the late teen and early adult years.[16] This study shows that in Australia, young males drown while jumping or swimming and wading in coastal waterways, especially at rocky or cliff locations, more than other adults, but are significantly less likely to drown due to precipitating medical factors or organised and heavily regulated activities such as boating and scuba diving. These findings align with previous research highlighting impacts of behavioural factors thought to be synonymous with younger males: an overestimation of swimming abilities,[10 16 18 20] ambivalent safety attitudes (eg, disregard of safety messaging or signage)[10] and an increased likelihood to engage in risky behaviour (ie, jumping into the water without precaution).[5 10 21]

Developing a better understanding of the social contexts surrounding these incidents is crucial for creating effective messaging, which is particularly challenging for this demographic.[15] It is well established that males are more likely to take risks than females[19 22] and that young males have a higher propensity towards risk taking than older males.[23] Risk-taking behaviours have evolved in young males and serves as costly signalling of high-quality characteristics to potential mates and demonstrates strengths or abilities to peers.[24] Swimming, wading and jumping activities at coastal locations often involve the social context of a group of peers where behaviours could be determined as attention--vseeking[21 24] or in line with social rules and controls that typify 'dangerous masculinities'.[5] Under these pretences, they may also be undertaken surreptitiously in remote, unsupervised locations.[21] Physiological (ie, testosterone) and social drivers (eg, peer pressure) have also been suggested to

Table 5 Difference in toxicological ratios present in the patient's blood serum compared with the relevant threshold value (either physiological or toxic)

	Count (n)	Mean	SD	df	P value
Alcohol (BAC)					
Other adults	123	0.20	0.086	1	**0.0066****
Young males	57	0.17	0.084		
Residuals				178	
Amphetamine					
Other adults	18	9.63	11.6	1	**0.02***
Young males	16	3.96	4.1		
Residuals				32	
Cannabis					
Other adults	34	4.78	3.43	1	**0.018***
Young males	26	8.79	9.44		
Residuals				58	
Benzodiazepines/Sedatives					
Other adults	44	6.82	9.46	1	0.65
Young males	6	9	16.3		
Residuals				48	
Opiates					
Other adults	29	8.71	8.03	1	0.55
Young males	NP	4	N/A		
Residuals				28	
Antidepressants					
Other adults	19	1.74	0.987	1	1
Young males	NP	1.6	N/A		
Residuals				18	

*p<0.05, **p<0.01.
NP, not presented in line with ethics requirements.

spur young males to overextend their actual swimming abilities to dangerous levels.[16 25] In terms of aquatic activities, swimming, wading and jumping are also less regulated (when compared with boating, scuba diving or rock fishing for example) such that they may more easily facilitate risky 'larrikin' behaviours that appear to be firmly engrained in the social norms of young males.[5 21]

Young adult responses probably rely more on previous safety training opportunities, meaning developmental circumstances may impact on their understanding of risks and influence their ability to make safer decisions. In Australia, water safety education is a high priority and is incorporated into most school programmes; however, inequities are still apparent.[26 27] Socioeconomic status has been shown to positively correlate with water safety knowledge,[28] linked to access and exposure to education opportunities. Young males were less likely to drown while boating and scuba diving, both expensive and heavily legislated activities, especially compared with swimming, wading and jumping, suggesting that young males may either participate less or make safer risk assessments in these activities. While the extent of affluence and legislation as drivers behind these results is not measured, it does raise the question of how does affluence during childhood increase risk awareness and instil decision-making that promotes survival in young males. Poor risk assessment and a lack of survival skills are suggested to increase the drowning risk for young males,[19 25] and since the mortality rate almost tripled at 18 years old (an age when school and family supervision levels drop), our results provide further evidence to support that the development of survival skills and risk assessment earlier in life may be an effective strategy for young males.

Young males were more likely to drown on a public holiday and during the afternoon, and less likely to drown in the morning. These patterns may reflect the recreational and social constructs of these incidents, where participation and exposure rates could be higher in the afternoon, when young males are likely to be socialising, less vigilant regarding coastal safety and more likely to make poor decisions. The influence of social and recreational aspects on coastal drowning of young males is further substantiated by the increased risk of coastal drowning almost doubling on public holidays compared with other adults. This increased risk (along with those higher risks for rocky cliff locations and during swimming, wading and jumping activities) supports previously identified links between drowning on public holidays and aquatic activities at beach and rock locations in Australia.[29] Public holidays in Australia are highly celebrated and are commonly associated with social events, aquatic recreation, travel to unfamiliar environments and higher use of alcohol and drugs.[29] Our results support that fatal coastal drowning of young males occurs disproportionately more on public holidays than other days, and that the afternoon is the riskiest time of day.

The role of alcohol and drugs in Australian young male coastal drowning deaths

Alcohol and drugs are known risk factors for drowning[30–32] and are commonly implicated in injury-related fatalities for this demographic.[15 17 25 33] Young males were 1.17 times more likely to drown after consuming alcohol than other adults, but the RR did not differ statistically. BACs were significantly higher in other adults who were four times above the legal driving limit (an average BAC of 0.20%), but while young males were lower than other adults, they were still more than three times above (an average BAC of 0.17%) the legal driving limit. High BAC levels for other adults could suggest acquired or functional tolerance to alcohol, such that individuals can consume greater quantities, but have a lower capacity to perceive physiological and psychological cues of intoxication.[33] These results confirm that alcohol remains a major risk factor for drowning across the population, highlighting that this is not a problem specifically for young males.

Young males were more likely to drown under the influence of illicit drugs, with amphetamines and cannabis more than doubling their drowning risk when compared with other adults. In particular, cannabis is identified as of specific concern with concentrations significantly higher in young males, with the average cannabinoid concentration determined to be 8.79 times above physiologic, psychologic and psychomotor thresholds—further confirming the impacts drug-taking behaviour can have on functionality and our capacity to respond in dangerous situations. Interestingly, other adults had significantly higher amphetamine concentrations (9.63 times above physiologic and psychomotor thresholds), which again raises eludes to the phenomenon of acquired tolerance that can arise with prolonged amphetamine use, meaning they consume more to receive the same physiologic effect.[34] These results, along with the knowledge that these substances are illegal and are taken deliberately (and often in secrecy), emphasise the complications and challenges surrounding managing this concern.

Potential intervention strategies

Gathering information to develop effective drowning prevention strategies underpins most water safety research. Young males have been identified as a challenging demographic to reach with simpler drowning prevention initiatives[28] to address behaviours such as recreational jumping[21] and alcohol or drug consumption.[10 25] Public education, awareness and legislation are commonly proposed strategies,[10 25] but unfortunately, have at times had negative impacts that further encourage the risk-taking behaviours.[25] Greater establishment and enforcement of alcohol-free areas (via random testing) at coastal locations may decrease the combination of aquatic activities with alcohol, with benefits that extend to the wider population. For young males, the social context is important for decision-making, highlighting that peer-oriented interventions that promote the negative consequences of risky behaviours[15] in combination with reciprocal learning may capitalise on the male dependence on their peers' understanding of water safety[5] and create a multilevel prevention strategy.[35] Potential prevention avenues are suggested in box 1. Passive interventions (eg, the promotion of safety messaging on social media, television and radio platforms) targeting young males may be more effective when encouraged by legislation or regulation,[25] when exposure to preventative education occurs during development periods that are less chaotic (eg, early childhood),[25] and when parental attitudes disapprove of risk-taking behaviours (eg, drinking and swimming).[15] Preparation is key to halting the drowning process,[36] therefore integrated passive interventions and active risk mitigation education such as water safety education[37] where young males learn how to react in dangerous situations are crucial to guide behaviour change for this high-risk group.[38] Preventative strategies must also be evaluated to determine their effectiveness.

Limitations

This study provides a comprehensive analysis, yet there are some limitations that need to be acknowledged. First, gender differences in risk-taking behaviours are known to vary with context and age,[22] and by comparing young males to other adults, the influence of age and gender has not been disentangled. Second, levels of hardship vary and can shape the risk-age association.[23] Australia is a high-income country and interventions suggested here may not be appropriate for low-income or middle-income countries where hardship levels differ. Similarly, this study is limited to fatal drowning and does not explore the impact of non-fatal incidents, which are known to have considerable community impacts.[39]

Box 1 Potential prevention strategies for young adults, especially young male adults

Suggested intervention strategies

- Passive safety campaigns targeting young male attitudes and behaviours to risk taking (including drinking and swimming) social media and online tools
- Preventative, peer-led education that encourages ownership of safe behaviours by young males and their peers, which takes place at multiple points during development
- Increased random drug and alcohol testing at high-risk locations, especially on public holidays and long weekend
- Establishment of intensive water safety refresher courses, including rescue and survival strategies, for young adults in secondary and tertiary education curriculum
- Safety signage, remote surveillance and active enforcement at swimming and jumping hotspots (which could be determined by incident data and social media content)

CONCLUSION

This study describes coastal drowning deaths involving young males. These results support the impact of risk factor combinations: that unsafe behaviours can prove deadly combined with certain activities (ie, swimming and recreational jumping) or locations. A relationship between behaviours (specifically age, activity, attitude and affluence) is proposed, where young males tend to drown more while participating in less regulated and more affordable activities, suggesting that underlying social

What is already known on the subject

- Young male adults (15–34) represent a significant proportion of the global burden of drowning.
- Young males participate in higher risk-taking activities than other demographics. This leads to a suite of attitudes and behaviours including an underestimation of risks, an overestimation of abilities and an ambivalence to safety precautions.

What this study adds

- This study is the first epidemiological analysis describing key characteristics of young male coastal drowning deaths in Australia.
- Young males comprise 25% of Australia's coastal drowning and are significantly more likely to drown while jumping or swimming/wading, at rock/cliff locations and under the influence of illicit drugs, particularly amphetamines and cannabis.

determinants could further impact on these incidents and need to be explored further. Our results support the call for multilevel strategies deployed at different life stages[35] to prevent young males from drowning on our coasts. This research has extended our understanding of young male coastal drowning deaths and provides novel insights that have the potential to guide the development of future effective educational messaging that target this high-risk demographic.

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Supplementary Table 1. Contributory drug concentration table used to interpret forensic toxicological analyses and reports

Class of drugs	Drug name	Toxic/lethal range	Range to impact decision/ Drowning	Reference
Cannabinoids	Cannabis/THC		0.0021 mg/L (often report in ng/mL or ug/L: 2.1 ng/mL 2.1 ug/L)	[1, 2]
Benzodiazepines			Therapeutic or above	[2-4]
	Alprazolam	0.1 – 0.4 mg/L	0.005 – 0.05 mg/L	[3]
	Bromazepam + OH-	0.3 – 0.4 mg/L	0.08 – 0.2 mg/L	[4]
	Chlordiazepoxide	3.5 – 10 mg/L	0.4 – 3 mg/L	[4]
	Norchlordiazepoxide		0.3 – 2 mg/L	[3]
	Demoxepam		0.5 – 0.74 mg/L	[3]
	Clobazam	0.5	0.03 – 0.3 mg/L	[4]
	Norclobazam		2.0 – 4.0 mg/L	[3]
	Clonazepam	0.1 mg/L	0.02 – 0.08 mg/L	[4]
	Aminoclonazepam		0.02 – 0.07 mg/L	[3]
	Desalkylflurazepam		0.01 – 0.15 mg/L	[3]
	OH-ethylflurazepam		0.01 – 0.07 mg/L	[3]
	Lorazepam	0.3-0.5 mg/L	0.02 – 0.25 mg/L	[4]
	Lormetazepam		0.00-0.02	[4]
	Midazolam + OH-midazolam	1 – 1.5 mg/L	0.04 – 0.1 mg/L	[4]
	Nitrazepam	0.2-3 mg/L	0.03 – 0.1 mg/L	[4]
	Oxazepam		0.2 -1.5 mg/L	[4]
	Temazepam	> 1 mg/L	0.02 – 0.15mg/L	[4]
	Diazepam	3-5 mg/L	0.1-2 mg/L	[4]
	Nordiazepam	1.5 – 2 mg/L	0.2-0.8 mg/L	[4]
	Estazolam		0.055-0.2	[4]
Hypnotics	Zolpidem	0.5 mg/L	0.08 – 0.15 mg/L	[4]
	Zopiclone	0.15 mg/L	0.01 – 0.05 mg/L	[4]
Antidepressants	Fluoxetine	1-5.9 mg/L		[4]
	Norfluoxetine	1.0 – 5.6 mg/L		[5]

	Sertraline	0.29 mg/L		[5]
	Venlafaxine	1-1.5 mg/L		[4]
	O-desmethylvelafaxine	1 mg/L		[6]
	Citalopram	0.22 mg/L		[4]
	Mirtazipine	1 mg/L		[4]
	Amitriptyline	0.5-0.6 mg/L		[4]
	Nortriptyline	0.3-0.5 mg/L		[4]
	Paroxetine	0.35 – 0.4 mg/L		[4]
	Duloxetine	0.24 mg/L		[4]
	Dothiepin	0.3 – 0.8 mg/L		[4]
	Fluvoxamine	0.5 – 0.97 mg/L		[4]
Opioids	Codeine	0.5 - 1 mg/L	0.03-0.25	[4, 7, 8]
	Morphine	0.1 mg/L	0.01-0.1 mg/L	[4]
	Propoxyphene	0.6-1 mg/L	0.05 – 0.3 mg/L	[4]
	Methadone	> 0.2 mg/L	0.25-0.35 mg/L	[4, 9, 10]
	Oxycodone	0.2 mg/L	0.005-0.1 mg/L	[4]
	Fentanyl	0.003 – 0.3 mg/L	0.003 – 0.3 mg/L	[4]
	Tramadol	> 1 mg/L	0.1-1 mg/L	[4]
Analgesics/anti inflammatory	Paracetamol	100 – 150 mg/L		[11]
	O-desmethyl tramadol	> 0.1 mg/L		[6, 12]
Antipsychotic	Pericyazine	0.1 mg/L		[13]
	Clozapine	0.6 – 1 mg/L mg/L	0.1-0.6 mg/L	[4]
	Olanzapine	0.15 – 0.2 mg/L	0.02-0.08 mg/L	[4]
	Quetiapine	1-1.8 mg/L		[4]
Anti-convulsants	Carbamazepine	10 mg/L	2 – 9 mg/L	[4, 14] > 8 mg/L causes poor cognitive performance
	Phenobarbitone	30 – 40 mg/L		[9]

	Valproic Acid	150 - 200 mg/L		[4]
Amphetamines	Methylamphetamine	> 0.15 mg/L	0.1 mg/L	[4]
	3,4-Methylenedioxymethamphetamine (MDMA)	0.35-0.5 mg/L	0.1-0.35 mg/L	[4]
	Dexamphetamine		> 10 ng/L > 0.01 mg/L	[15] Drug effects felt after plasma concentration > 10 ng/L
	Amphetamine	0.2 mg/L	7.5 ng/mL 0.01 mg/L	[4, 16] Amphetamine group showed intoxication greater than control for more than 7 hours after administration, approximately 45 ng/mL
	Methylphenidate	0.1-0.5		[4]
Other	Amlodipine	0.088 mg/L		[4]
	Irbesartan	> 5.3 mg/L (therapeutic conc.)		[12]
	Flecainide	1-2		[4]
Cocaine	Cocaine	0.25-1 mg/L	50 ng/mL 50 ug/L 0.05 mg/L	[4, 17] Euphoric/ behavioral/physiological effects returned to baseline 60 min after administration, approx. 50 ng/mL)
	Benzoylecgonine		0.1 mg/L	[4]

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