DROWNING

“The process of experiencing respiratory impairment from submersion/immersion in liquid.”

-WHO 2002

Submersion

- the airway goes below the level of the surface of the liquid

Immersion

- a liquid is splashed across a person’s face, e.g water-boarding

A neurological problem

- respiratory impairment must be present for drowning to have occurred

- but the main focus should be on reversing hypoxia and preventing brain anoxia

Time is brain.

Terms no longer used

~~near drowning~~

~~dry or wet drowning~~

~~secondary drowning~~

~~active and passive drowning~~

~~delayed onset of respiratory distress~~

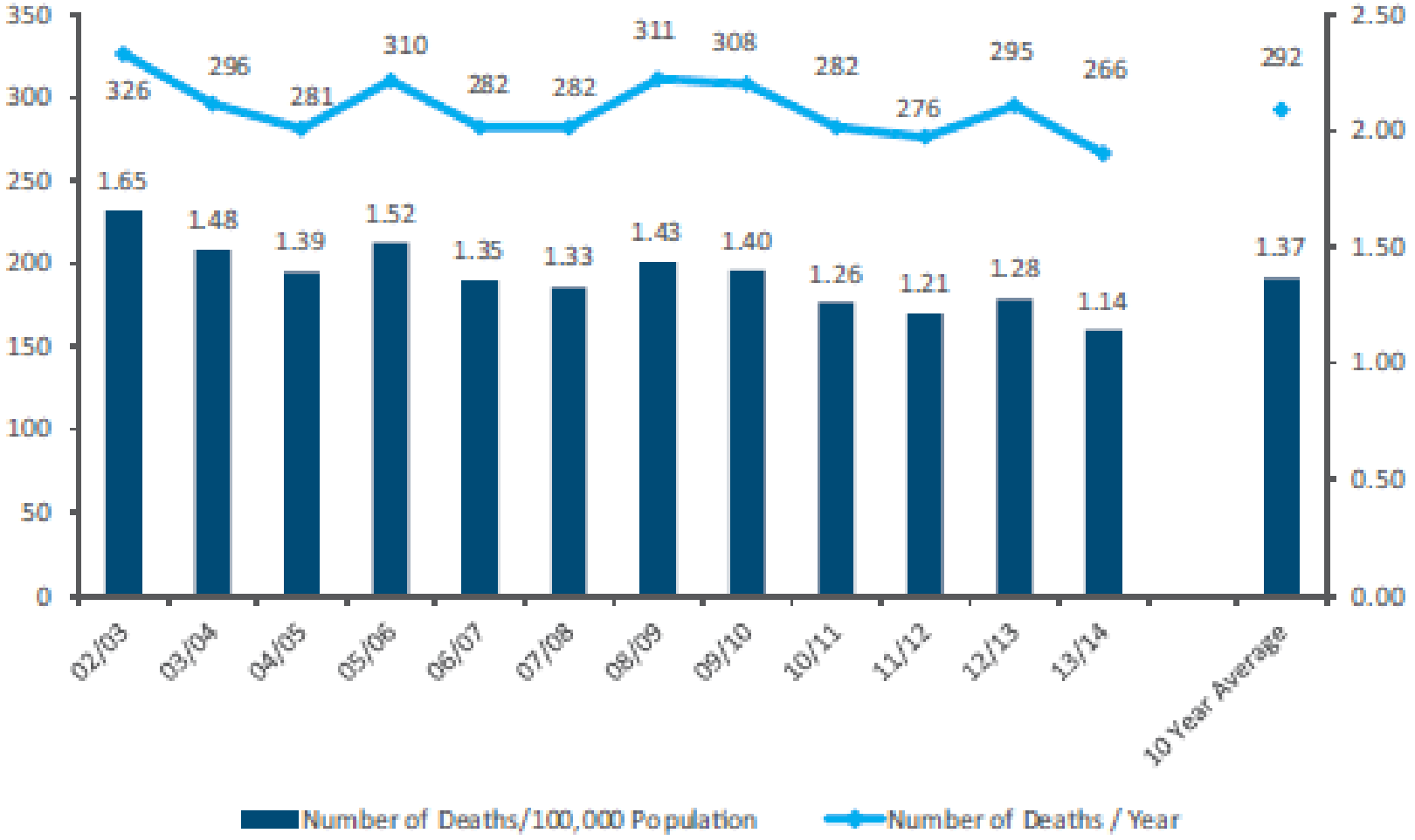
Sequence of events

- water enters the mouth when no longer able to be kept clear
- voluntarily spat out or swallowed at first
- next conscious response is to hold one's breath, lasts ~ 1 minute, until inspiratory drive is too high to resist
- water is aspirated into the airways, and coughing occurs as a reflex response
- laryngospasm may occur (rapidly terminated by the onset of brain hypoxia)
- continued aspiration -> hypoxemia -> loss of consciousness and apnea
- Final mode of death involves cardiac dysrhythmia: tachycardia -> bradycardia -> PEA -> asystole

Causes

- misadventure
- inadequate supervision of small children
- neurological event e.g. epilepsy, stroke
- cardiac event e,g, MI, HOCM, dysrhythmia, long QT, short QT
- impaired judgement e.g. intoxication
- trauma
- overdose
- foul play

Trends over time: Fatal drowning in Australia



In Australia

- Average 292 deaths per year over past 10y
- 18% of these were in Victoria
- 0.14 - 0.21% of all deaths
- Crude drowning rate 1.37 per 100,000

- All seasons, slightly more in summer.
- Sundays
- Afternoons

State by state

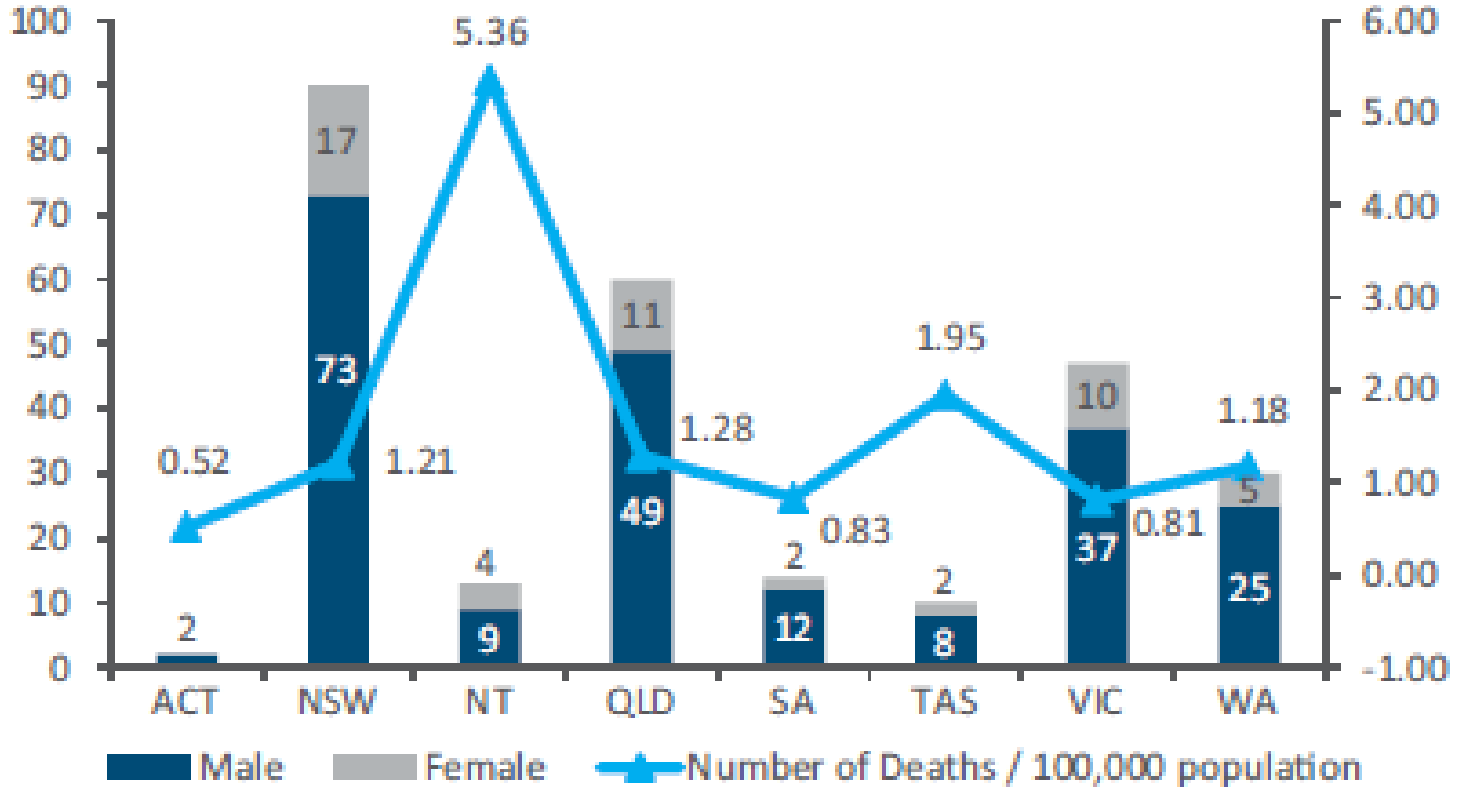


Figure 3: Drowning Deaths by Sex and State / Territory, Drowning Death Rates, 2013/14

Who drowns?

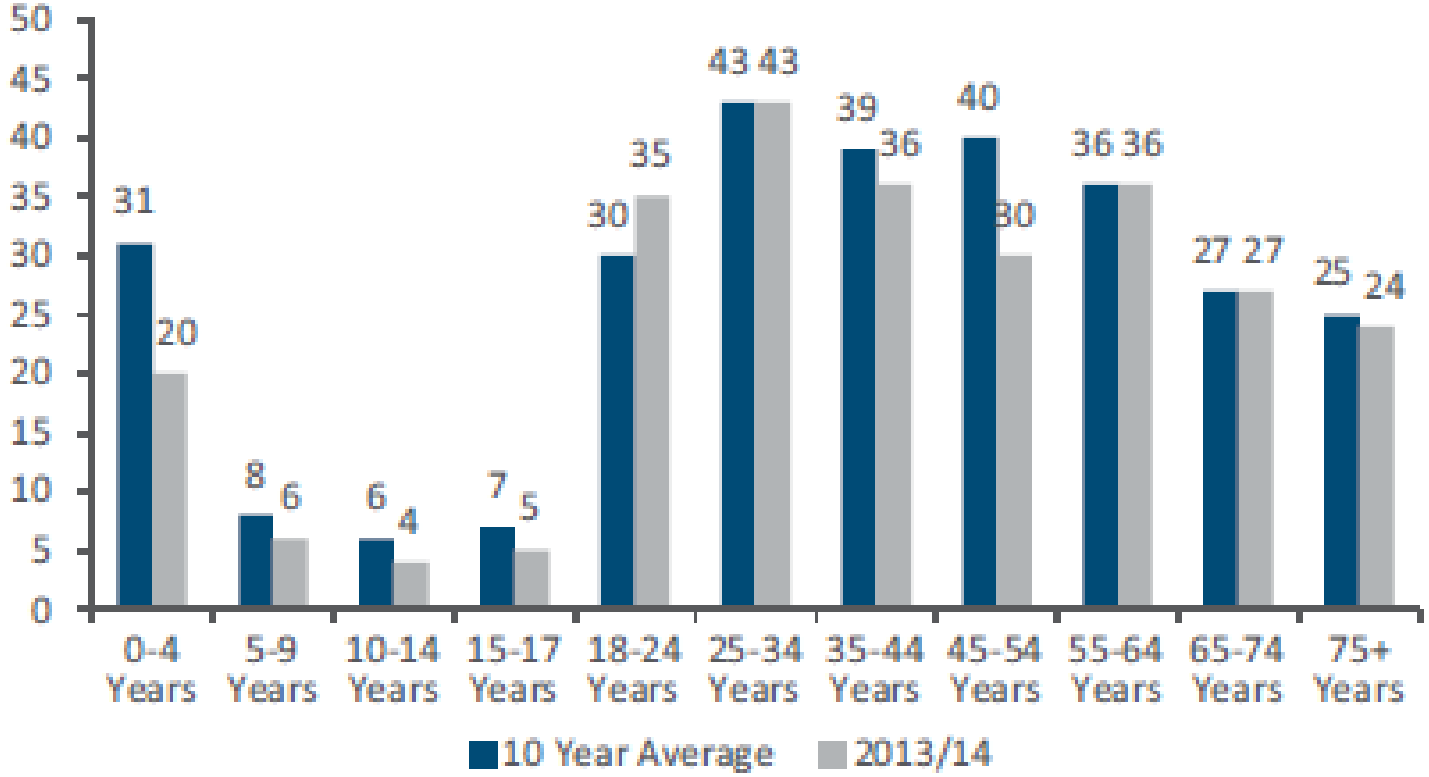
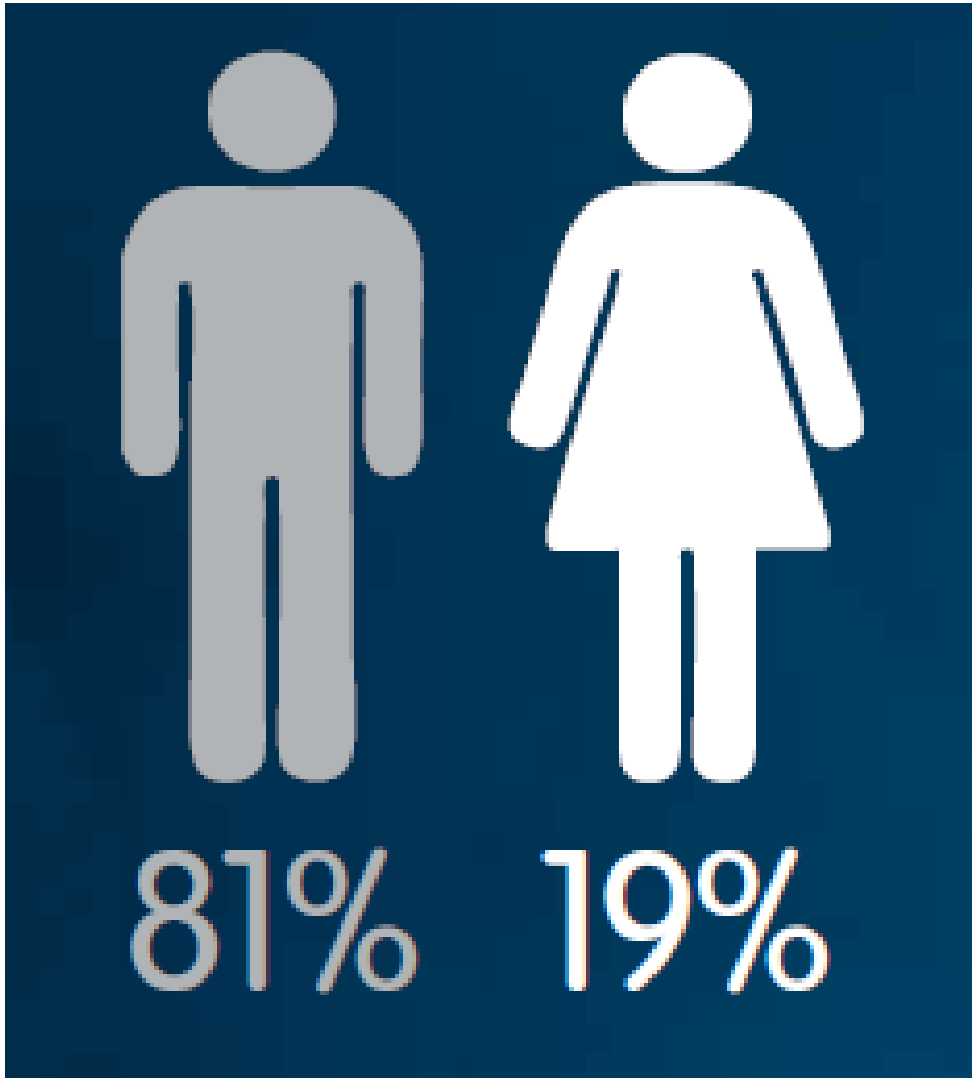
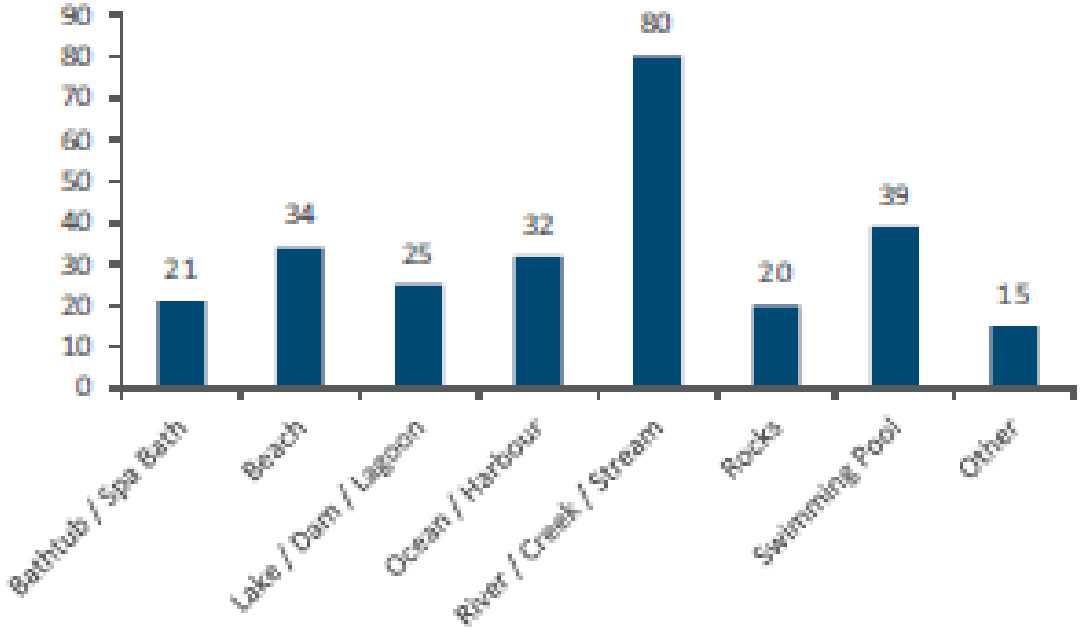
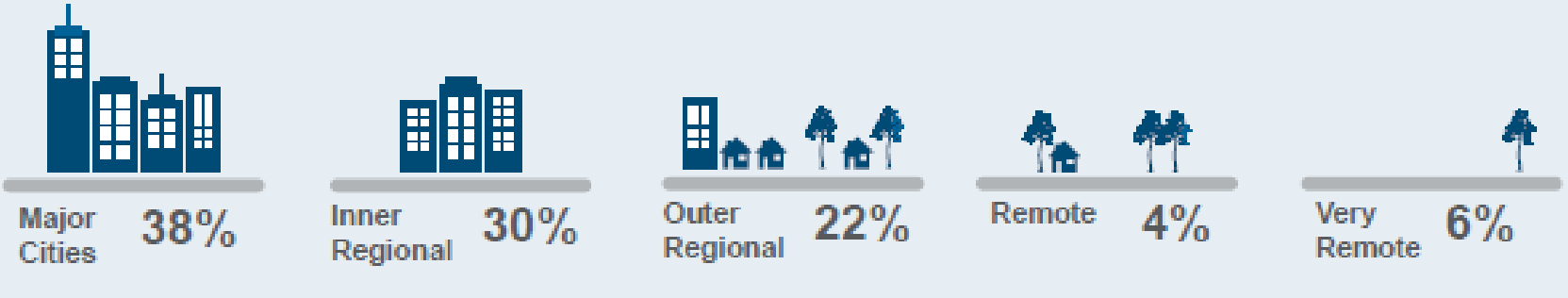


Figure 4: Drowning Deaths by Age Group, 10 Year Average, 2013/14

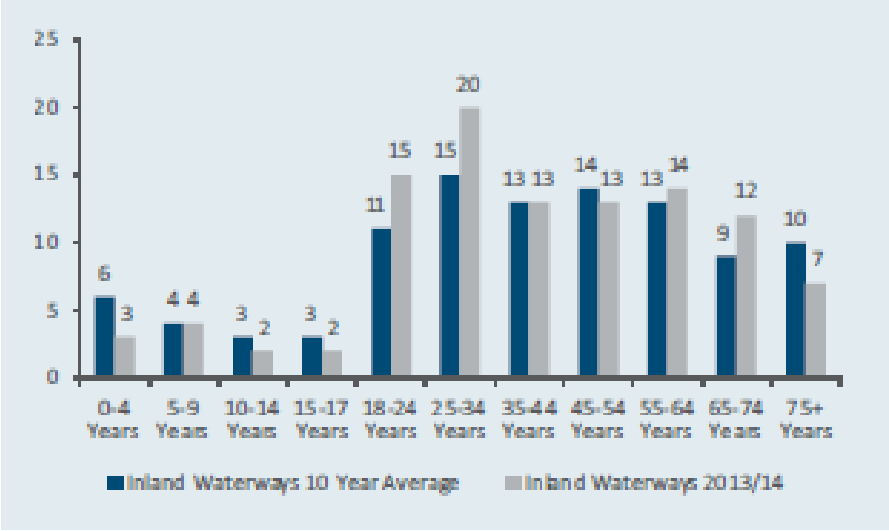

81%
19%

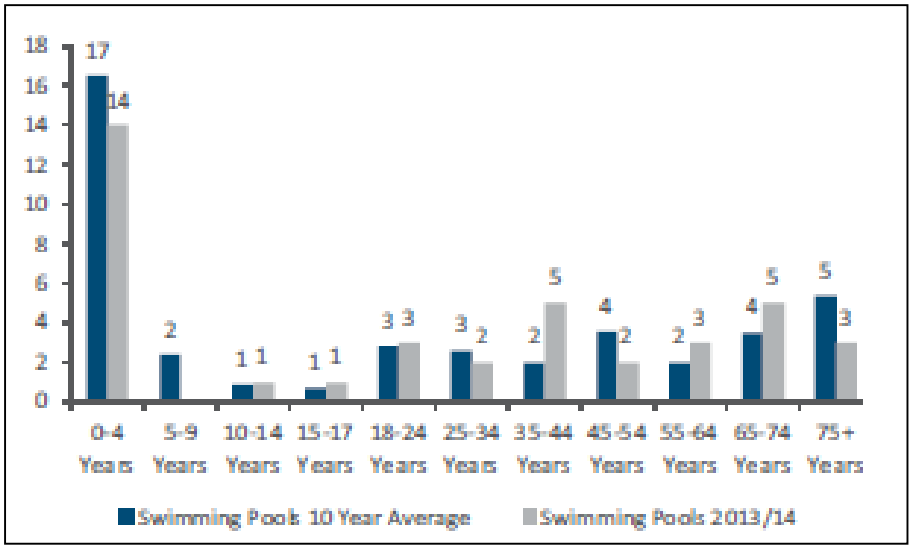
Where do they drown?



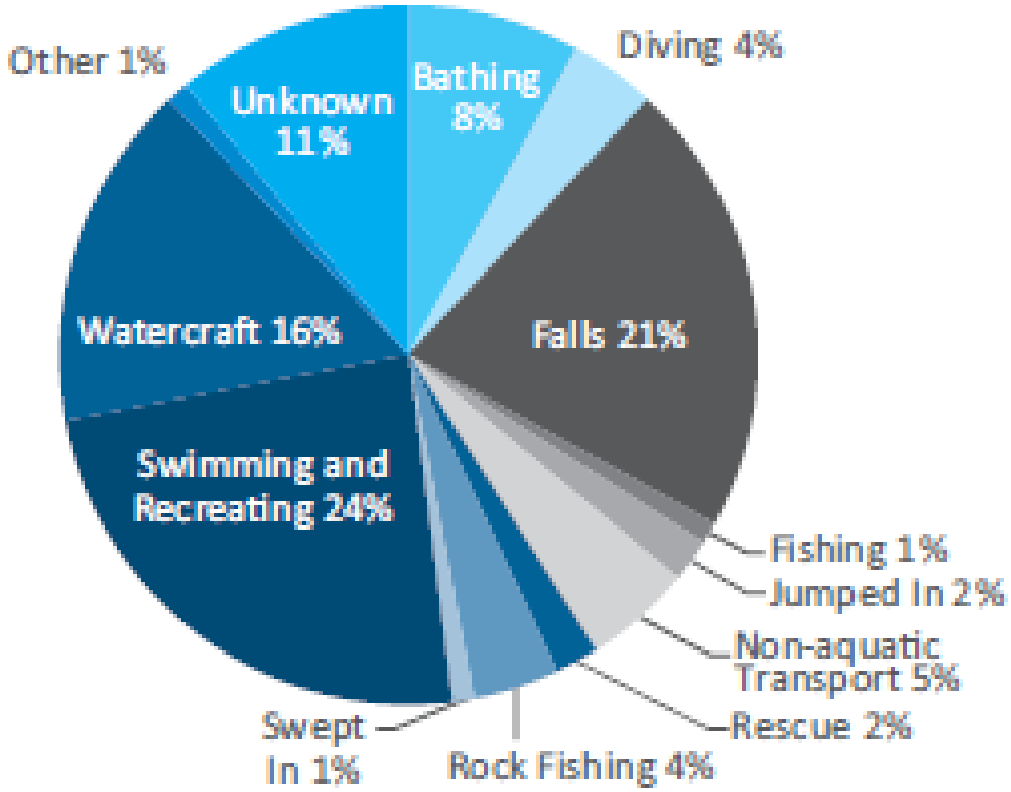


Inland waterways v Swimming Pools





How do they drown?



3 possible outcomes

- Full recovery
- Morbidity
- Death

In survivors the long-term morbidity reflects the severity and duration of cerebral anoxia experienced

Sea water v Fresh water

- no significant differences in electrolytes abnormalities or degree of lung injury despite differences in osmotic gradient

- bacterial burden is greater in fresh water (gram negatives, anaerobes, Staphylococci, fungi, algae, protozoans, Aeromonas)

Hypothermia

- hypothermia can provide a protective mechanism that allows persons to survive prolonged submersion episodes

- rate of cerebral oxygen consumption is reduced by ~5% for each reduction of 1°C in temperature within the range of 37°C to 20°C

- Prolonged CPR may be necessary

‘They’re not dead until they’re warm and dead’

(Lung injury)

- surfactant dysfunction and washout
- osmotic gradient damages the alveolar–capillary membrane:
  - disrupts the integrity of the membrane
  - increases its permeability
  - exacerbates fluid, plasma, and electrolyte shifts
- often massive bloodstained pulmonary edema
- results in decreased lung compliance, V/Q mismatch, atelectasis and bronchospasm

Complications

- laryngospasm
- aspiration pneumonitis
- negative pressure pulmonary edema
- ALI / ARDS
- ischemic cardiomyopathy
- arrhythmias
- hypoxic ischemic encephalopathy
- MODS
- hypothermia
- electrolyte disturbance
- associated trauma e.g. TBI, spinal cord injury
- sequelae of underlying causes

Prehospital Management

- do not attempt CPR in the water
  - patients with purely respiratory arrest typically respond following a few rescue breaths
  - if no response get patient out of the water ASAP
  - only trained individuals should attempt in-water rescue as this is highly dangerous
- lift patient out horizontal (counters possible sudden circulatory collapse on release of water pressure)
- remove wet clothing
- wrap in thick blankets
- commence basic life support (immediate, uninterrupted CPR)
- ALS when available
- maintain c-spine precautions if trauma is possible
- Heimlich manoeuvre no long recommended

Drowning:
Critical Points For Care In The Field

- https://vimeo.com/57826732

Hospital management

Resuscitation Goals:

1) support A, B, C
2) rewarm to 34 C for 24 hrs
3) prevent secondary brain injury

- NGT to decompress stomach

- Rewarming:
  - Passive
    - remove wet clothes
    - insulate with blankets
  - Active
    - peripheral (forced air warmer, hot water bottles),
    - central (warmed humidified inspired gases, warmed IVF, lavage, intravascular thermal regulation via vascath, haemofiltration, cardiopulmonary bypass)

Neuroprotective care

- Head up
- Normal pO2 and pCO2
- MAP of 80mmHg (no need for ICP monitoring)
- Benzodiazepines for seizures
- Euglycaemia
- Consider therapeutic hypothermia (after actively warming to >34 C during resuscitation phase)

Oxygenation strategies

- ALI and ARDS -> protective lung ventilation
- Bronchodilators
- Advanced ventilation
  - iNO
  - Prone
  - ECMO
- in vivo PaO_2 in cold patient is much lower than the measured value as it is warmed to 37 C

Metabolic issues

- severe lactic acidosis occurs in the majority of patients and is usually corrected by:
  - the patient's spontaneous effort to increase minute ventilation
  - or by setting a higher minute ventilation or a higher peak inspiratory pressure (35 cm of water) on the mechanical ventilator
- rhabdomyolysis

Cardiovascular issues

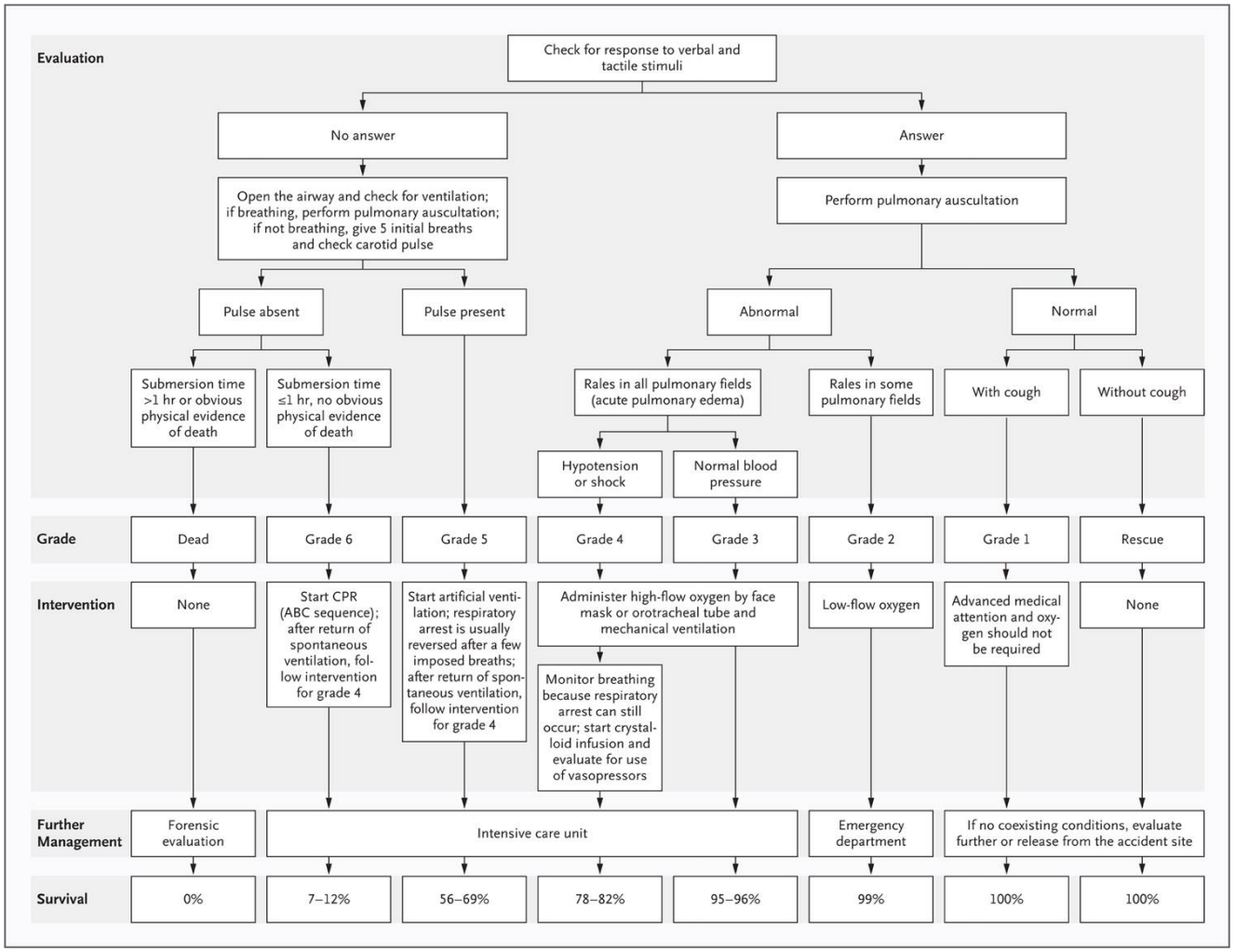
- In most persons who have been rescued from drowning, the circulation becomes adequate after oxygenation, rapid crystalloid infusion, and restoration of normal body temperature.
- VF is common below 30C
- Extravasation of systemic and pulmonary capillaries + cold diuresis
  = hypovolaemia
- Early cardiac dysfunction can occur, which adds a cardiogenic component to the noncardiogenic pulmonary edema.
- SIRS post resuscitation, often require cardiac output monitoring

INFECTION

- Pneumonia only occurs in 12% of drownings so empiric antibiotics should be withheld

- But consider antibiotics if patient was submerged in grossly contaminated water

Treatment of Persons Who Have Drowned, with Classification System.



Szpilman D et al. N Engl J Med 2012;366:2102-2110.

The NEW ENGLAND JOURNAL of MEDICINE

Predictors of poor outcome

- Scene
  - immersion > 10 min
  - delay to CPR (e.g. no bystander CPR, unwitnessed)
  - time to first breath
  - water temperature (drop in brain temperature 10C doubles time that brain can survive)
  - presence of cardiac arrest (pulseless or absence of respiratory effort upon rescue)
  - identifiable precipitants; e.g. did the person have a cardiac arrest secondary to an AMI while in the swimming pool?

Predictors of poor outcome

- ED
  - asystole
  - CPR > 25 minutes
  - dilated, non-reactive pupils and pH <7.0
  - dilated, non-reactive pupils and GCS < 5
  - lactate

Predictors of poor outcome

- ICU
  - loss of grey-white matter differentiation on CT within 36 hrs
  - absence of purposeful motor response (GCS < 5) and absence of brainstem reflexes, pupillary response and spontaneous respiration at 24 h

Summary

- Reverse hypoxia early
- Consider:
  - Hypothermia
  - Trauma
  - Comorbidity
- Neuroprotective care