

Snorkelling and breath-hold diving fatalities in Australian waters, 2014 to 2018

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Keywords

Diving deaths; Cardiovascular; Fatalities; Freediving; Immersion; Snorkelling; Spearfishing

Abstract

(Lippmann J. Snorkelling and breath-hold diving fatalities in Australian waters, 2014 to 2018. *Diving and Hyperbaric Medicine*. 2023 September 30;53(3):210–217. doi: 10.28920/dhm53.3.210-217. PMID: 37718294.)

Introduction: This study investigated snorkelling and breath-hold diving deaths in Australia from 2014–2018 and compared these to those from 2001–2013 to identify ongoing problems and assess the effectiveness of countermeasures.

Methods: Media reports and the National Coronial Information System were searched to identify snorkelling/breath-hold diving deaths for 2014–2018, inclusive. Data were extracted from witness and police reports, medical histories, and autopsies. An Excel® database was created and a chain of events analysis conducted. Comparisons were made with the earlier report.

Results: Ninety-one fatalities (78 males, 13 females, median age 48 years [range 16–80]) were identified with one third likely doing some breath-hold diving. Fifty-two of 77 with known body mass index were overweight or obese. Approximately two thirds were inexperienced snorkellers and 64 were alone. Fifty-one were tourists. Planning shortcomings, such as solo diving and diving in adverse conditions, as well as pre-existing health conditions and inexperience predisposed to many incidents. Primary drowning was the likely disabling condition in 39% of cases with drowning recorded as the cause of death (COD) in two thirds. Cardiac events were the likely disabling conditions in 31% although recorded as the COD in 21% of cases.

Conclusions: Increasing age, obesity and associated cardiac disease have become increasingly prevalent in snorkelling deaths and there is a need for improved health surveillance and risk management. Closer supervision of inexperienced snorkellers is indicated. Apnoeic hypoxia from extended breath-holding and poor supervision remain a problem. The increased risk of harvesting seafood in areas frequented by large marine predators needs to be appreciated and managed appropriately.

Introduction

Snorkelling involves a person using a mask and snorkel and often fins while swimming to enable them to observe the underwater environment. In addition to swimming on the surface, snorkelling may also involve breath-hold diving underwater. Snorkelling is a popular recreational activity in Australia, but despite some estimates based on relatively small samples, there are no reliable data on the number of participants.^{1–3}

Immersion counters the effect of gravity and encourages redistribution of venous blood into the thorax, so increasing the cardiac workload.⁴ It can also be strenuous and anxiety provoking and aspiration of water through the snorkel is common in novices. Breath-holding diving elicits the diving reflex which involves peripheral vasoconstriction, hypertension and bradycardia.⁵ The physiological changes, physical challenges, other environmental factors and pre-existing medical conditions in snorkelling participants has an associated incidence of fatalities which has shown a marked increase over time with various peaks and troughs,

largely but certainly not solely associated with levels of activity (Figure 1). Earlier Australian epidemiological studies have reviewed snorkelling-related deaths from 1987 to 1996, 1994 to 2006, and 2001 to 2013.^{6–8} The last of these highlighted increasing age and prevalence of pre-existing medical conditions of the victims as increasingly common risk factors, in addition to the traditional issues such as inexperience, environmental challenges, planning deficiencies, and unsafe practices.

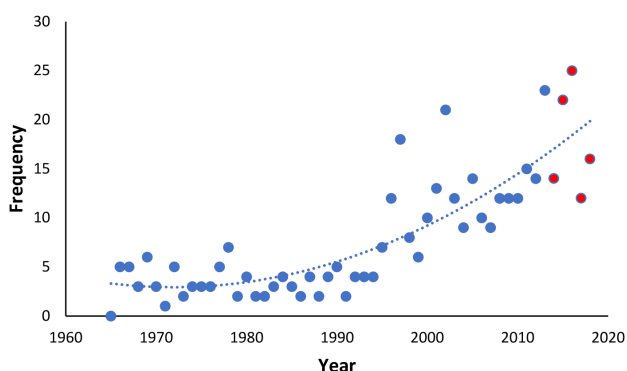
This current report investigates snorkelling and breath-hold fatalities in Australian waters from 2014 to 2018 inclusive. Causation and outcome data are compared to that of the previous reporting period of 2001–2013 to determine ongoing problems and assess countermeasures.

Methods

Ethics approvals for the collection and reporting of these data was received from the Victorian Justice Human Research Ethics Committee to access the National Coronial Information System (NCIS Approval number CF/21/18434).⁹

Figure 1

Annual snorkelling and breath-hold diving fatalities from 1965 to 2018. The red dots signify the study period



This represents a complete, or near-complete, case series of snorkelling and breath-hold diving deaths in Australia from 1 January 2014 to 31 December 2018. For inclusion, the diver generally must have been reported to have been wearing at least a snorkelling mask. However, an exception to this is a person who partakes in breath-hold diving and who is specifically practicing extending their breath-holding in water to increase their diving limits.

SEARCH

A comprehensive keyword search was made of the NCIS for snorkelling and breath-hold-related deaths throughout Australia for the period 1 January 2014 to 31 December 2018. Keywords included snork*, spear fish*, free diving, underwater fishing. Data obtained from the NCIS was matched with that listed on the Australasian Diving Safety Foundation (ADSF) fatality database¹⁰ obtained via media or word of mouth.

REVIEW PROCEDURE AND OUTCOME MEASURES

The investigator reviewed all datasets, a range of outcome measures were extracted for each case and entered into a specially created anonymised and protected Microsoft® Excel spreadsheet. Where available, these data included demographics, health factors, experience, origin of victims, dive location and conditions, buddy circumstances and oversight, dive purpose and setting, equipment worn and rescue and resuscitation factors.

ANALYSIS

A chain of events analysis (CEA) was performed for each case using existing templates with modifications to better tailor these to snorkelling incidents.¹¹ Categories were defined as follows:

Predisposing factor: A relevant factor(s) that was present prior to the dive, and/or prior to the trigger occurring, and which was believed to have predisposed to the incident and/or to key components in the accident chain (e.g., the trigger or disabling agent).

Trigger: The earliest identifiable event that appeared to transform an unremarkable dive into an emergency.

Disabling agent: An action or circumstance (associated with the trigger) that caused injury or illness. It may be an action of the diver or other persons, function of the equipment, effect of a medical condition or a force of nature.

Disabling condition: Injury or condition directly responsible for death, or incapacitation followed by death from drowning.

Cause of death: As specified by a medical examiner, which could be the same as the disabling injury or could be drowning secondary to injury.

Descriptive analyses based on means and standard deviations or medians and ranges, and *t*-tests, χ^2 and Mann-Whitney U tests for comparisons of age or body mass index (BMI), as appropriate, were conducted using SPSS Version 29.0.0.0 (IBM Armonk, NY; 2022). The level of statistical significance assumed was $P < 0.05$.

Results

Between 2014 and 2018 there were 91 identified fatalities in snorkellers and breath-hold divers (hereafter generally combined with snorkellers) throughout Australia. The annual counts were 14, 22, 25, 13 and 16 deaths for the consecutive years from 2014 to 2018, respectively. Based on their reported experience and activity at the time, it is likely that around 55 of the victims were predominantly 'surface snorkelling' and 33 were breath-hold diving. Brief summaries of individual cases can be found at [Appendix 1](#).

DEMOGRAPHICS

There were 78 males and 13 female victims. The median (interquartile range [IQR]) age of the victims was 48 (32, 64) years with a range of 16 to 80 years. There was no significant difference in ages between males and females ($P = 0.65$). The surface snorkellers were older than the breath-hold divers with median (IQR) ages of 55 (33, 70) and 38 (31, 50) years, respectively ($P = 0.003$).

Body mass index was available for 77 of the snorkellers (mean [SD] 28.4 [7.4] kg.m⁻²) and, although higher for the females (30.6 vs 28.1 kg.m⁻²), this was non-significant ($P = 0.70$). Twenty-nine of the victims (25 men and

Table 1

Location of the incident and origin of the snorkelling victims; NSW – New South Wales; QLD – Queensland; SA – South Australia; VIC – Victoria; WA – Western Australia

State	Deaths	Local	Interstate tourist	Overseas tourist
QLD	48	9	6	33
WA	16	5	3	8
NSW	14	11	1	2
VIC	8	8	0	0
SA	5	3	0	2

four women) were classified as overweight (BMI 25–29.9 kg.m⁻²), and 23 (19 men and four women) were obese (BMI ≥ 30 kg.m⁻²). The highest BMI was 66.4 kg.m⁻² in a male victim. There was no difference in the BMI for the surface snorkellers and breath-hold divers ($P = 0.71$).

Although higher, the mean (SD) BMI for Australian victims (29.8 [9.2] kg.m⁻²) was not significantly different than for overseas visitors (27.3 [5.3] kg.m⁻²) ($P = 0.06$).

TRAINING AND EXPERIENCE

There was some indication of perceived swimming ability in 53 cases. At least 38 of the victims were reported to have been ‘good’ swimmers, but at least 16 were reportedly ‘weak’ or ‘non-swimmers’.

Of the 58 incidents where there was some indication of the victim’s snorkelling experience, 22 (37%) were reported to have been experienced snorkellers. Seven were certified scuba divers, two being instructors. The remainder were novices, with at least five first-time snorkellers. Breath-hold divers were reportedly more experienced than the surface snorkellers (67% vs 13%).

ORIGIN, LOCATION AND SETTING

Of the 91 snorkel victims, 46 (51%) were Australians or Australian residents, 35 of whom were snorkelling locally and 10 were snorkelling interstate. Forty-one (45%) of the victims were overseas tourists, three overseas workers, and one was a student from overseas. The overseas visitors were from Asia (25), North America (7), the United Kingdom (7), and Europe (6). The locations of the incidents are shown in Table 1.

Sixty-three (69%) of the victims were snorkelling privately, while 28 (31%) were with a commercial operator, all but six of these in Queensland. Thirty-nine of the 48 victims in Queensland (81%) were tourists as were 11 of the 16 (69%) of those in WA. Forty-two (88%) of deaths in Queensland occurred on the Great Barrier Reef (GBR). Surface snorkellers were less likely to dive locally than the breath-hold divers (16% vs 78%).

BUDDY SITUATION AND SUPERVISION

At least 42 (46%) of the snorkellers had set off without a buddy, including 10 who were solo but within a large group under some sort of supervision. Only 26 (29%) of the victims were with a buddy when the incident occurred. Forty-two (47%) were under some supervision, whether from shore, a pontoon, or a boat. Only 11 of the 42 who set out solo were known to have been reasonably experienced snorkellers.

DEPTH OF INCIDENT

At least 70 (77%) of the incidents occurred on the water’s surface, similar to the earlier period (71%). Seven occurred underwater, whilst two victims collapsed after boarding the boat or pontoon. The maximum reported water depth for a breath-hold dive was 21.5 metres of seawater (msw).

EQUIPMENT WORN

At least 46 (51%) victims were wearing a mask, snorkel and fins, with 14 of these also wearing a wetsuit, and another 10 wore a stinger suit. At least 17 victims were not wearing fins, and this was unclear in another 19 cases. At least 12 snorkellers were using floatation devices such as a lifejacket, vest, ring or noodles. Sixty-four were not using additional floatation and the remainder were unreported. Only three of the 11 victims who were known to have set off wearing a weight belt had ditched their weights when found. Only one victim was confirmed to have been wearing a full-face snorkel mask but there was an unconfirmed report that another may have been.

ACTIVITY

Fifty-seven snorkellers (63%) were sightseeing, including one each during organised whale shark and sea lion encounters. Twenty-six (29%) died while hunting or gathering seafood, and four died while practising breath-holding – one from a boat with scuba divers nearby, two in pools with others nearby and one was diving solo close to a crowded beach in 4.5 msw depth. One diver died while trying to retrieve a tender in a strong current, and one while doing research.

Seventeen of the victims were relatively new Australian residents, half of Asian origin. All but one of the latter were hunting seafood at the time of their demise, with six looking for abalone in Victoria. Three of the non-Asian Australian residents were known to have been hunting seafood.

RESCUE AND RESUSCITATION

A rescue attempt appears to have been made with 65 (71%) of the victims and all but four of the bodies, or in some cases the remains of the other snorkellers, were later recovered after extended submersion periods of up to one week. In-

Table 2

Predisposing factors associated with 89 snorkelling deaths from 2014 to 2018; some incidents involved multiple predisposing factors and no factors were identified in three deaths; IHD – ischaemic heart disease

<p>61 (68%) – Planning Solo or poor buddy system Deep breath-hold diving Failure to check weather forecast</p> <p>48 (53%) – Health Significant medical history Obesity Undiagnosed IHD</p> <p>33 (37%) – Experience/skills Inexperience Poor skills</p> <p>15 (17%) – Equipment-related Lack of fins and/or buoyancy aids Wearing weights but no fins Full-face mask</p> <p>11 (12%) – Activity Extended apnoea (some including hyperventilation) Obviously unsuitable conditions Spearfishing</p> <p>10 (11%) – Poor supervision Lookout failure Inappropriate ratios</p> <p>4 (4%) – Organisational Poor participant skills screening Poor participant medical screening Inadequate supervision ratio planning</p> <p>2 (2%) – Communication Participant failure to declare medical condition Failure to inform boat staff of medical condition</p>

water rescue breathing (IWRB) was attempted in at least five incidents, including in-water chest compressions in one.

Cardiopulmonary resuscitation (CPR) was attempted in 72 (79%) cases. It was not performed in other cases due to the delays in body recoveries and the absence or condition of the bodies. Twenty-six of the reports mentioned that blood, froth, water and/or stomach contents were cleared from the airway, two indicated that this was not a factor, and no relevant information was available in 47 cases.

An automated external defibrillator (AED) was available at the site and attached to 39 of the victims, 32 of whom were

in Queensland. There was little or no information about the timing of application, but it appears likely that it was less than 10 minutes in only two cases. No shock was advised in at least 20 cases, shocks (1–7) were delivered to 10 victims, and there was no information for the other nine cases.

No relevant information about oxygen (O₂) administration was available for 34 incidents. Oxygen equipment was unavailable in at least 18 cases and O₂ administration was not applicable in 14 cases due to the absence of a body or delays to recovery. Supplemental O₂ was reported to have been available and administered to 25 (28%) of the victims. Nine of these were in a private setting, and 16 in a commercial setting, all but two of these in Queensland. The O₂ delivery method was only reported in three cases, which included two manually-triggered ventilators and one bag-valve-mask.

CHAIN OF EVENTS ANALYSIS

Predisposing factors

One hundred and eighty-five possible or likely predisposing factors were identified in 87 of the incidents as shown in Table 2. There were no PFs identified in three incidents. The most common PF were planning-related, most often a decision by the victim to snorkel without a buddy and/or set off or continue to snorkel in unsuitable conditions.

Health-related predisposing factors were also common and generally involved victims with diagnosed or occult moderate to severe ischaemic heart disease (IHD, 27), obesity (22), hypertension (16), diabetes (13), cardiomegaly (17) and left ventricular hypertrophy (LVH, 21), the latter two only identified at autopsy. Five victims had a history of seizures. In five cases, toxicology revealed the presence of drugs at intoxicating and/or supratherapeutic levels.

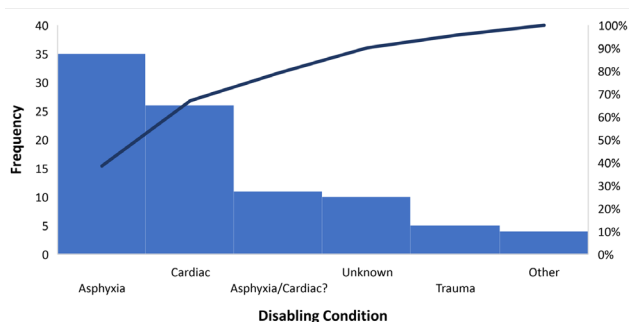
Inexperience and the consequent lack of skills were identified as a contributory factor in many cases, a common theme in snorkelling incident investigations. Lack of appropriate equipment was identified in 15 (17%) of cases but may well have been a factor in more.

Some activities carried a higher likelihood of an incident. These included five examples of spearfishing in areas frequented by large sharks or crocodiles, and six extended apnoea events with or without hyperventilation. Supervision shortcomings arising from insufficient lookouts and/or lookouts failing to identify persons requiring rescue were identified.

Organisational failures included inadequate screening of participants’ medical status and/or skills to enable the implementation of appropriate countermeasures, as well as planning for adequate supervision for the expected number of participants.

Figure 2

Disabling conditions associated with 91 snorkelling deaths from 2014 to 2018



Poor communication predisposed to at least two deaths, one involving the withholding of relevant and required medical information by the victim. In the other, although the victim declared relevant medical conditions to office staff (albeit possibly downplaying their impact), this information was not communicated to the dive supervisor who might have re-considered site suitability and/or countermeasures to reduce the risk of an incident.

Triggers

Seventy-four likely or possible triggers were identified in 49 of the incidents with many incidents involving multiple likely triggers. The most common triggers were environment-related involving adverse sea conditions (17), and the direct effects of immersion often combined with exertion (14). Attacks by sharks (4) or a crocodile (1) led to five deaths. Water aspiration was witnessed in seven incidents but was likely associated with many more. Extended apnoea led to at least six deaths. Diver error was the trigger in one incident in which the breath-hold diver's arm became trapped in a rock crevice while trying to catch a crayfish.

Disabling agents

Likely or possible disabling agents were identified in 76 incidents. The most common disabling agent (in up to 38 incidents) was pre-existing cardiac pathology. Two victims with a history of epilepsy and snorkelling solo were likely disabled by seizures. Environmental disabling agents were apparent in at least 14 cases and were mainly adverse conditions, but also including the shark and crocodile attacks and entrapment. Apnoeic hypoxia was highly likely to have disabled six, and possibly seven victims, buoyancy problems were identified as the likely disabling agent in five incidents but may have been an issue in more cases, and immersion pulmonary oedema (IPO) was a possible disabling agent in up to three cases although the evidence was relatively weak.

Disabling conditions

Asphyxia was the likely disabling condition in 35 (38%) cases although IPO was an alternative for one of these.

Table 3

Comparison of some snorkelling fatality victim characteristics between the 2001–13 and 2014–18 periods; there were no statistically significant differences between the two time periods

Characteristic	2001–13	2014–18
Age (median, years)	51	48
Male sex (%)	90	86
Experienced (%)	50	37
Solo (%)	27	34
Commercial setting (%)	37	31
Tourists (%)	50	60
Disabling condition		
Cardiac (%)	34	31
Asphyxia (%)	41	38
Body mass index classification		
Overweight or obese (%)	66	68
Obese (%)	24	30

Cardiac causes were identified as the likely disabling condition in 28 (31%) incidents although, again, IPO was a possibility in two (Figure 2). In another 11 (12%) of cases it was too difficult to determine whether a cardiac event or asphyxia was the probable disabling condition. The disabling condition could not be determined in ten cases; three as the victims' bodies could not be retrieved. The trauma deaths were associated with shark and crocodile attacks. The remaining disabling conditions were likely seizures (2), drug toxicity (1) and neck dislocation from trauma in one diver.

There was a higher frequency of asphyxia as a disabling condition in breath-hold divers than in surface snorkellers. This occurred with 18/33 (55%) of breath-hold divers and 18/54 (33%) of surface snorkellers (OR = 2.40, 95% CI = 0.99 to 5.84, $P = 0.0735$). There was a higher frequency of cardiac disabling conditions in surface snorkellers, occurring in 26/54 (48%) compared to 2/34 (6%) of breath-hold divers (OR = 14.39, 95% CI = 3.13 to 66.23, $P = 0.0006$).

Cause of death

The reported causes of death were: drowning (60, 67%), cardiac (19, 21%), trauma (4, 4%), olanzapine toxicity (1, 1%) and unascertained (7, 8%).

COMPARISONS WITH PREVIOUS PERIOD

When comparing various characteristics from this current period to those of the period 2001–13 or part thereof, although there were some apparent differences, they were not significant. These included the 33% increase in deaths from the previous five-year period and the 50% lower percentage of experienced victims and higher proportion of tourists during the 2001–13 period (Table 3).

Discussion

The victims of these snorkelling incidents were predominantly middle-aged males, many of whom had pre-existing medical conditions which predisposed them to an incident while snorkelling. Almost one half were overseas tourists, most of whom were inexperienced and unfamiliar with the snorkelling sites. Two thirds of the victims were snorkelling privately, and many were snorkelling without a buddy or supervision which caused delays to rescue. Most were sightseeing, but more than a quarter were hunting or harvesting seafood. Rescue and resuscitation attempts were made in most cases although the commonly associated delays greatly reduced the likelihood of survival.

The finding that half of the victims had pre-existing health conditions that may have contributed to their deaths is consistent with the age and prevalence of obesity of the cohort – predominantly middle-aged males with two thirds being overweight or obese. This is similar to the 67% reported in the general Australian population,¹² whilst epidemiologically there are known links between significant health conditions, especially cardiovascular disease, and both obesity and increasing age.^{13,14} The finding in this cohort at autopsy of significant IHD, cardiomegaly and LVH increases the risk of a cardiac event which is much more likely to prove fatal in the aquatic environment.

This prevalence of cardiomegaly and LVH reflects the high level of hypertension in the community, reported to affect one in three Australian adults.¹⁵ Although only 18% of these victims were known to have hypertension, the autopsy findings suggest missed diagnoses and a need for improved health vigilance. Left ventricular hypertrophy is associated with an increased risk of cardiac arrhythmias, and, when combined with moderate to severe IHD, likely explains the high incidence of cardiac-related deaths in both snorkellers and scuba divers.¹⁶ The effects of immersion, exertion, anxiety, aspiration, the diving reflex, cold and increased respiratory resistance, provide a potent mix of precipitants to a cardiac event in a susceptible individual.^{4,7}

At least half of the victims in both periods were tourists, predominantly from overseas, who would have been unfamiliar with the location and were often inexperienced snorkellers. Lack of experience and unfamiliarity with the site and conditions (e.g., currents, other tidal effects and local marine life) is a potent mix for increasing risk. The majority of all the victims had little or no experience snorkelling. Inexperienced snorkellers are more likely to be anxious, to aspirate water through their snorkel or mask, and less able to manage the effects of chop, swell and current. They are less familiar with the equipment and more likely to have difficulty with it. In addition, about two-thirds of the victims over both periods were snorkelling in a private setting, often without supervision. This is generally associated with more substantial delays to recognition of a problem and to rescue with a consequent reduced likelihood of survival.

Concern has been raised about the disproportionate incidence of drowning deaths in Victoria of people born overseas.¹⁷ This is reflected in this study by the apparently disproportionate number of overseas-born snorkellers (mainly of Asian origin) who died collecting abalone in Victorian waters, where conditions can often be more challenging than in tropical regions, especially for those less familiar with such sites.

Consistent with the previous period and as reported elsewhere,¹⁸ the majority of victims were alone at the time of their incident, whether they had set off solo or become separated from their buddy or group beforehand. Despite repeated advice about the benefits of an effective buddy system, which may enable more rapid recognition of a problem and subsequent assistance, sadly this is often ignored, and the serious consequences persist. Snorkelling without a designated buddy as part of a large group often provides a false sense of security, even in the presence of supervision.¹⁹

Some snorkelling activities carry a higher risk. Yet again, this series includes fatalities from apnoeic hypoxia in individuals who were pushing their breath-hold limits. Some were distracted while spearfishing, others were practising extending their breath-hold time. Two of these occurred in pools, with other swimmers and bystanders very nearby albeit distracted, highlighting how easily such an incident can occur. Some of these incidents involved pre-dive hyperventilation, a practice that is still relatively common despite its known risks. Many breath-hold divers still fail to appreciate that such blackouts occur rapidly, generally without warning and, unless a vigilant buddy is present and accessible, drowning is the likely outcome.

In addition to the risk of apnoeic hypoxia, spearfishing (and other seafood collection) can attract the unwanted attention of marine predators. As well as the four fatal shark attacks in this series, there were around 20 documented non-fatal shark attacks of snorkellers during the same period, at least half of these while spearfishing.²⁰ This is likely an underestimate as all such injuries may not be recorded centrally. Of the 13 known fatal shark attacks on snorkellers in Australia from 1960 to 2018, at least 11 were hunting or harvesting seafood, nine spearfishing.²¹ Seafood hunters and harvesters should be familiar with the marine life likely to frequent their potential dive sites and, where possible, keep their catch distant from themselves.

In this series of 91 fatalities, only up to three cases were identified as possibly due to IPO. Diagnosis of IPO in the Australian fatalities is appropriately conservative and relies heavily on witness accounts and the victims' medical and snorkelling history.²² Dyspnoea with coughing, often with frothy, blood-stained expectoration are used as primary indicators of severe IPO. In the absence of these indications, other potential disabling conditions such as primary drowning, or cardiac arrhythmias with or without secondary

drowning, are prioritised depending on supporting evidence, which can sometimes be rather speculative in the absence of definitive tests.

Hawaii is another popular snorkelling destination with frequent fatalities. From 2009–2018 there were 206 snorkelling deaths in Hawaiian waters, the victims being predominantly males with an average age of 59 years and most of whom were tourists (very similar demographics of the Queensland cohort).^{23,19} Many victims had been wearing full-face snorkel masks (FFSMs), raising concerns about the safety of such devices. By comparison, FFSMs are not commonly used in Australia with only one victim confirmed to have been wearing such a mask in this series.

A recent report from Hawaii argues that what it terms rapid onset pulmonary edema (ROPE) is a very common cause of what it describes as ‘silent’ snorkel drownings.^{24,25} The report describes the results of a study which included mainly survivor accounts (37% had worn FFSMs), some autopsy reviews, and basic testing of the breathing characteristics of a wide array of snorkels including FFSMs. It was reported that while all snorkels tested showed some (variable) degrees of resistance to inhalation, only some were increased to serious levels requiring very elevated negative transthoracic pressures believed likely to have been one of the factors precipitating ROPE. (Foti P, personal communication, 2023 February 26). It concluded that: *“rapid onset pulmonary edema-induced hypoxia is a mechanism leading to some, possibly most, fatal and non-fatal snorkel-related drownings.”*

However, the above claim that possibly most of these deaths may be due to IPO/ROPE is not supported by the Australian fatality data. The main symptoms reported by the Hawaiian respondents were dyspnoea, fatigue, and limb weakness, which arguably could result from exertion and breath-holding alone, or comparatively mild IPO. There was no specific question about coughing or expectoration, likely indications of a more severe event. In addition, the survey respondents were younger and evenly gender balanced, and may not represent the cohort of deceased snorkellers in Hawaii. It is also interesting to note that some of the serious IPO incidents and deaths are not necessarily ‘silent’, often showing significant signs of distress.²²

Concern about FFSMs inspired a Duke University study in which the breathing characteristics and inhaled and exhaled gas composition of an array of FFSMs were tested. It concluded that: *“while this testing yielded no conclusive ‘smoking gun’ to explain the snorkeller deaths, some of the mask models showed patterns of increased breathing resistance with water intrusion ... and this increased resistance could potentially create elevated levels of respiratory distress in snorkellers during real world use”*.²⁶ A potentially relevant example from the present series is case 74 ([Appendix 1](#)).

While there is no doubt about its existence, the potential severity, and the very probable underreporting of IPO in snorkellers (as well as scuba divers and swimmers), long-term Australian data does not support an assertion that it is possibly associated with most snorkelling deaths and cardiac factors are often more convincing.

LIMITATIONS

Even using multiple sources, it is possible that some fatalities were not recorded due to limitations in recording and NCIS searches. As with any uncontrolled case series, the collection and analysis of the fatality data are subject to inevitable limitations and uncertainties associated with the investigations. Witness reports varied in their likely reliability. Police reports varied in their content, often related to the expertise of the investigators. Given that many incidents were unwitnessed, some of the assertions in the reports are speculative. Many data items were not available which rendered the study data incomplete, thus limiting the conclusions that can be drawn. The CEA attempts to identify the predominant features of each case, but there always remains an element of uncertainty.

Conclusions

As with the preceding review of Australian snorkelling fatalities, and in common with their scuba counterparts, advancing age, obesity, and cardiac comorbidities were prevalent in this cohort, many of whom were disabled by a cardiac event. Almost forty percent of incidents were identified as likely primary drowning events, although secondary drowning occurred in others with drowning reported as the cause of death in two thirds of cases. Inexperience, unfamiliarity with the site, poor conditions, and the absence of, or an ineffective buddy system, were once again substantial contributors to the incident itself or delays to rescue. These need to be better addressed through improved health surveillance, on-going education, and better pre-dive briefing, screening, and supervision.

Drowning following apnoeic hypoxia persists and the inherent dangers of hyperventilation and pushing breath-hold limits needs to be continually reinforced, as does the need for close buddy scrutiny during extended apnoea, even in a pool. Risks can arise through environmental and human factors and need to be managed by careful planning and execution snorkelling activities.

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Acknowledgements

Acknowledgements to the National Coronial Information System, the Victorian Department of Justice and Community Safety for enabling access to its database, and to those State and Territory Coroners who provided additional information. Thanks also to David Natoli and Dr Chris Lawrence for their input and to Dr Neil Banham and Dr Mike Davis for their feedback.

Conflicts of interest and funding

This study was supported by the Australasian Diving Safety Foundation. No relevant conflicts of interest were declared.

Submitted: 5 March 2023

Accepted after revision: 30 June 2023

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