THE UNIVERSITY OF QUEENSLAND

AUSTRALIA

DROWNING IN QUEENSLAND CHILDREN AND ADOLESCENTS 0-19YRS 2002-2008: INCIDENCE, RISK FACTORS AND INTERVENTIONS

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School of Medicine

ABSTRACT

BACKGROUND

Every three minutes somewhere in the world a child dies from drowning. In Queensland, the burden of drowning is underestimated as incidence, mechanisms and consequences of non-fatal events have not been explored.

Data are collected at all points from the moment a patient is retrieved from the water, attended by emergency services and transported for care or to the mortuary. These data are not accessible in one database. The aim of this study was to link identified data from each of these data collection points to describe the mortality and morbidity of drowning episodes. This achieves the most accurate assessment to date of the incidence of fatal and nonfatal drowning episodes for this age group in Queensland.

METHODOLOGY

Data were sourced, accessed extracted and linked from multiple portals for fatal and non-fatal drowning events from January 2002 to December 2008 for those aged 0-19yrs. Fatal drowning data were accessed from the National Coronial Information System, Royal Life Saving Society Australia, and the former Commission for Children Young People and Child Guardian. Non-fatal drowning data were accessed from Queensland Ambulance Service, coded emergency data and then linked to admitted patient data. A composite dataset were obtained by linking identified data manually.

RESULTS

The aetiology of fatal and non-fatal drowning is described in each of the chapters:

Interventions were reviewed in the literature and risk factors identified. A lack of consistency in measured outcomes, drowning and water safety terminology limited the confident replication of these interventions, and impedes conclusive recommendations. Positive results were in intervention themes: education, swimming lessons and water safety, and pool fencing. Rigorous, well-designed studies using consistent terminology are required to demonstrate effective prevention solutions. Context-specific risk factors such as age, gender, location and socio-economics are identified.

Characteristics revealed 1299 drowning cases (120 fatal; 1179 non-fatal) were identified over the seven years, equating to 17 fatalities and 168 non-fatal drowning episodes every year. Males and young children 0-4yrs (68%) were affected most. Major Cities (49%) and more advantaged areas (70%) incurred higher drowning numbers. The health system usage was highest in pre-hospital and emergency department (33% respectively) and admissions to hospital (30%) with a stay of at least ≤24hrs (41.2%). The majority of fatalities died within 24 hours (87%). GCS<= 5 was related to fatality (76%) and one third (23) survived the drowning event with unknown outcomes.

Incidence of fatal and non-fatal drowning was quantified with a previously unknown drowning death to survival ratio of 1:10, and two out of three of those who survived requiring hospital admission. Incidence rates for non-fatal drowning more than doubled over the period while fatalities showed no significant change. Children aged 5-9yrs and 10-14yrs incurred the lowest incidence rates and the highest were among children 0-4yrs. Male drowning increased 44% over the seven years ($p<0.001$) and they were over-represented in all age groups except 10-14yrs.

Drowning locations are contextual and are necessary to aid prevention efforts. Drowning locations ranked in order of overall incidence were pools, inland water, coastal water,

baths and other man-made water hazards. Swimming pools had the highest incidence rates (7.31/100,000) for overall drowning events and were more often privately owned pools and in affluent neighbourhoods. Pools affected more age groups than any other location.

Toddlers 0-4yrs were most at risk around pools for all drowning (23.94/100,000), and static water bodies (e.g. dams and buckets) – these two locations had higher fatality ratios than pools. Children 5-14yrs incurred the lowest incidence rates regardless of location. Adolescents 15-19yrs were more frequently involved in drowning incidents on the coast shoreline, followed by inland dynamic water bodies.

Indigenous populations are known to be vulnerable to injury and these data are the first presented for Queensland. Among the Aboriginal and Torres Strait Islander population for every fatality, nine children and adolescents were rescued, (average 12/yr). Indigenous children have a risk 44% greater than Non-Indigenous children ($p<.000$). Although there were no statistically significant changes in Indigenous drowning events of any type over the period, a 44% increase in non-fatal drowning indicates intervention is required to reduce the risk of potential fatality.

Recommendations and approaches to drowning prevention synthesised from these results are presented in the final chapter.

CONCLUSION

This is the first study on drowning to use linked data accessed from multiple portals across the continuum of care to effectively map the patient journey after a drowning event. The inherent value of this approach is evidenced by the previously unexplored magnitude of non-fatal drowning, and the impact on health services. Fatalities significantly understate the extent of drowning as a cause of morbidity. The first non-fatal drowning location rates emphasise the value of narrative text for evidence-based prevention strategies.

Political will is required at government level to achieve the benefits of routinely linked data to increase the public health benefits to those identified as most in need – males, 0-4yrs, Indigenous children and those in disadvantaged areas. Pools and bath drowning require supervisory behaviour change to reduce the toll. Rigorous, well-designed studies which use consistent descriptors are necessary to demonstrate effective prevention solutions.

This study demonstrates that better informed drowning prevention strategies should consider non-fatal counts, severity, locations and risk factors, and that this can be achieved through data linkage.

"Counting the dead is an unsatisfactory method of gauging safety"

(Harrison, 1990)

DECLARATION BY AUTHOR

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

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PUBLICATIONS DURING CANDIDATURE

PEER REVIEWED PAPERS

Wallis BA, Watt K, Franklin RC, Taylor ML, Nixon JW, Kimble RM. Interventions associated with drowning prevention in children and adolescents: systematic literature review. ***Injury Prevention*** 2015:(21);195-204. doi: 10.1136/injury-prev-2014-04216

Wallis BA, Watt K, Franklin RC, Nixon JW, Kimble RM. Drowning mortality and morbidity rates in children and adolescents 0-19yrs: a population-based study in Queensland, Australia. ***PLOS One*** 2015:10(2);e0117948

http://www.plosone.org/article/fetchObject.action?uri=info:doi/10.1371/journal.pone.0117948&representation=PDF

Wallis BA, Watt K, Franklin RC, Nixon JW, Kimble RM. Drowning in Aboriginal and Torres Strait Islander Children and Adolescents in Queensland (Australia). **BMC Public Health** 2015:(15);795. doi: 10.1186/s12889-015-2137-z

Wallis BA, Watt K, Franklin RC, Nixon JW, Kimble RM. Where children and adolescents drown in Queensland: a population-based study (accepted for publication BMJ Open – October 2015)

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B Wallis, K Watt, R Franklin, R Kimble. (2012) Out of sight but not out of mind: Rural Drowning in Queensland. Injury Prevention Oct 2012:18 (suppl 1: A136) Published Online: 7 October 2012 doi:10.1136/injuryprev-2012-040590h.16

B Wallis, K Watt, R Franklin, J Nixon, R Kimble. (2010). Non-fatal drowning in children and young people in Queensland (Australia) 2002-2008. Inj Prev 2010;16:Suppl 1 A138 doi:10.1136/ip.2010.029215.494 Abstracts Safety 2010 World Conference, London, United Kingdom,

K Watt, RC Franklin, B Wallis. GBD2005: estimating mortality and morbidity associated with fatal and nonfatal unintentional drowning episodes Inj Prev 2010;16:Suppl 1 A202-A203 doi:10.1136/ip.2010.029215.722 Abstracts Safety 2010 World Conference, London, United Kingdom (A1-A138). 21-24 September 2010.

PUBLISHED LETTER TO THE EDITOR

K Watt, R Franklin, B Wallis, B Griffin, P Leggat, R Kimble. Comparing apples with apples? Abusive Head Trauma, Drowning and LSVROs. Injury Prevention 2013 19(1)p.75. Online 3 Sept 2012) doi:10.1136/injuryprev-2012-040620

DROWNING PREVENTION DVD

One of a series of DVDs on child injury prevention utilised to education parents of children who attend the Lady Cilento Children's Hospital for Burns or Trauma. The DVD can be seen at www.coolburns.com.au/videos "Safety Outside the Home" duration 7mins 37s and specifically mentions pool and bath safety, pool fencing and CPR.

OTHER DROWNING PUBLICATIONS

This work was funded by a grant from the Queensland Injury Prevention Council. A final report was prepared for the funding body. That work provided the basis for this thesis, however substantial further analyses were conducted for the thesis after the report was completed. The Report is available within the public domain:

Wallis BA, Watt K, Franklin RC, Nixon JW, Kimble RM. (2012) 7-Year Review of Drowning in Children and Young People 0-19yrs in Queensland 2002-2008. Centre for children's Burns & Trauma Research, Queensland Children's Medical Research Institute, Royal Children's Hospital, Brisbane, Australia. ISBN: 978-0-9924946-4-3.

Pearn JH, Wallis, BA. Safety legislation and injury prevention an analysis from the Brisbane Drowning Study. Journal of Paediatrics and Child Health 48 (Suppl.2) 2012, 1-13.

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Author Richard C Franklin	Study Design 10% Data collection 15% Data analyses 10% Writing/Editing paper 10%
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Author James W Nixon	Study Design 10% Writing/Editing paper 5%
Author Roy M Kimble	Study Design 10% Writing/Editing paper 10%

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	Data analyses 20% Writing/Editing paper 15%
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Author James W Nixon	Study Design 5% Writing/Editing paper 5%
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Author Richard C Franklin	Study Design 15% Data collection 15% Data analyses 20% Writing/Editing paper 15%
Author Roy M Kimble	Study Design 15% Writing/Editing paper 10%

CONTRIBUTIONS BY OTHERS TO THE THESIS

All aspects of the work contained in the thesis were the primary responsibility of the candidate. In relation to jointly published works, the candidate took primary responsibility for the following:

- Study Concept and Design
- Data collection / extraction / collation
- Data Analyses
- Interpretation and Synthesis of Results
- Writing the Manuscript
- Critical revision of the Manuscript

STATEMENT OF PARTS OF THE THESIS SUBMITTED TO QUALIFY FOR THE AWARD OF ANOTHER DEGREE

Chapters two and three were originally submitted for MPhil, The University of Queensland, 2010. The thesis was withdrawn from assessment and project converted to PhD.

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The catalyst for this thesis was (and still is) a sincere passion for childhood injury prevention. It began through my studies of the Built Environment where my final year design thesis focussed on designing playgrounds both with and for children. Landscape Architect professionals work to design and create environments that invoke health and well-being, and such interdisciplinary skills bring a new perspective to clinical and public health research.

My husband, Paul has nurtured this desire and has always said that this PhD late in my career is an appropriate recognition of what I have already achieved, along with the priceless investment in our children. As they have grown, they fearlessly bounced and climbed their way across play structures to be photographed for my presentations. Thanks to my dear friend Stephanie who always checks in on me and has been there for a therapeutic whinge, walks and support.

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KEYWORDS

Drowning, Paediatrics, Childhood injury, prevention, respiratory, emergency medicine, asphyxia

AUSTRALIAN AND NEW ZEALAND STANDARD RESEARCH CLASSIFICATIONS (ANZSRC)

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FoR code: 1117 Public Health and Health Services, 25%

FoR code: 1103 Clinical Sciences, 15%

ETHICS AND APPROVALS FOR THIS STUDY WERE SOUGHT AND GRANTED FROM:

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Institutional Approval from the Children's Health Services District at Royal Children's Hospital (RCH)

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Mater Health Services Human Research Ethics Committee #1446E; Mater Adults Hospital and Mater Children's Hospital #1446E

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Commission for Children and Young People and Child Guardian (CCYPCG)

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Health Statistics Centre, Queensland Health (QHAPDC)

Hospital Access Unit, Queensland Health (EDIS, SATR)

Queensland Ambulance Service (QAS)

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CHAPTER 1: FATAL AND NON-FATAL DROWNING IN CHILDREN AND YOUNG PEOPLE 0-19YRS

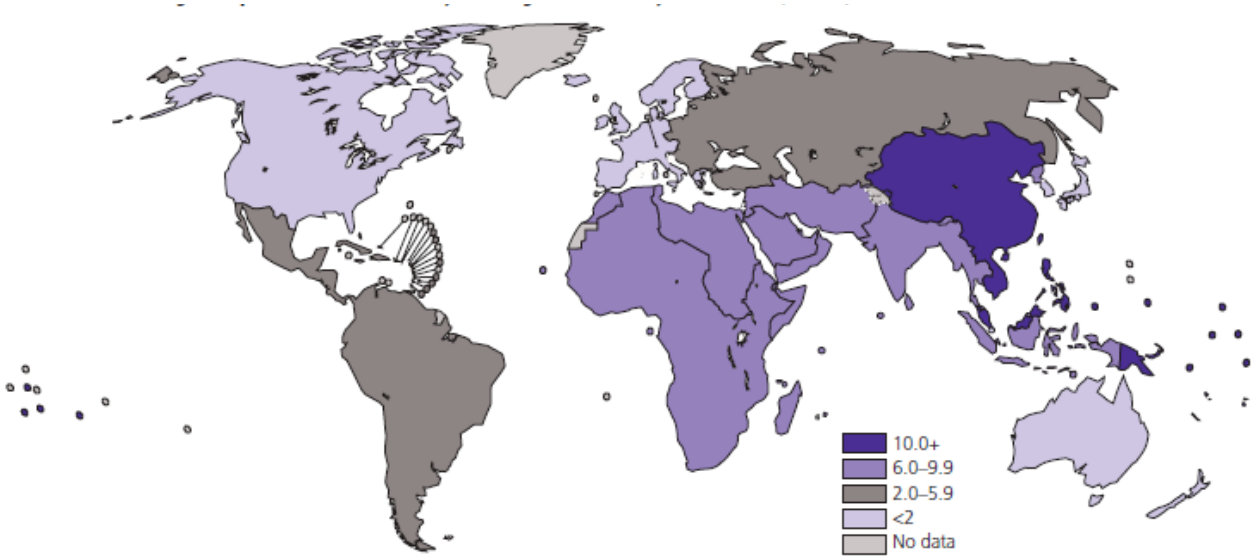
1.1 SCOPE OF THE PROBLEM

Drowning is a preventable cause of injury and death, yet in most industrialised countries of the world it ranks among the top three causes of death(1-3) **Table 1-1.** Approximately every three minutes somewhere in the world a child aged between 0-19yrs fatally drowns. Males and children less than 5yrs are disproportionately affected. Those 175,000 child deaths are said to be underestimated because drowning that occurs due to natural disasters, transport or those intentionally inflicted are not included.(3, 4) More significantly, the morbidity of drowning events world-wide is unknown as these published figures do not account for the burden of those who survive a drowning episode. This thesis will fill this void for Queensland children and adolescents 0-19yrs.

Table 1-1 Drowning in high income countries and low and middle income countries in the Western Pacific Region (%) (injury related trauma is highlighted)

Western Pacific Region – High Income Countries (HIC)		
Rank	Cause of death	Proportion of total (%)
1	Perinatal conditions	28.1
2	Congenital anomalies	23.3
3	Road traffic injuries	6.0
4	Drowning	3.3
5	Leukaemia	2.9
6	Lower respiratory infections	2.9
7	Endocrine disorders	2.3
8	Violence	1.8
9	Inflammatory heart diseases	1.2
10	Self-inflicted injuries	1.1
11	Epilepsy	1.0
12	Falls	1.0
13	Fire-related burns	1.0
14	Cerebrovascular disease	0.8
15	Meningitis	0.5
WHO World Report on child injury prevention, Peden ed 2008, p.189 HIC Western Pacific Region include Australia, Brunei, Japan, New Zealand, and Singapore		

Drowning data across the world are not collected in a uniform manner, and lack of consistency in data quality and reporting standards make it difficult to compare rates world-wide. Estimates for drowning death rates for children under the age of 15yrs range from 1.2/100,000 in high income countries (HIC) to 13.9/100,000 in low and middle income countries (LMIC) in the Western Pacific Region **(Figure 1-1)**.(1)

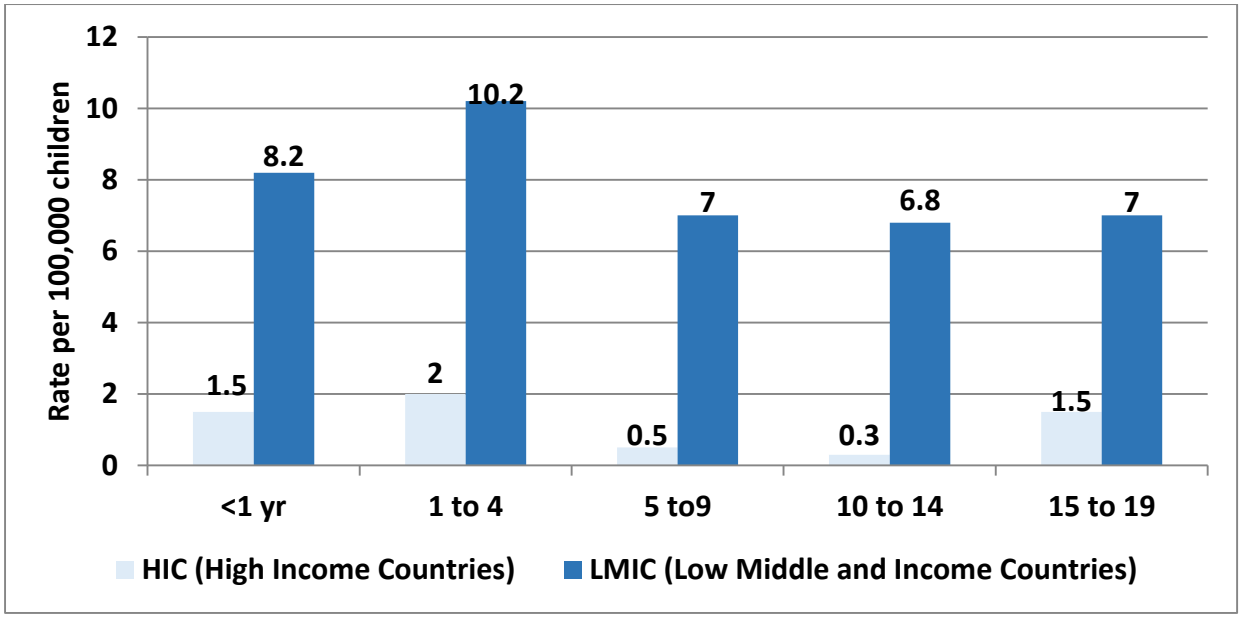


Africa	Americas		South-East Asia	Europe		Eastern Mediterranean		Western Pacific	
LMIC	HIC	LMIC	LMIC	HIC	LMIC	HIC	LMIC	HIC	LMIC
7.2	1.3	3.4	6.2	0.6	4.0	6.2	6.8	1.2	13.9

These data refer to those less than 20 years of age.
HIC = High income countries; LMIC = Low and middle-income countries.
Source: WHO (2008) Global Burden of Disease, 2004 update.

Figure 1-1 Fatal drowning rates per 100,000 children <20yrs by region and country income level, World, 2004

Figure 1-2 illustrates that children between the ages of 1-4yrs are the most vulnerable age group for fatal drowning in both high and low and middle income countries.



Source: WHO (2008), Global Burn of Disease: 2004 Update.

Figure 1-2 Fatal drowning rates per 100,000 children by age and country income level, World 2004

1.2 DEFINITION

Drowning has been referred to by as many as 33 definitions.(5) There has also been controversy in the forensic context as to whether 'immersion' or 'drowning' is an actual cause of death. A recently developed model(6) **(Figure 1-3)** proposed drowning as a mechanism of death under asphyxia because drowning deaths involve developing hypoxia that ultimately becomes irreversible. That model proposed that such deaths are then sub-classified further when investigating bodies which are recovered from water. From the injury surveillance perspective this has the potential to make drowning even more difficult to differentiate within data from other mechanisms, particularly unintentional strangulation. In order to identify drowning cases specifically, the search terms 'drowning', submersion', 'immersion', 'near drowning' would have to be added to 'asphyxia', and all terms associated with hypoxic events. Cross matching with activity or sites related to water would make this

significant cause of death more difficult to identify in data, particularly in non-fatal events where the location is not consistently noted.

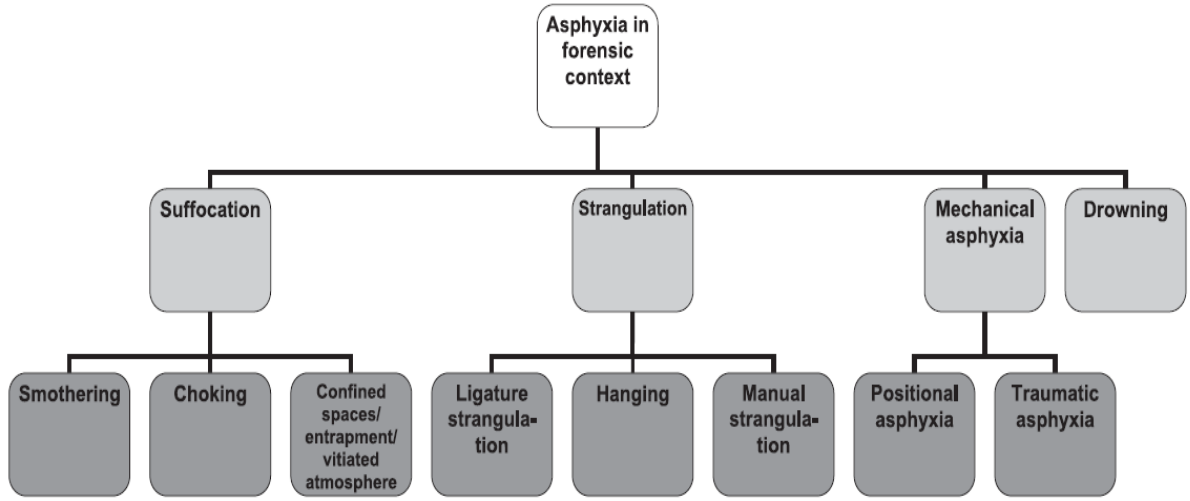


FIG. 2—*The proposed unified classification of asphyxia in forensic context.*

Figure 1-3 Proposed model of deaths involving asphyxia(6)

DEFINITION

Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid.

Outcomes:

- Death
- Survival (non-fatal)
  - No morbidity, or
  - Disabled
  - Vegetative
  - Brain death

More than a decade has passed when in 2002 the International Liaison Committee on Resuscitation (ILCOR) reached international consensus for a definition that incorporates the concept that "drowning" is a process that can result in death or survival.(2, 7) (See definition) This definition was further refined by Idris et al in 2003(7) with the emphasis of the process being a continuum of physiological effects from the moment of entry into water, until respiration is restored,(2) or brain death when somatic death ensues.

The outcomes of survival (non-fatal drowning) are then further categorized as "moderately disabled", "severely disabled", "vegetative state/coma" and "brain death" **(Figure 1-4).** To comply with international consensus, the terms "wet", "dry", "active", "passive", "silent", "secondary" and also the term "near drowning" should no longer be used. Submersion and immersion have been used interchangeably to also describe drowning the drowning process and should qualify death or survival.

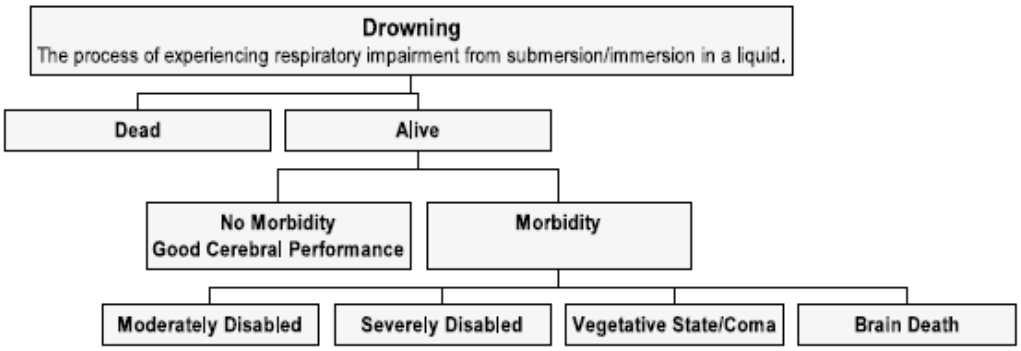


Figure 1-4 Tracking drowning death outcomes(7)

In this thesis the nomenclature as agreed by the International Liaison Committee on Resuscitation,(7) is used. The terms 'fatal', 'non-fatal' drowning are used where it is required to qualify whether 'drowning' or near drowning', 'submersion' or 'immersion' has resulted in death or survival. Survival indicates that the victim was successfully resuscitated from cardiac or respiratory arrest and was discharged from hospital. The terms 'all drowning' or 'total drowning' are used to describe fatal and non-fatal drowning combined.

1.3 DROWNING IN AUSTRALIA & QUEENSLAND

Drowning prevention is recognised as a high prevention priority nationally, and forms part of the National Water Safety Strategy 2012-2015 and supported by Royal Life Saving Society Australia (RLSSA) and Surf Life Saving Australia (SLA) among many other member organisations.(8) At a state government level drowning surveillance is part of the overall injury-death picture produced in annual reports for children 0-17yrs by the Child Death Review Team.(8, 9) Prevention initiatives from State Departments of Health and Local Government have used various strategies over the years including summer education campaigns for pool fencing, and most recently a pool register and enforced pool fencing compliance.(10) A more pro-active strategy of the state government was to form a Pool Safety Council who were investigating pool fencing compliance at the home of any child pool drowning event occurring in Queensland. This was the first initiative utilising non-fatal drowning, and on the disbanding of the council after a change of government in November 2014 the council's functions were passed to the Queensland Building and Construction Commission (QBCC).

1.3.1 COST OF DROWNING

There have been three major studies on the cost impact of all fatal and non-fatal drowning in Australia. Cost estimates can take into account the direct costs calculated on the treatment for a fatal or non-fatal drowning and indirect societal costs of lives lost, or lives affected by drowning survival; and productivity losses associated with premature death or disability. This last measure takes into account the long term effects of any neurological disability which may have occurred. These differing approaches resulted in figures for all Australia which range from AUD$5.5m(11) (direct costs in 1993-94) to AUD$132.4m (direct and indirect costs

1995-96).(12) Figures have been estimated at AUD$19.5m for the state of Victoria (direct and indirect for the year 1993-94) with a per-person estimate of AUD$62,000,(13) and for the state of Western Australia AUD$46.5m. The higher costs were attributed to different underlying assumptions used in methods to estimate costs (i.e., the value utilised to estimate statistical life). These figures will have increased over the 20 years since they were produced. Drowning was not reported in a recent report on cost of acutely admitted patients, however costs related to respiratory admissions were quoted at AUD$9,700 per admission for the whole of Australia. State-based costs were not available.(14)

Despite limited comparable data, drowning imposes a considerable burden on society at large as well as the families of those affected. This is particularly poignant because 0-4yr olds constitute the majority of drowning cases, thereby disproportionately affecting young families and productivity losses.

1.3.2 DROWNING DATA SOURCES AND LIMITATIONS

In Australia, fatal child and adolescent drowning data are collected at a state level through the Office of the State Coroner (child drowning deaths are reportable to the Coroner) and may also be investigated through police, autopsy, and toxicology. Once certified, the drowning death is then recorded with the Registry of Births Deaths and Marriages (RBDM) and the National Coronial Information System (NCIS) and then uploaded to the Australian Bureau of Statistics (ABS). Where there are no unresolved queries relating to the death, (such as may be the case in drowning when the body is missing) the data are released to the public via ABS

annual Cause of Death reports.(15) RLSSA also produces annual drowning reports and using data from both the ABS and more recently, the NCIS.

Limitations relating to this process for researchers are that the fatal drowning data available to the public through ABS are aggregated data, and provide limited information on location through ICD10 coding. Due to small numbers, this information is hard to extract for children aged between the aggregated 5-19yrs and there is no information about the circumstances. There is a time lag for cases to be closed pending cause of death certification, as "death records which are certified by a coroner have little or no information in the fields relating to causes of death when supplied to the ABS by RBDM, because at the time the death is required to be registered the information necessary to certify the causes of death is not available. Causes of death information becomes available over time as coronial cases are closed and the information is posted on the NCIS."(15)

Other organisations that have access to these ABS and NCIS data are RLSSA annual drowning reports which include a small amount of information on the number of drowning deaths by age group, sex and locations. The (former) CCYPCG through the Child Death Review Team collects comprehensive data from RBDM on the circumstances of drowning events; however data are limited by age with child deaths in Queensland up to the age of 17yrs being included. This means there are no 'real time' collections of fatal drowning available to researchers, and no state-wide systematic collection of data on non-fatal events, and cases not closed on the NCIS are not accessible to researchers.

Prior to 2010 the only exploration and recording of non-fatal drowning has been conducted in research studies in Brisbane City.(16-18) Non-fatal data has been intermittently published for various populations in Australian national reports.(19-21) In January 2011, the State Department of Local Government and Planning[1] (DGLP) began prospective collection of hospitalised drowning events in Queensland, but only for pool immersion events.(22)

The specific location of a drowning event is routinely noted for fatal drowning only. The site or location for non-fatal drowning events is provided for drowning episodes that result in hospitalisation via current ICD10. Even then, information on location is limited to three locations (baths, pools and natural water).(23) The tendency to code location as "unspecified" can exceed recordings of specified locations by as much as 50-90%.(24) Location data coded as "unspecified" or "specified" impedes the development of prevention interventions. Thus, it is understandable to see why pools over other locations have received more attention in prevention strategies. More accurate information on drowning location can be obtained from dedicated injury surveillance systems such as Queensland Injury Surveillance Unit (QISU). However in Queensland, this surveillance only covers approximately 25% of the state. This means that detailed, population-level information about location of non-fatal drowning events can only be obtained through purposely-designed studies requiring access to medical records, which requires substantial resources. The current coding system lacks detail and will continue to hamper prevention progress in relation to drowning unless changed to make drowning locations are more explicit.

[1] Pool Safety relocated to Department of Housing and Public Works under machinery of government changes in 2012, and then to Queensland Building and Construction Commission in November 2014 after change of government.

In Queensland, and elsewhere in Australia, there is no one data source that accurately captures all of the required information on fatal and non-fatal drowning in a consistent manner (i.e., covering the same fields of information). Ascertaining the incidence of these events is therefore difficult. There are several barriers to understanding the true magnitude of the burden drowning across the age spectrum. These include the fact that there is no real-time collection of data in the public domain, state-wide non-fatal events have not been recorded in any consistent fashion, nor held in one easily accessible place. Thus it is difficult to document adequate information about the true magnitude of the problem, the risk factors associated with drowning incidents, and the associated morbidity and mortality. This thesis fills this void.

1.3.3 FATAL DROWNING BURDEN

In Australia, the average rate of death by drowning for the five years 2002/03- 2007/08 was 1.43/100,000 or 288 persons per year.(25) Annual Reports from Royal Life Saving Australia (RLSSA) provide fatal drowning numbers (not rates) for age groups (0-4yrs, 5-14yrs and 15-24yrs), gender, location, activity and season of drowning deaths in Australia for the previous financial year. Numbers or rates of fatal and non-fatal drowning were not available by age group, for state or territory, and were only available by financial year. Unpublished RLSSA data **(Table 1-2)** for the target age range show that Queensland has the second highest numbers of drowning deaths of all states and territories.

Table 1-2 Frequency of fatal drowning 0-19yrs by Australian states and territories 2002-11

	Year of Incident (numbers of deaths)										Total
State of death	2002 *	2003	2004	2005	2006	2007	2008	2009	2010	2011 **	
ACT	1	1	2	2	1	0	0	0	1	1	9
NSW	11	26	20	16	21	33	20	14	19	11	191
NT	0	5	0	0	1	2	3	2	1	1	15
QLD	11	8	19	24	21	27	19	23	17	14	183
SA	2	4	2	2	5	5	2	3	2	2	29
TAS	5	0	1	0	4	0	1	1	1	0	13
VIC	4	6	10	12	9	10	6	8	13	3	81
WA	6	15	7	8	4	8	7	9	3	4	71
Total	40	65	61	64	66	85	58	60	57	36	592
* Half financial years											
* *Half financial years and latest year so may be missing cases (Source: unpublished data RLSSA)											

Fatal rates for specific ages up to the age of 17yrs are provided by the by the (former)[2] Commission for Children and Young People and Child Guardian (CCYPCG). The Commission's Child Death Review Team indicate that the drowning problem continues to be a significant cause of preventable death. Death rates for children aged 0-17yrs of 1.8/100,000 ranked it as the leading cause of death from all causes after transport. It is the leading cause of death for Queensland toddlers aged 1-4yrs at a rate of 5.9/100,000 **(Figure 1-5).**(26)

State-wide non-fatal drowning data are not reported, and only children 0-17yrs are included in the Child Death Review. Differing age groups, and figures by financial years make it difficult to compare data produced elsewhere in the world. Also, the incidence, mechanisms, locations and consequences of non-fatal events remain unexplored in the Queensland population.

[2] Commission for Children Young People and Child Guardian has transitioned to the Queensland Family and Child Commission (QFCC) from 1 July 2014.

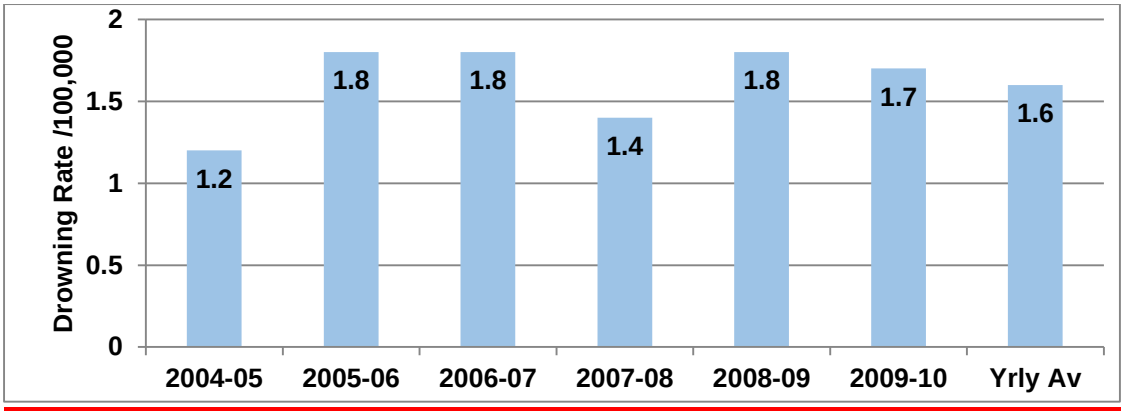


Figure 1-5 Drowning death rates per 100,000 children in Queensland 0-17yrs Source: CCYPCG Annual Report 2009-10

1.3.4 DROWNING LOCATIONS

Circumstances of drowning can vary by age and aquatic setting.(27-29) and it is rarely the result of a single cause. (30) Detailed data on fatal and non-fatal drowning in published literature, including any information on location and age in Australia, historically have stemmed from medical research(31-35) rather than from surveillance of publicly accessible data.(36) Childhood drowning in backyard swimming pools was first identified as a significant issue as early as 1974.(37-39) During the period 1971-1991 more than 1,000 children died or were rescued from backyard swimming pools across Australia.(40) Traditionally, studies of drowning deaths of children have focused on the 0-4yr age group with little or scant attention paid to the 5-14yr age groups;(33, 36),(41) and some attention, with a specific focus on alcohol and the 15-19yr age group.(42-44) RLSSA (through National Coronial Information System (NCIS) data extraction) has only in recent years begun to include data on activity and location.(45)

Other common locations where children have drowned include rivers, lakes, lagoons, dams, and the bathtub, but little has been published on many of these locations in Australia. Bath drowning was first exposed as a significant risk in the late 1970's,(30, 39) and more recently

bath seats (46) and shared bathing were recognised as risks for drowning.(47) In 2005 Bugeja and Franklin examined rural drowning in dams in Victoria, and Mitchell and Franklin found that drowning in dams was the most common mechanism for death in rural children 5-9 years.(31, 34)

To date the greatest success in reducing child drowning deaths has been through a range of strategies that have focussed on domestic pools, and in targeting the 0-4 year age group. These successes are due to greater pool owner compliance to physical barriers, and heightened awareness and publicity of pool drowning.(48, 49) (See Appendix 1) Changes in demographic patterns and lifestyles over the past decades however, have led to higher population densities and to a dramatic growth in swimming pool installation. In 2005 the Swimming Pool and Spa Association (SPASA) in Queensland estimated 2700 new pools were being installed every year (See Appendix 1).

1.4 RISK FACTORS ASSOCIATED WITH DROWNING

Risk factors for drowning are those attributes or characteristics associated with an increased probability of a drowning event occurring (for example the presence of a rip in the surf increases the likelihood).(50) Drowning prevention is the process where the probability of a drowning is reduced by aiming interventions at the risk factors for a drowning event.(40)

Identification of risk factors related to the environment and behaviour were first recognised by Haddon working with transport injury through the application of a model originally developed for infectious disease control. This resulted in the development of the very

effective model subsequently referred to as Haddon's Triad – where risk factors are described according to the three domains of host, agent, and environment.(51-54)

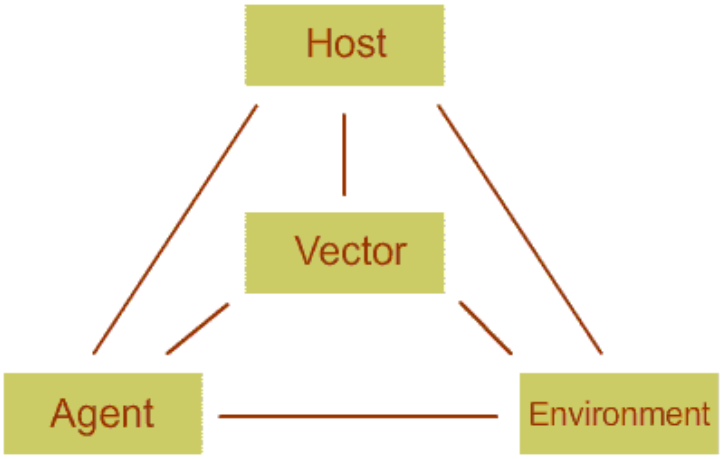


Figure 1-6 Haddon's Triad is used to inform injury prevention initiatives

Source: (http://www.cdc.gov/osels/scientific_edu)

In this model, the host is the person at risk; the agent is the available energy interrupted or transferred to the person via a vector; the vector is the vehicle of energy exchange (person, animal, or object); and the environment is the physical or social context in which the injury occurs **(Figure 1.6)**. In the case of drowning, the agent is an interference of energy exchange patterns (i.e., the process of asphyxia from immersion in a liquid) resulting in asphyxia or hypothermia. It is thus a loss of physiological homeostasis. The vector therefore, is the type of water body that inflicts the interference. Risk factors for drowning that I have identified in the literature to date are summarised in the table below (**Table 1.3**), according to Haddon's triad (with the addition of vector). A further extrapolation of these attributes for the drowning scenario is shown in **Figure 1.7**.

Table 1-3 Risk Factors associated with drowning by Haddon's Triad

<table>
<tr><th colspan="2">RISK FACTORS</th></tr>
<tr><th colspan="2">HOST
(Person at risk)</th></tr>
<tr><th>Child attributes</th><th>Carer attributes</th></tr>
<tr><td>Age group 0-4yrs (31, 33, 36, 55-72) 1-4yrs and 5-14yrs (17, 73, 74) <1yr (75) 5-14yrs <10yrs(76, 77) (78-80)
Masculine gender (31, 33, 59-62, 78-86)
Ethnicity (Indigenous / immigrants / tourists) (32, 36, 56, 64, 77, 78, 81, 84, 85, 87-90)
Poor swimming ability for children (65, 74, 75, 77, 78, 80, 86, 91, 92)
Lack of water safety education (57, 66, 77, 82, 83, 86, 89, 91-96)
Pre-existing medical conditions (69, 74, 85)
Severity of harm / time missing (17, 74)</td><td>Lack of supervision (17, 31, 59, 65, 66, 68, 69, 72, 74-77, 80, 86, 89, 91, 92, 97, 98)
Age /health / education / income / landless: (55, 73-75)
Lack of CPR knowledge (55, 74, 76, 91)
Unfamiliarity with the hazard: (17)</td></tr>
<tr><th colspan="2">AGENT
Energy transfer / energy interference to person via vector</th></tr>
<tr><td colspan="2">Watercraft / Boating & MVA (60) Hot Tubs / Spas (68)
Activity: (17) (55, 65, 74)</td></tr>
<tr><th colspan="2">VECTOR
Person / animal / object</th></tr>
<tr><td colspan="2">Water body type /Aquatic locations
Pools (17, 32, 56, 61, 63, 64, 66, 70, 73, 86-88, 94, 97)
Bathtubs (66, 87, 99)
presence of bath seats – one study reported a positive association (69) and another found no association(100)
co-bathing (69)
Dams / Ponds / Rivers (31, 33, 35, 58, 59, 65, 67, 72, 74, 75, 80, 86)
Sea / Coast (56, 62, 78)
Buckets (56)</td></tr>
<tr><th colspan="2">ENVIRONMENT</th></tr>
<tr><th>Physical</th><th>Socio-economic</th></tr>
<tr><td>Pool fences (including legislation / proper installation / inspection) (55, 58, 63, 66, 76, 86, 89, 91, 94, 101-105)
Access to water (Lack of or inadequate pool fencing) (55, 64, 94, 104, 106, 107)
Seasonality - Summer season (58, 66, 68, 72-74, 80)Monsoon (75)
Higher pool density: (i.e., more pools /capita) (73)
LMIC/HIC: Pitt (73) (55, 74, 75)
Lack of safety signs: (74)</td><td>Alcohol and adolescents (44, 55, 82, 97) (62, 108, 109)
Availability /Legislation of life vests and lifeguards (70, 89, 110, 111)
Drowning event in own home or close to home: (17, 73, 74)
Detached housing: (17, 73)
Time: Daylight hours (74, 75)
LMIC/HIC: (73) (17) (74, 75)</td></tr>
</table>

Young children, masculine gender, and lack of supervision are risk factors that appear to be universal, whereas other factors relate specifically to ethnicity, caregiver factors, socio-demographics in developing, or developed countries and do not necessarily transfer across these boundaries. Drowning locations are many and varied and are generally related to the age of the child. Other potential risk factors identified in studies for which there is conflicting, inconclusive or minimal evidence, include: the presence of bath seats – one study reported a positive association,(69) and another found no association (100); co-bathing.(69); birth order - last born children are over-represented in drowning cases;(112) socio-economic status;(74, 75, 112) poor caregiver health;(74) and lack of life jackets.(74) Additional risk factors specific to older children (i.e., adolescents) include: pre-existing medical conditions;(85, 113) and alcohol consumption.(44, 55, 62, 82, 97, 109)

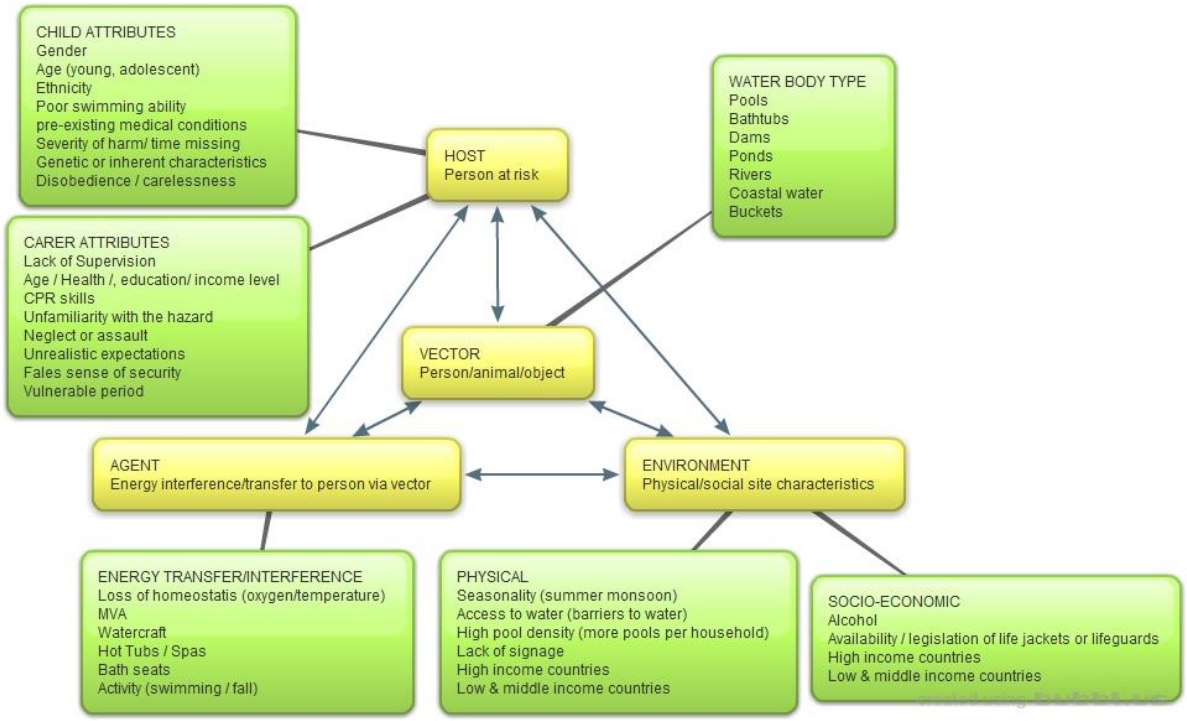


Figure 1-7 Haddon's Triad showing risk factors and attributes derived from literature review

While a large body of literature exists on potential risk factors associated with drowning, interpretation of findings described in these studies must be done with caution. Several biases and other methodological limitations are present, limiting validity and reliability of study findings. Studies on risk factors are limited by inconsistent definitions of drowning (fatal or non-fatal), risk factors such as what swimming and swimming lessons entail. As well, measurement bias associated with self-reported data, recall bias and lack of consideration of relevant confounders were also apparent. Importantly, many studies did not utilise consistent or high quality measures of exposure data. Exposure information is essential, such as accurate numbers of pools, numbers of dwellings, presence of children in dwelling and the presence of pool fencing configuration and status when exploring the effectiveness of pool fencing. The analyses of these risk factors are described in 1.6 Theoretical framework and rationale.

Methodologically sound studies on risk factor identification are much needed in this area. Such methodological improvements will allow definitive intervention evaluation, and identification of risk factors. This will inform prevention strategies, and ultimately, reduce drowning in children. High-quality, population-based surveillance data on fatal, as well as, non-fatal drowning is essential for identify causal pathways, and to aid the intervention process. Because fatal drowning incidents are infrequent events, the inclusion of non-fatal data provides greater numbers to make statistical analyses and evaluations more reliable. Data on antecedent events leading up to the drowning event are limited for many studies that have examined risk factors for drowning. It is evident that data are required from across the continuum of care - from pre-hospital to admission or death – to facilitate identification of risk factors along the causal pathway.

1.5 CONCLUSIONS

It is evident that drowning is a considerable burden worldwide imposed disproportionately on the very young. Despite the fact that drowning ranks so highly as a leading cause of injury death across the world, it has not been a prioritised addition to routine data collection systems in Australia. A decade has passed since international agreement that drowning can result in death or survival. Yet the true magnitude of the burden from non-fatal drowning is yet to be seen consistently in data collected in Australia, and is still an unknown quantity to be added to the fatal burden.

In Queensland, drowning data are not held in one easily accessible place; comparable data are rarely published; there is no real-time collection of drowning death data in the public domain; non-fatal drowning events have not been recorded in any complete fashion; locations and other information about circumstances leading to the drowning event are only recorded for drowning deaths; there has been no recent estimate of the cost of drowning. Consequently, the development of interventions has been hampered by lack of detail in routinely available data.

Fundamental to any prevention effort is an understanding of where, how and why drowning occurs within that sequence of events, and what associated factors may affect the outcome.

1.6 THEORETICAL FRAMEWORK AND RATIONALE

A drowning event begins when a child or friend is missing, hasn't resurfaced or is found in the water. A Triple Zero call is made to emergency services, who attend and hopefully take over bystander revival attempts. If responsive, the patient is transported for treatment to hospital or emergency department and is either treated and discharged, admitted to hospital, or transferred to the mortuary if declared dead. Those who are unable to be revived at the scene will not enter the hospital system and are transferred direct to the mortuary. Tragically, some who don't resurface can take many days to be found, or may never be found. All along this patient journey, data are collected by each agency involved in the rescue. The data for this thesis was chosen from multiple points. Non-fatal drowning data were accessed from pre-hospital emergency services (Queensland Ambulance Service (QAS), Queensland Health Emergency Department (EDIS and SATR) and Admitted Patient Data. Fatal drowning data were extracted from the NCIS, CCYPCG and RLSSA.

The purpose of this thesis is to review evidence-based drowning prevention interventions in the literature, and then access and link as much data as possible from the patient journey to effectively describe the aetiology of all cases of death and survival from drowning incidents in Queensland. The incidence and magnitude of drowning at various locations will be described, and whether these characteristics differed with respect to Indigenous status. Risk factors will be extracted from case narrative text in pre-hospital and emergency data collections to provide recommendations that are contextually specific to Queensland.

The public health approach to injury prevention provides the ideal framework to investigate and understand the causes of drowning in children and young people in Queensland(114, 115). The public health approach to injury control is an interwoven four-stage process: 1) define the nature and extent of the problem; 2) identify associated risk and protective factors; 3) develop effective interventions; and 4) implement these interventions in effective programs.

Despite a vast body of literature on drowning, the evidence-based detail required for prevention interventions is lacking, and the causal pathway and risk factors can only be derived from fatal drowning data where access is available to detailed case notes. In particular, the lack of research activity within the second phase of the public health process (i.e., identification of risk factors) has impeded the public health response.

Through the collection of information about the magnitude, scope, characteristics and consequences of both fatal and non-fatal drowning data for children and adolescents in Queensland from all relevant data sources, this thesis focuses on the first two stages of this process **(Figure 1.8)**; 1) defining the nature and extent of drowning in Queensland; and 2) identifying the associated risk and protective factors.

Figure 1-8 Four steps of the interwoven public health approach(115)

Prevention strategies depend on understanding the circumstances surrounding the drowning incident. In 1979 Pearn and Nixon used the concept of 'critical incidents' where they sought factors, which are not necessarily fatal in themselves, but that occur as one link in a potential series of critical errors or events leading up to the drowning incident.(30, 116) It is intended that the linking of several databases may reveal such a sequence of events, ensure an accurate case capture, and provide information on precipitating and contributing factors. Vital information as to how the event occurred, the drowning site, and as well patient care prior to, during, and after the incident may be revealed. The antecedent information can identify risk factors not only across various age groups, but locations as well.

As outlined in section 1.5 (Risk Factors for Drowning), Haddon's triad provides a useful tool for identifying risk factors associated with drowning. This framework is used throughout the thesis as a context in which to report the findings (Figure 1-7 Section 1.5). The examples provided in Table 1-4 also highlight the dynamic nature of a drowning event, and by incorporating the concept of time – pre-event, event and post-event - reinforces the need for a multi-layered approach to interventions.(117) Haddon's Matrix proved successful in being able to see how a sequence of events could lead to a drowning event.

Table 1-4 Interventions to prevent pool drowning in young children using Haddon's matrix

	HOST	**VEHICLE (Vector and Agent)**	**ENVIRONMENT**
PRE-EVENT (Primary)	Teach children 2-4yrs to swim Teach parent about water safety	Do not leave attractant objects in pool after use Empty wading pool after use	Fence the pool with 4 sided fencing Limit access from house to yard Ensure gate is self- closing and not propped open
EVENT (Secondary)	Never leave child in water alone or in the care of a sibling	Provide child with approved flotation device	Install pool/gate alarm Sign with CPR instructions
POST-EVENT (Tertiary)	Learn CPR	Healthcare and social resources for rehabilitation	Parent and child education on water safety devices

The extrapolation of risk factors/attributes shown in **Figure 1.7** show the method by which risk factors were sorted for analysis for Chapter 2 (Interventions associated with drowning prevention in children and adolescents: Systematic literature review). This same framework was used for the descriptive analyses undertaken in Chapter 4 (Demographic and clinical characteristics: What about those who survive?); Chapter 6 (Where children and adolescents drown in Queensland: a population-based study); Chapter 7 (Drowning in Aboriginal and

Torres Strait Islander children and adolescents in Queensland (Australia); and for the recommendations for future policy, practice and research in Chapter 8.

Cohen and Swift proposed the *Spectrum of Prevention* model to describe the various levels of society that need to be accessed and influenced in order to prevent injury.(118) This model has been applied to the findings of this thesis to develop recommendations, which are presented in the final chapter of this thesis (Chapter 8: Summary of key findings and implications for future policy practice and research). The application of this model to findings presented in the thesis relates to Stages 3 & 4 of the public health approach to injury prevention. While these stages were beyond the scope of the thesis, this model facilitates the synthesis and application of the findings. For example, **(Figure 1-9)** interventions could begin with a focus on the individual and family; community norms; or insitutional practices and laws. Specific action levels for the recommended primary prevention initiatives to be developed, evaluated or developed into practice are offered within this spectrum. In combination with Haddon's models for identifying risk factors and a sequence of events, these models move drowning prevention practice beyond the more commonplace education campaigns.

Figure 1-8 Levels of influence within the Spectrum of prevention

A population-based study of fatal and non-fatal drowning episodes in Queensland has not previously been conducted across the age spectrum 0-19yrs. It is at least three decades since Pearn and Nixon(16) conducted their review of child drowning (0-14yrs) incidents in the Brisbane Drowning Study. Changes in demographic patterns and lifestyles over the past decades have led to higher population densities and dramatic growth in swimming pool installation. An accurate incidence rate of fatal and non-fatal drowning incidents is a much needed surveillance tool for appraisal of new or changing needs in the population. The strength of this type of data collection is in providing enriched and extra data for analysis, particularly where the fatality case rate is low, but the frequency of survivors can therefore indicate the potential burden from death or severe disability. Linked data from the continuum of care will provide information to allow intervention strategies to be targeted at multiple points. In combination with the theoretical framework, such robust and comprehensive data will allow the setting of priorities and identify points where interventions will be most effective.

1.7 AIM AND OBJECTIVES

Aim: To collate comprehensive population based data on fatal and non-fatal drowning episodes of children and young people aged 0-19 years in Queensland for the years 2002-2008 utilising data linkage techniques.

To achieve this aim, a series of underlying objectives form the research developed for each of the chapters.

Objectives:

1. Provide a list of evidence-based drowning prevention interventions for children and young people (0-19yrs) and review associated risk factors for drowning within this literature to inform recommendations.

2. Identify relevant data sources, access and extract fatal and non-fatal episodes of drowning in children aged 0-19yrs in Queensland for the years 2002-2008.

3. Describe the characteristics of fatal and non-fatal drowning events in Queensland.

4. Estimate the incidence of fatal and non-fatal drowning events in Queensland involving children aged 0-19yrs.

5. Identify locations of drowning events in Queensland and quantify the magnitude of drowning at particular sites, to examine how drowning location varies in relation to other characteristics such as age, gender or socio-economic status.

6. Determine whether the incidence of drowning events, characteristics of children sustaining these events, or injury characteristics differed with respect to Indigenous status.

7. Provide a set of recommendations including priorities and approaches to prevention of drowning deaths in children aged 0-19 years in Queensland.

The structure of this thesis is a series of published (peer reviewed) articles and linked chapters which conform to The University of Queensland requirements for PhD submission. An author contribution statement is included with each article, and abbreviations and references are contained within each chapter. The format for referencing is that required by the journal where the article is submitted. Figures and tables are inserted in the text where they would normally appear.

1.8 THESIS STRUCTURE

Chapter 1: is an overview of drowning, providing global and Australian perspectives; definition; estimated cost of drowning; limitations of current data collection on drowning; a summary of risk factors in current literature; concluding with a theoretical framework and rationale for undertaking this study.

Chapter 2: is a systematic literature review of drowning interventions and is published in Injury Prevention. The most rigorous studies of evidence-based interventions are identified along with associated risk factors. Shortcomings of current studies are identified and the implications for this thesis are highlighted. (Objective 1)

Chapter 3: outlines the methodology and the design approach to access and acquire the data for both fatal and non-fatal drowning from multiple datasets and custodians. The barriers and benefits are highlighted for replication of this process. (Objective 2)

Chapter 4: provides analyses which were conducted to determine the distribution and determinants ("who, what, when, where and why") of drowning. Characteristics of fatal and non-fatal drowning for the sample demographics, location of drowning and clinical characteristics are presented. Narrative text was examined and associated contributing factors have been extracted. These descriptive analyses and interpretation of these statistics have been included in a published paper (Chapter 6) "Where children and adolescents drown in Queensland". (Objective 3)

Chapter 5: provides analyses for quantifying the first incidence and severity of fatal and non-fatal drowning events across Queensland 0-19yrs. Analyses are conducted to quantify the

magnitude by age, severity and trends over the time of the study. The results are published in PLOS One and the manuscript as it appears online is inserted. (Objective 4)

Chapter 6: identifies the locations of fatal and non-fatal drowning to describe differences in age, severity, and trends over the time of the study in relation to drowning location. The narrative text revealed contributing factors which are also presented to inform prevention strategies. The chapter is a manuscript published in BMJ Open in October 2015. (Objective 5)

Chapter 7: examines the difference in drowning by Aboriginal and Torres Strait Islander origin. Drowning incidence is quantified and compared with the non-Indigenous population by age and severity for the first time. Descriptive analyses such as season, time, locations and geographic remoteness are also studied. Results are published in the Journal BMC Public Health, submitted in April, 2015. (Objective 6)

Chapter 8: the final chapter summarises the key findings of each of the chapters and considers the benefits and feasibility of data linkage to track drowning. It also presents discussion on the value of the data extracted, particularly with regard to the drowning survival ratio calculated, and the implications of these results for drowning prevention. The detail revealed in contributing factors mined from the case narratives is worthy to inform preventative stratagems, and recommendations are suggested for a way forward to achieve this. (Objective 7)

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CH 2: SYSTEMATIC REVIEW

CHAPTER 2: INTERVENTIONS ASSOCIATED WITH DROWNING PREVENTION IN CHILDREN AND ADOLESCENTS: SYSTEMATIC LITERATURE REVIEW

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2.1 CHAPTER CONTEXT

This review addresses Objective 1 which was to identify and critically analyse studies that offered the best evidence of interventions which have been introduced to reduce drowning events or reduce the severity. The risk factors within this literature are also identified. Very few studies met the inclusion criteria, mainly due to a lack of methodological rigour, and high levels of evidence to assess the impacts of the interventions. Most evidence for interventions has been on education-based interventions with very little work done in the area of behaviour change interventions or evaluating the effect of legislation. High quality data are required in order to inform the development and implementation of countermeasures, and to gauge any benefits. There is a lack of population-based studies of sufficient quality including relevant information on the true magnitude of fatal and non-fatal drowning, and more specifically, on the circumstances leading to the event.

The interventions selected were education-based and focussed on injury prevention (not just drowning) counselling in the ED setting, a school based curriculum) and a life vest loan programme. While none was conclusive, each provided some evidence of success.

Swimming lessons were found to have some protective effect against drowning but only in children aged between 2-4yrs and most importantly do not place a child at extra risk. Whether skills are sustainable or will transfer to other water setting was not shown. Swimming ability in older children was not found to protect against drowning as proficient swimmers do still drown, and no children under two years were included. Importantly, swimming skills alone are not enough to protect against drowning.

Four-sided pool fencing that separates a pool from the house and yard is proven to be effective, but only for children under 3yrs, and only when maintained with an automatically closing and latching gate. Literature shows that merely passing legislation on pool fencing is not effective as it needs to be actively enforced and accompanied by education campaigns. The numbers of pools per household (pool density) has been shown to contribute and this is a proxy for exposure. For example 100 houses and 10 pools results in a density of 1:10.

Risk factors hypothesised to increase the risk of drowning are: age 1-4yrs; male sex, lack of supervision, race/ethnicity; caregiver attributes (such as health and education); drowning location (water body type); swimming ability; seasonality; activity at the time of drowning; unfamiliarity with the water hazard; and lack of safety barriers.

2.1.1 LIMITATIONS WITH TERMINOLOGY

Limitations with this review were that the definition particular terms were not given, for example, what constituted a ‘drowning death’, the terminology around “swimming” was not clear. There was no validated measure in any of the included studies as to whether any of the

children studied could swim; studies relied on self-report; or if the child had swimming lessons (which were not described). A list of terms is provided here, and further research should consider defining these terms: supervision, swim, swimming, swimming lesson, water safety, PFD – Personal Flotation Device (now referred to as a life jacket in Australian Standards AS4758.1 2009).

2.1.2 LIST OF FIGURES AND TABLES INCLUDED IN PUBLICATION

2.2 INSERTED PUBLISHED ARTICLE

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Interventions associated with drowning prevention in children and adolescents: systematic literature review

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ABSTRACT

Introduction Drowning remains a leading cause of preventable death in children across the world. This systematic review identifies and critically analyses studies of interventions designed to reduce fatal and non-fatal drowning events among children and adolescents or reduce the injury severity incurred by such incidents.

Methods A systematic search was undertaken on literature published between 1980 and 2010 relating to interventions around fatal and non-fatal drowning prevention in children and adolescents 0–19 years of age. Search methods and protocols developed and used by the WHO Global Burden of Disease Injury Expert Group were applied.

Results Seven studies fulfilled the inclusion criteria. Interventions were categorised into three themes of Education, Swimming Lessons and Water Safety, and Pool Fencing. All are possible effective strategies to prevent children from drowning, particularly young children aged 2–4 years, but very little evidence exists for interventions to reduce drowning in older children and adolescents. There were methodological limitations associated with all studies, so results need to be interpreted in the context of these.

Conclusions Relatively few studies employ rigorous methods and high levels of evidence to assess the impact of interventions designed to reduce drowning. Studies are also limited by lack of consistency in measured outcomes and drowning terminology. Further work is required to establish efficacy of interventions for older children and adolescents. There is a need for rigorous, well-designed studies that use consistent terminology to demonstrate effective prevention solutions.

INTRODUCTION

Drowning is a global problem, and drowning prevention is a worldwide challenge. It is a leading cause of death in young children in most industrialised countries of the world. Current estimates suggest that there are 175 000 child deaths annually,[1] although this is thought to be underestimated as it does not include drowning from transport, floods and cataclysms of nature and intentional drowning.[2]

Drowning is rarely the result of a single cause, nor is there a single prevention solution.[3 4] Circumstances can vary widely by age and aquatic setting,[5–7] and the activity being undertaken prior to drowning. In high-income countries (HIC), among children up to the age of 1 year, most drowning deaths occur in bathtubs.[6 8 9] However, when the child becomes progressively mobile after the first year of life, swimming pools and man-made ponds (dams) or reservoirs are more frequently involved.[10] Pivotal to any prevention effort is an understanding of where, how and why drowning occurs within that sequence of events, and what associated factors may affect the outcome.[11] Consequently, any prevention effort must take into account risk factors such as age, aquatic location, behaviour, proximity of water, social and physical environmental factors.

This systematic review aims to identify and critically analyse studies of interventions designed to reduce drowning events in children and adolescents aged 0–19 years or reduce the injury severity incurred by such incidents.

METHODS

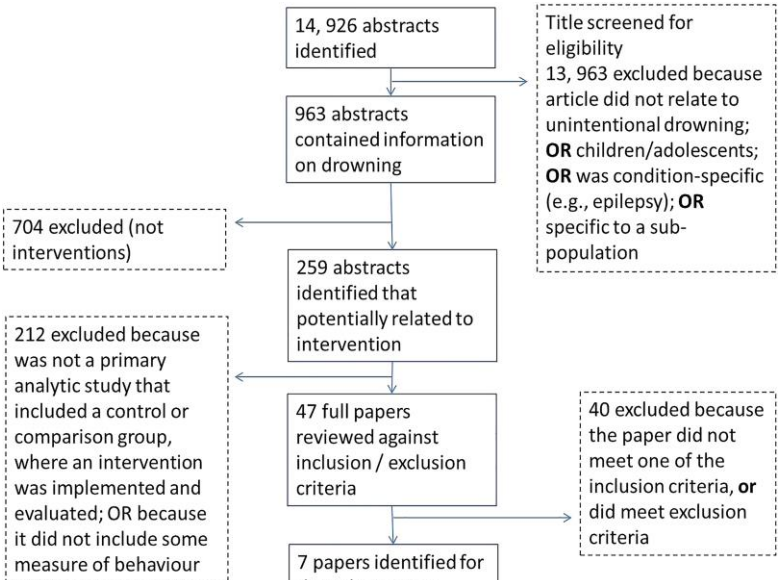
Search methods and protocols developed and used by the WHO Global Burden of Disease Injury Expert Group in their revision of estimates of the burden of fatal and non-fatal injury were applied to this study.[12 13] The search procedure was adapted to facilitate our focus on intervention studies. A modified version of the PRISMA flow chart (PRISMA, 2011) was used to graphically articulate the search results (figure 1).

Literature published in the English language between 1980 and 2010 were searched using Medline; Embase, PsychInfo and SportsDiscuss and the Cochrane Central Register for Controlled Trials. Initial search terms were "drown*" and "human"—these were deliberately broad and were not qualified by publication type or methodology to ensure that all relevant articles could be located. A manual search was completed for all references retained for data extraction. Investigators did not search grey literature, and only peer-reviewed literature with primary data was included.

Four reviewers used standardised criteria to identify potentially eligible articles. Titles and abstracts were first screened by two reviewers (KW, RF). The full paper for 47 articles was assessed against the inclusion and exclusion criteria by three reviewers. The full text of potentially relevant articles was retrieved and reviewed by a further two reviewers (MT, BW), and where there were inconsistencies regarding inclusion, the paper was independently assessed by a third reviewer (KW) and consensus achieved. Papers were assessed according to the following inclusion criteria:

(1) Data from primary analytic studies that included a control or comparison group, where an

Figure 1 Process for extracting relevant articles.



intervention was implemented and evaluated; (2) some measure of behaviour was included (this did not have to be objective)—thus studies that included only measures of attitudes/knowledge were excluded; and (3) drowning event was unintentional; (4) sample comprised children and adolescents aged 0–19 years or at least 75% of the sample or data specifically related to 0–19 years and was presented separately for that age range. Articles that related to condition-specific drowning events such as epilepsy or seizure were excluded, as were articles that related to specific sub-populations such as occupational injury commercial fishermen, SCUBA, snorkelling, caving and diving, air crashes, wilderness workers, hurricanes and tsunami.

The data extraction form used to assess the methodological quality of articles for the purpose of this review is available from the authors upon request. It included study design, number, characteristics and recruitment of participants, geographical location of study, aims of the research, methodology, nature of intervention, outcome measures, main findings and methodological limitations (e.g. sources of bias). The studies were analysed according to their characteristics, measures, results and study quality. Study quality included issues related to study design, sample (composition and size), measurements and potential biases affecting validity. Level of evidence was also assessed.[14 15]

RESULTS

Initial searches identified 14 926 papers from which 963 were identified as potentially relevant after reading title only. Of these 963 articles, 704 were excluded because they did not relate to interventions. Abstracts of the remaining 259 papers were assessed against the inclusion and exclusion criteria, and 212 were excluded, primarily because they did not fulfil either or both inclusion criteria 1 and 2. The full paper for 47 articles was assessed against the inclusion and exclusion criteria.

Seven articles were retained for inclusion in the review. The process for retention of seven articles is outlined in figure 1.

Seven studies met the inclusion criteria[16–22] and are described in tables 1–3 under the themes of Education, Swimming and Water Safety, and Pool Fencing. Characteristics of the included studies, and the level of evidence yielded by the study, are also presented.

There were two randomised controlled trials with control groups[19 22]; and one without[16]; three case–control studies[18 20 21]; and one evaluation of a community awareness campaign (pre-post study).[17] Six of the articles were from the USA[16–20 22] and one from Australia.[21]

The most common age group targeted in the studies of 0–19 year olds included in this review was 0–4 years —all but one study examined this age group. An intervention[19] specifically designed for school-age children in the USA and delivered in school setting to grades 1, 2 and 3 was the only exception. Ages of children included in the study were not specified; however, children in grades 1–3 are likely to be aged 6–9 years.[23] In three papers,[20–22] children aged less than 1 year old were included as part of an overall age group up to age 13 years. Only one study[18] included adolescents beyond 14 years.

Education on injury prevention

Educational interventions are designed to teach a specific group to either increase their knowledge about hazards, consequences and possible solutions, or to attempt to achieve a behaviour change within the target group.

Of the three studies (table 1) that used education interventions, two were randomised controlled trials,[19 22] and the third was a community-wide awareness campaign.[17] Drowning fatalities were an objective measure in one study.[17] However, the number of drowning events did not change significantly during the study period, and numbers were too small to definitively assess between-group differences.

Two interventions contained drowning prevention as part of an overall injury prevention programme where drowning was one of many possible causes of trauma or injury topics.[19 22]

The studies delivered programmes in specific settings to reach the selected target age groups. One intervention was delivered to parents of infants and toddlers who presented at an emergency department (ED) with an unintentional injury[22] and the other was delivered to children aged 6–8 years within the school setting.[19] The third study was an awareness campaign that focused only on drowning prevention and promoted life

Table 1 Effectiveness of drowning interventions using education (included studies)

Interventions				
Study characteristics (quality)	Intervention description	Key elements	Measures	Results
Bennett et al, 1999[17]: Life Vest community-wide awareness campaign and evaluation				
Pre-post Evidence level: III-3 No control Parents of children 1–14 years USA	Media awareness campaign and evaluation county-wide over three summers 1992–1994 (print, promotions and special events). Life Vest retail programme (discount and loan options) Telephone surveys at baseline (n=332), twice during (n=400 each) and once after (n=480).	Messages: "Wear a life vest" "Supervise children around water" "Learn guidelines for water safety" Community-wide Evaluation: recall of campaign messages during and 12 months after campaign	Self-report knowledge surveys by telephone. Life vest ownership and use at beach/pool/boats. Drowning fatality rates. 3 years prior to vs 3 years during campaign. Other variables: Demographics, parent confidence. child swimming ability, perceived susceptibility of child to drowning, perceived life vest efficacy.	Life vest ownership 11% (95% CI 3% to 17%).* Life vest use (OR=1.6; 95% CI 1.1 to 2.5) (self-reported).* Drowning fatalities: 12 deaths in 3 years among 1–14 years prior to campaign, and 8 deaths in 3 years during campaign (inc bathtubs).† Life vest use significantly associated with: child ownership of a vest (OR=2.6 95% CI 1.5 to 4.4) parent <40 years (OR=2.3 95% CI 1.5 to 3.6) child's poor swimming ability (OR=1.6 95% CI 1.1 to 2.4) parent confident fitting a vest (OR=3.2 95% CI 1.5 to 7) parent recalling campaign (OR=1.6 95% CI 1.1 to 2.5).
Gresham et al, 2001[19] Injury prevention curriculum delivered in schools—water safety component only				
Randomised controlled trial (RCT) Evidence level: II Intervention vs no intervention Grades 1–3 (6–9 years) USA	Integrated curricula and evaluation on injury and risk behaviour. Classroom delivery over 6-week period in fall 1997. 15 schools (8 intervention and 7 control), randomly allocated to control (n=1126) or Intervention (n=851) matched on SES, reading scores and race.	Trained teachers and school nurses delivered 6-week injury prevention curriculum. Water safety one of 6 topics. Self-report pre- and postintervention surveys.	Self-report knowledge surveys completed at school within 10 days. Knowledge of hazard of brain and spinal cord injury in different bodies of water. Knowledge of safety rules.Awareness of preventing water-related injury and drowning. Individual responsibility in prevention.	Water safety knowledge improved from pre- to postintervention (p<0.01 for each grade).* Note: self-report rather than injury reduction or observation. Contamination possible through community activities and media.
Posner et al, 2004[22] Injury prevention home-based safety information for parents attending ED				
RCT Evidence level: II Intervention vs no intervention Parents of children <5 years USA	Child presentations to ED with unintentional injury sustained at home September–December 2001. Randomly assigned to (intervention=49; control=47) Telephone survey 2months after ED visit.	Trained RAs delivered to caregivers, usual care (injury focused) vs comprehensive home safety education. Drowning one of 7 topics), a free home safety kit (a non-slip bath decal was the only water safety related device).	Knowledge of caregivers surveyed on 51-item multichoice home safety questionnaire to obtain overall safety score. (submersion category=4 items). Other: demographics and injury characteristic information.	No significant improvement (p>0.05) observed for drowning prevention.† Significant improvement (p<0.01) in overall safety scores in intervention group vs control group, attributed to increase in use of safety devices (p<0.001).* Self-reported use.

*Statistically significant association.
†No association not statistically significant.
ED, emergency department; SES, socioeconomic status.

Table 2 Effectiveness of drowning interventions using swimming lessons and water safety (included studies)

Interventions				
Study characteristics (quality)	Intervention description	Key elements	Measures	Results
Asher et al[16] Water safety training and swimming lessons				
Randomised trial no control Evidence level: III-3 Swimming skills and water safety in two groups 24–42 months USA	Swimming skills and water safety lessons delivered in two groups twice weekly for 8 weeks (n=48) or 12 weeks (n=61) duration. Participants recruited by letters sent to Child Care Centres located near public pools in middle-income Seattle area 1990s.	Trained instructors. Lessons adapted from American Red Cross programme Instruction provided in groups of six children in pool with parent. Lesson time not published. Evaluation by blinded observers and follow-up phone calls over 18-month period. Participants offered $50.	Three skills sets: 1. Out of water safety behaviour (deck behaviour—e.g. running around pool, pushing others, entering water without an adult). 2. Swimming ability (face underwater, recover from prone, roll back to front, propulsive kicking, beginner stroke, independently enter and exit pool, jump into pool independently). 3. In-water safety skills (water recovery ability to stand up when dropped from above water and ability to jump in and swim to edge of pool). Swimming ability assessed by instructors. Water safety skills measured by independent blinded observers (instructors) four times in two groups. Self-report surveys for parental demographics and child development.	Evidence that swimming lessons improve swimming ability in children aged 2–3 years. Swimming ability significantly improved in both 8- and 12-week groups p<0.001* Deck behaviour not improved p<0.03.† Water recovery showed significant improvement in both groups p<0.001.* Jump and swim improved over time in both groups p<0.005.* No control group—effect could be explained by water familiarity. Impact of skills effecting parent vigilance not studied and no children <2 years. Recommends swimming part of comprehensive approach including barriers, PFDs adult supervision and safety awareness. Found no support for concern that water safety instruction increases young children's risk of drowning Incentive payment. Simulated risk as proxy for drowning. No children <24 months included.
Brenner et al[18] Swimming lessons (formal and informal) and drowning assessed				
Case–control population-based Evidence level: III-2 Formal lessons vs informal/no lessons 1–19 years USA	Fatal drowning among 1–19 years, April 2003–September 2005 (2.5 years). Cases (n=88) (1–4 years n=61; and 5–19 years n=27) fatalities identified from Coroner's data. Controls (n=213) matched to cases on age, sex, residence and presence of pool at their home. Telephone interviews by random digit dialling or mail with next of kin. $25 inducement fee paid to participants.	Formal and informal swimming lessons assessed for association with fatal drowning. Definitions: Formal lessons: child received paid lessons or through day care, school or camp. Informal lessons: child not received pointers about swimming or water safety. Non swimmers: no exposure to water or pointers or tips.	Outcome fatal drowning. Exposure to water (≤1 time, or more), swimming ability (Y/N float on back, float on stomach, jump in pool and swim 5 ft back to wall), participation in formal and informal swimming lessons (Y/N). Parental self-report child development, temperament (1–4 years), risk taking, medical conditions and household characteristics.	Swimming lessons: 1–4 years. Cases less likely than controls 3% vs 26% to have participated in previous formal swimming lessons (adjusted OR=0.12 95% CI 0.01 to 0.97).‡ No significant association between formal swimming lessons and drowning in older children 5–19 years (OR=0.36, 95% CI 0.01 to 1.51)† No significant associations were observed between informal swimming instruction and drowning in either age group. 1–4 years: cases less skilled at floating on back for 10 s 5% vs 18% controls p=0.01‡ Cases were also more likely to be non-white p=0.4; low income p=0.03, low education p=0.003; risk takers p=0.03; temperament p=0.06; other medical condition p=0.07. 5–19 years: less likely to swim > 1 min cases 42% vs controls 16% p=0.01† Cases more likely to be non-white, low income or have seizure disorder p<0.01. Limited by small sample numbers. Incentive payment.

*Statistically significant improvement.
†No improvement not statistically significant/no change.
‡Improvement but not statistically significant.
PFD, personal flotation devices.

Wallis BA, et al. Inj Prev 2014;0:1–10. doi:10.1136/injuryprev-2014-041216

Table 3 Effectiveness of drowning interventions using pool fencing (included studies)

Interventions				
Study characteristics (quality)	Intervention description	Key elements	Measures	Results
Morgenstern et al[20] Pool deaths and the effect of local ordinances				
Retrospective cohort and case–control Evidence level: III-2 Pool deaths matched to pools with no deaths <10 years USA	Incidence of drowning deaths in residential swimming pools (N=146) matched to pools with no drowning (1:5) between 1 January 1990 and 31 December 1995. Cases stratified to age and location for comparison that included housing and property characteristics.	Whether a pool fencing ordinance was in effect when pool was built and the effect on pool drowning fatalities.	Outcome: incidence of fatal pool drowning. Exposure: presence or absence of pool fencing ordinance when pool built or altered. Other: Demographic and other potential confounders also investigated.	Pool fencing ordinances and drowning not significantly associated RR=1.27 (95% CI 0.72 to 2.25)*. Incidence rate 1.77/100 000/year 1–9 years for fatal drowning. 1–4 years 3.61/100 000 81% of all drowning occurred in pools in areas regulated by pool fencing ordinances. Possible explanations: ineffective building codes for pool isolation, insufficient ordinance enforcement and/or inadequate operation or maintenance of fencing equipment by pool owners. Ordinance did not specify four-sided fencing. Other risk factors: Positive associations were observed between drowning and: Age 1–4 years; male; ethnicity (Hispanic/Latino and white non-Hispanic); summer season; high and medium pool density; low parental education; high family income (none significant in adjusted analyses).
Pitt and Balanda [21] Domestic pool drowning (fatal and non-fatal) and the effect of pool fencing				
Case–control population-based Evidence level: III-2 Domestic pool fatal and non- fatal drowning and pool fencing 0–13 years Australia	Risk of drowning in fenced or unfenced pool calculated through ratio of immersions to fenced and unfenced pools. Immersion cases (n=139) presenting to ED July 1984–June 1989. Controls (n=204) randomly selected from Home Safety Survey conducted in July 1989. Stratified by existence of pool fencing. Drowning death certificates accessed for 1984–1989.	Pool fencing defined as four-sided vs unfenced/three-sided. Survey of pool fencing conducted by interviewers on-site. Telephone interview for retrospective pool/patient information.	Outcome: fatal and non-fatal drowning Fatal and non-fatal drowning where unintended pool access was gained. Exposure: fenced vs unfenced pools. Pool type: above ground, in ground and spas. Fencing configuration: 4-sided vs unfenced, which includes three-sided fencing. Incidence rates calculated for drowning in different pool types.	Compared to fenced domestic pools: RR=3.76 all unfenced domestic pools (95% CI 2.14 to 6.62)† RR=4.10 unfenced in-ground pools (95% CI 2.11 to 8.00)† RR=4.30 unfenced above-ground pools (95% CI 1.09 to 16.97† Incidence rates: Overall 0–13 years fatal and non-fatal 3.3/100 000 Non-fatal 0–13 years 15.5/100 000. Non-fatal 1–3 years 64.9/100 000. Other descriptive risk factors 71% child and family unfamiliar with hazard; 28% of children granted access. 0–13 years: 72% of drowning locations in domestic pools; 72% of all pool drowning cases had unintended pool access 1–3 years: 89% of pool drowning;

*No association and not statistically significant.
†Statistically significant association. ED, emergency department.

vests (personal flotation devices (PFD)).[17] Even though a specific prevention intervention and age group were targeted in this study, the programme was delivered to the entire population of the county.

Swimming and water safety lessons

Swimming and water safety lessons (table 2) have been proposed as possible prevention strategies for drowning as they provide children with the required skills and knowledge to keep themselves safe or remove themselves from danger. The included studies[16 18] examined the effect of swimming and water safety lessons.

The effects of formal or informal swimming lessons on drowning risk were examined in a case–control study.[18] The results of this study indicate that prevention skills can be learned in young children aged 1–4 years, through formal instruction for swimming lessons, but the apparent protective effects did not extend to infants or older children aged 5–19 years. The second study, by Asher et al[16], was a study where children were randomly assigned to either 8 or 12 weeks of swimming lessons, but had no control group. This study also provides evidence that swimming lessons can improve swimming ability in young children (aged 2–3 years). However, with no control group in this study, it is possible that the effect can be explained by water familiarity rather than improved skill level. Little detail was provided regarding the composition and duration of swimming lessons in the case–control study, so it is not possible to determine whether the two studies were comparable.

A further limitation of the study by Asher et al[16] was that no children younger than 2 years took part, yet these children are at high risk for drowning and are often targeted for such aquatic programmes.[24] Other limitations such as a lack of a control group, volunteer bias (towards higher socioeconomic strata and incentive payments), simulated risk as a proxy for drowning (ethically this is difficult to validate), a relatively small sample size (109 participants) and short duration (12 weeks) with no long-term follow-up for sustained skills or negative effects (such as over confidence) mean that results should be cautiously considered. Benefits of training must be viewed in the context of age of the child, particularly when pool deck behaviour (and the risk of falling in) was not affected as positively. Swimming and water safety skills were acquired more easily than behaviour change; however, reliability or sustainability was not tested.

The study by Brenner et al[18] should also be considered in the context of its limitations, including small sample size, a small proportion of children 1–4 years who had participated in swimming lessons, volunteer bias, potential measurement bias because of difficulty in contacting next of kin for cases and quality of information when obtained. However, the study did attempt to control for known confounders such as age, race, education, income and medical condition.

Pool fencing

In HIC, pool fencing (table 3) is proposed as an intervention to prevent children from drowning in home swimming pools by restricting access to the pool.

Two case–control studies (one US and one Australian)[20 21] examined the effect of pool fencing on drowning. The studies had conflicting results due to differing outcome measures. Pitt and Balanda[21] measured the role that fencing plays in preventing drowning, while Morgenstern et al[20] measured the effect of pool fencing ordinances, rather than fencing itself. The protective effect of pool fencing has previously been shown[25] to only protect young children aged less than 3 years from gaining unintended access. However, both these studies included children who were older and who were presumably able to gain access to a pool even if a fence were in place. Both of these studies found that toddlers aged 1–4 years were most commonly involved in pool drowning deaths. In the USA, the pool death rate for children aged 1–4 years was 3.6 per 100 000; and in the Australian study for children aged 1–3 years, it was 4.8 per 100 000. Morgenstern accessed coroner's data to measure drowning deaths, while Pitt and colleagues accessed data for fatal and non-fatal drowning events to describe the involvement of access to domestic pools in drowning in Brisbane City South.

In the Brisbane study, cases were fatal and non-fatal drowning incidents in the City of Brisbane presenting to the ED of one of the children's hospitals (where 'immersion' presentations were commonly admitted for observation). Deaths were validated through Registry records. Interviews were conducted with parents to ascertain pool fencing details. Controls were recruited from a Home Safety Survey conducted by the Australian Bureau of Statistics (ABS), where on-site inspections of 204 randomly selected homes with pools provided details of pool fencing. The sample population for cases and controls differed somewhat, as the cases were from Brisbane South and the controls from greater Brisbane City, which included Brisbane North. An assumption was made that fencing would be similar on both sides of the city. In this study, four-sided pool fences were more effective (RR 3.76 95% CI 2.14 to 6.62) than unfenced or three-sided fenced pools. The authors acknowledged that the effectiveness of four-sided fencing is limited by whether a functioning self-closing gate is fitted, as all children with unintended access did so through an open gate or house door.

Conversely, Morgenstern et al[20] used a combination of retrospective cohort study and case–control design to measure the effect of pool fencing ordinances on childhood drowning deaths using the same population and the same timeframe in Los Angeles County. Coroner's data were accessed to identify cases and estimate a fatal drowning rate in children <10 years. Cases were matched to five control pools (identified by a private firm of county records) where drowning did not occur. The measure of exposure for the case–control analyses was whether a pool fencing ordinance was in effect where the pool was located rather than pool fencing itself. In this study, overall drowning rates were not lower in pools regulated by fencing ordinances (OR=1.27; 95% CI 0.72 to 2.25). The passing of legislation had not lowered drowning risk on its own. The confounding effects of community campaigns and household characteristics were not ruled out. The study did compensate for the non-retrospective nature of some ordinances by restricting the control sample selection to pools built before 1996; however, the study did not document the presence or configuration of the fencing in existence to test the level of enforcement. Isolation fencing (four-sided) was also not a requirement under the ordinances, which is a factor that the Brisbane study has highlighted as important.

Quality assessment

Methodological limitations of the included studies are presented in the 'Results' section. Overall, there was a lack of consistency in the ages targeted for study, which makes comparative analysis difficult. For intervention studies, measures of effectiveness are challenging as none of the included studies reported results based on objective morbidity or mortality reduction figures and none reported significant changes, primarily because numbers were

too small to definitively assess between-group differences. While objective data were included in four studies, most of the reported analyses relied on self-reported knowledge, attitudes and behaviour. Because fatal drowning incidents are infrequent events, including non-fatal data provides greater numbers to make statistical analyses and evaluations more reliable. Such data can facilitate evaluation of population-level interventions by providing an objective measure of drowning. Intervention studies were limited by short follow-up time preventing capacity for studies to demonstrate sustained effects of the intervention as well as measurement bias associated with self-reported data, recall bias and lack of consideration of relevant confounders. Importantly, studies on interventions and risk factors did not use consistent measures of exposure data. When exploring the effectiveness of pool fencing, exposure information is essential—such as accurate numbers of pools, numbers of dwellings, presence of children in dwelling and the presence of pool fencing, configuration and status.

A consistent definition of drowning has been formalised along with recommended guidelines for uniform reporting of data from drowning[26 27] The terms fatal and non-fatal drowning are used here in preference to immersion, submersion, drowning and near drowning. It is important that future studies use these guidelines for clarity and comparability in scientific communications, particularly when discussing fatal and non-fatal incidents. Consistent use of other terminology such as 'swimming ability' and 'learning to swim' highlights the need for standardisation of terminology. We were unable to determine whether included studies that investigated swimming lessons as an intervention employed the same definition, making comparison difficult.

Excluded literature

Twenty-eight studies excluded from this systematic review did not fulfil the selection criteria, principally due to study design and/or other methodological limitations. There were a wide range of other strategies described that proposed to reduce drowning deaths. Interpretation of their findings must be undertaken with caution because of methodological limitations. There is little or no evidence provided that any are effective in relation to reduction in drowning deaths and reinforces the need for well-designed, controlled studies where interventions are implemented. Risk factors identified in these articles are also reported (box 1).

DISCUSSION

Drowning continues to be a significant public health challenge globally. While there have been a large number of published studies exploring drowning and possible prevention solutions, there is a dearth of large population-based studies that produce high levels of evidence. This systematic review analysed studies of drowning over a 30-year period; however, it was not until 2005 and that a universal definition of drowning was developed that has limited our ability to compare studies.[27]

The seven studies that met our inclusion criteria explored the drowning prevention interventions associated with education, swimming ability and pool fencing. What is clear is that child drowning is a significant issue, especially for children aged less than 5 years. There is very little information about the older adolescents aged 15–19 years. Each of the intervention strategies has some impact on reducing drowning deaths with the strongest evidence coming from pool fencing. This is consistent with Haddon's Hierarchy of Control, where restricting the child's access to water is higher in the hierarchy.[56 57] However, no one strategy is independently effective in preventing all drowning.

Interventions

Education

Few studies reported results based on morbidity or mortality reduction figures. Most relied on self-report evaluations rather than independent observations of behaviour change[17 19 22] potentially creating bias. The short time period between the intervention and postintervention evaluations may have contributed to high recall scores and has limited any capacity to demonstrate whether the effects were sustained for any length of time. It is also possible that control group participants were exposed to drowning prevention information from other sources in the community or media, which could have improved their knowledge as much as the intervention groups. One study did not include a control group, limiting ability to definitively attribute any observed changes to the intervention.

While none of the studies on education interventions was conclusive, each of the three studies provided some evidence that education may have some effect. Success was attributed to education interventions that were (a) specific in their content and targeted in their reach, (b) delivered in settings appropriate to the target age groups, (c) contained information tailored to the specific injury type and (d) safety devices were provided. Increased overall safety behaviours were attributed to the provision of safety devices, but their use for drowning prevention was not easy to measure, with non-slip bath decals and PFD incentive/loan schemes inconclusive. Recent meta-analyses[58] support education as being effective, along with providing or discounting sales, on safety devices. In contrast to the successes stated above, interventions delivered in the home rather than clinical settings reduced injury, and meta-regression indicated that interventions may not necessarily need to be tailored for specific groups based on some socio-demographic factors.

Education interventions need to be considered in the context of feasibility of delivery in the setting. Commonly cited barriers to prevention in the primary care setting are time pressures on staff that prevent proper counselling; too much information being covered at one time on various injuries or that a parent may be consumed with the more pressing or acute problems associated with their visit to the primary care setting.[22] Studies such as these and those delivered in the home are labour intensive in their delivery and usually require trained staff to counsel or educate on an individual level. Smaller populations, longer timeframes and information on intensity of delivery could allow for greater understanding of effectiveness. Settings-based analyses or interventions that are appropriate to readiness (or stage) of change[11 56] may help to better define the audiences and appropriate education strategies for intervention.

Swimming lessons and water safety

These studies provided some evidence to show that swimming lessons improve swimming ability in children aged 2–4 years and most importantly do not place a child at increased risk of drowning. However, there is no evidence as to whether this is a sustained or enduring skill nor whether it is transferable to various aquatic settings. It is also not a viable intervention for children under 2 years old as swimming lessons in this age group is unproven.[59] Children in older age groups who can swim still drown, so while swimming ability can improve, this is an adjunct preventative intervention not a solution on its own. This area of research requires methodology that builds on that used in the studies used in this review, including measurable criteria for what a formal swimming lesson entails, participation, retention of skills and importantly those 0–2 years old who

Box 1 Interventions and risk factors discussed in studies that did not meet eligibility criteria

Interventions
- Pool fences (including legislation/proper installation/inspection)[28–40]
- Water safety education[33 35–37 39 41–48]
- Increased supervision[30 33 37 39 44 49]
- Swimming lessons for children[33 39 44 46 49 50]
- Cardiopulmonary resuscitation knowledge[28 30 33]
- Alcohol (reducing drinking age/limiting use)[51 52]
- Wearing life vest and lifeguard presence[36 53–55]

Risk factors
- Age group 0–4 years[28 32 34 37 43 49 55]
- Young age up to 10 years[30 44 50]
- Masculine gender[39 41 50]
- Ethnicity (indigenous/immigrants/tourists)[36 44 50]
- Lack of supervision[36 46 49]
- Pools[34 35 37 39 55]
- Pool fencing (lack of or inadequate)[35 38]
- Bathtubs[37]
- Dams/ponds/rivers[32 39 49]
- Sea/coast[50]
- Poor swimming ability[49]
- Summer season[32 37]
- Alcohol and adolescents[28 41 52]

undertake water familiarisation classes. Acquiring water safety skills is achievable by younger children; however, the average time taken to achieve these skills from the start of the formal lessons increases with the decreasing age of the child.[60]

Pool fencing

Pool fencing can restrict children's access to water; however, the fencing needs to be well maintained with an operating self-closing, self-latching gate; and when children are in the pool space, supervision and aquatic skills are required. Organisational change (at government level) is necessary to improve safety behaviour beyond the mere passing of safety laws. The success of the legislation is dependent upon it containing evidence-based building codes and standards,[20] four-sided isolation fencing that limits access from the house,[21] inspection regimes that ensure maintenance of fencing and dynamic gates[21] and retrospective application so that all types of pools (no matter when constructed) are captured within the legislation.[20]

There is less evidence to support the use of pool fencing for preventing non-fatal drowning incidents. Only one study[21] included non-fatal drowning cases in analyses. Better quality studies are required to demonstrate the efficacy of pool fencing to reduce non-fatal drowning.

Not surprisingly, the density of swimming pools has been found to contribute to the rate of drowning[20] as it is a proxy for exposure, and children are also more likely to drown in their own pool. It is important to note that in rare studies where detail is available[21] there were no cases where a child was known to have scaled a fence to gain access to a pool.[11 21] It is inevitable that as more pools use four-sided fencing and have secure gates, the phenomenon of children climbing fences or actively gaining access will occur and present challenges for prevention. Work conducted in the late 1970s by Nixon[25] found that 80% of children aged 2 years (the modal age for drowning) could not climb a 60 cm fence. However, 20% of 3 year olds could climb a 1.2 m barrier, which is the recommended minimum height of a pool fence. Regardless of the height, the time required to cross the barrier decreased as the child's age increased, with a mean range of 16–9 s for children aged 4–9 years to cross a 1.2 m barrier. This emphasises that pool fencing for this age group is a time-delaying mechanism and therefore cannot replace active supervision.

The effect of legislation on injury rates can only be measured by up-to-date and reliable surveillance, which includes pool numbers and the presence and status of fencing. Data collected should include the sequence of events leading to drowning, pool density, exposure and fencing configuration in place.

Methodological limitations that limited validity and reliability of the included studies' findings were discussed in the 'Results' section. Interpretation of findings must be used with caution. Meta-analyses were not appropriate due to heterogeneity in study designs, interventions and measures. The validity of conclusions from any systematic review depends on the evidence level of the included studies. In this case, many of the studies reviewed were limited in their ability to draw conclusions due to differences in methodology and definitions. The paucity of studies may be due to our search strategy, which excluded grey literature and papers not published in English. It is also possible that the included studies were not representative of all studies that have been conducted on this topic because of publication bias. Five of the seven studies were conducted more than 10 years ago, and so their currency is questionable.

Clearly, methodologically sound studies on evaluation of interventions are much needed in this area. Studies should employ appropriate study design, comparable control groups, use objective and reliable measures (including morbidity and mortality data where appropriate), sufficient sample size, be of sufficient time period, use consistent definitions and include an accurate measure of exposure. Such methodological improvements will allow definitive intervention evaluation and identification of risk factors. This will inform prevention strategies, and ultimately, reduce drowning in children.

Future interventions and strategies will predictably be affected by funding and need; however, expertise and collaboration between low and/or middle income countries (LMIC) and HIC is encouraged to employ rigorous methodology to achieve repeatable outcomes and high levels of evidence.

CONCLUSION

Few studies employ rigorous methods and high levels of evidence to assess the impact of interventions designed to reduce drowning. Seven studies met the inclusion criteria and demonstrate that interventions such as education, pool fencing and swimming and water safety are possible effective strategies to prevent children from drowning, particularly those 2–4 years of age. There were a number of promising studies identified that did not meet the inclusion criteria. Future research could validate the potential prevention strategies around many of these, such as cardiopulmonary resuscitation training and wearing of PFDs. Drowning is a significant public health challenge globally, and there is a need for rigorous, well-designed studies that use consistent terminology to demonstrate effective prevention solutions.

What is already known on the subject

The first four years of life are the most vulnerable for drowning; the risk increases with increasing mobility of toddlers.

What this study adds

- This review reports on interventions for drowning prevention across the age spectrum of children and adolescents up to the age of 19.
- Evidence-based strategies for reducing drowning in high-income countries are pool fencing, swimming and water safety lessons, and targeted education campaigns.

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CH 3: METHODS

CHAPTER 3: METHODS: MAPPING THE PATIENT JOURNEY THROUGH LINKED DATA FROM DROWNING RETRIEVAL TO DEFINITIVE CARE

3.1 CHAPTER CONTEXT

Chapter 3 addresses Objective 2 which is to identify relevant data sources, access and compile a composite dataset of fatal and non-fatal drowning in Queensland. The systematic literature review (Chapter 2) revealed very few interventions or case studies with rigorous evaluations or methodological quality. There is a lack of population-based studies of sufficient quality including relevant information on the true magnitude of fatal and non-fatal drowning, and more specifically, on the circumstances leading to the event. To fill this gap, patient data from multiple portals across the continuum of care were linked to collate comprehensive data on fatal and non-fatal drowning episodes in children aged 0-19yrs in Queensland for the years 2002-2008.

The process of acquiring and linking the data is presented in this chapter to set the context for the drowning dataset analyses which follow in later chapters. The significance of this multi-portal approach is illustrated by the fact that of some 3,000 total cases extracted, the 1299 unique cases was approximately 75% more than if only admitted patient data had been retrieved.

This is the first study on drowning to highlight the drowning process which can result in death or survival,[1] [2] and also reveal the true drowning burden which is understated when only fatality data are counted. Data have been linked comprehensively across the continuum of care and allow mapping of the 'patient journey' from rescue to recovery or death. Data provide antecedent information, the physiological effects of the drowning process, and an aetiology of fatal and non-fatal drowning events in Queensland children 0-19yrs.

3.2 CASE DEFINITION

The urgency of a drowning event usually begins with attendance by emergency services (ambulance), although some will go directly to hospital by some other means. Some will receive an ambulance response only; others will be transferred to emergency, and either treated or admitted to hospital. Some of those will be declared dead on arrival at the emergency department, and subsequently transferred to the mortuary. Those who are not able to be revived at the scene will be transferred to the mortuary with no involvement in the hospital system apart from a post mortem examination. All along this patient journey, data are collected by each agency involved in the rescue. Cases were included if they appeared in any one of these databases as described in Chapter 1.6 Theoretical framework and rationale.

The definition of drowning was described in Chapter 1: "Drowning is the process of experiencing respiratory impairment from submersion/immersion in liquid" … resulting in death or survival; this is further qualified by excluding "a water rescue case" (i.e., where "events in which no respiratory

impairment is evident …").[1 2] In this study it was assumed that if medical assistance was sought, that respiratory impairment was evident.

For this study, cases were defined as all fatal and non-fatal drowning episodes in children and young people aged 0-19yrs inclusive, where the drowning episode occurred in Queensland and within the time frame January 2002 to December 2008. **Fatal drowning** was defined as death resulting from a submersion incident. This may have been at the scene, at hospital (without discharge from hospital), or where life support was terminated. **Non-fatal drowning** cases were those who experienced a submersion incident involving some degree of respiratory impairment, and did not die as a consequence of the event.

3.3 DATA SOURCES

Data were obtained separately from each data source through direct contact with each custodian. **Table 3-1** summarises the data sources, custodians, and parameters for data extraction. A case was included if it appeared in any of the databases interrogated**,** provided it met the search (extraction) criteria.

Table 3-1 Data sources, data custodians, data scope, extraction criteria, and data coverage

Pre-hospital, Hospital Emergency and Hospital Admission	**Data Scope**	**Criteria for data extraction** **Jan 2002 – Dec 2008**	**Data coverage**
Queensland Ambulance Service (QAS) https://ambulance.qld.gov.au/research.html (Accessed Oct 2014)	Fatal and Non-fatal Pre-hospital Queensland	Case nature = drowning; eARF=0-19yrs; AIMS=all ages†	Information regarding all patients attended by QAS; data includes clinical information (vital signs) treatment administered by QAS or bystanders (e.g. CPR), facility and transfer details, and details of incident (location, events leading to)
Queensland Injury Surveillance Unit (QISU) http://www.qisu.org.au/ModCoreFrontEnd/index.asp?pageid=109 (Accessed Oct 2014)	Fatal and Non-fatal Emergency Admissions 25% of Queensland (a)	Nature of main injury = drowning and submersion; age=0-19yrs; principle diagnosis codes T7.51; Injury cause=11 & 12.	Emergency presentations to 20 hospitals (a); data includes demographic, attend and injury dates and times, transport, mechanism, activity, location, and triage notes.
Emergency Department Information System (EDIS) Hospital Access Unit, Queensland Health http://www.health.qld.gov.au/research-reports/data-requests/default.asp (Accessed Oct 2014)	Fatal and Non-fatal Emergency 67% of Queensland (b)	ICD10 T751 Drowning and non-fatal submersion; ICD10 W65-W74; age=0-19yrs	Emergency presentations to 101 hospitals with average 18,200 patients per year(b); data includes demographic, attend and departure dates and times, transport, diagnosis, and triage notes.
Surgical and Retrieval Team (SATR) Hospital Access Unit, Queensland Health http://www.health.qld.gov.au/research-reports/data-requests/default.asp (Accessed Oct 2014)		ICD10 T751 Drowning and non-fatal submersion and ICD10 W65-W74; age=0-19yrs	
Queensland Health Admitted Patients Data collection (QHAPDC) Health Statistics Centre http://www.health.qld.gov.au/research-reports/data/	Fatal and Non-fatal Admission Queensland	Principle Diagnosis/Other Diagnosis = ICD10 T75.1 Drowning and non-fatal submersion; age-0=19yrs OR where external cause code included V90, V92, W65-W70, W73-W74, X37-X38, X71, X92.	Admitted patients from all public and private hospitals in Queensland; data includes demographics, procedures, activity, location, transport, and presenting problem text.
Mater Health Services (MHS) (children and adults) Business Practice Improvement http://www.mater.org.au/Home/Services (Accessed Oct 2014)	Fatal and Non-fatal Emergency Admission Queensland (c)	Diagnosis description = Injury or Trauma including non-venomous bites drowning or near drowning 994.1; or Diagnosis = ICD10 T751; Drowning and non-fatal submersion); age=0-19yrs	Emergency presentations to Mater Children's and Adults' Hospitals; data includes demographics, attend and departure dates and times, diagnosis description text.

Fatal drowning data	Data Scope	Criteria for data extraction	Data coverage
National Coronial Information System (NCIS) http://www.ncis.org.au/how-to-access-data-on-the-ncis/ (Accessed Oct 2014)	Fatal Queensland 0-19yrs	Queensland jurisdiction; "Threat to breathing and downing and immersion" and string searches "drown*" and "immersion" and various truncations and misspellings ("dorn" "dron" "imer"; year of death 2002-2008 inclusive	All Queensland deaths. Includes coroner's findings, police investigation reports and toxicology reports; data includes demographics, cause of death, location information.
Commission for Children and Young People and Child Guardian Child Death Review Unit (CCYPCG)‡ http://www.qfcc.qld.gov.au/contact-us info@qfcc.qld.gov.au	Fatal Queensland 0-17yrs only	Death registered as drowning; 0-17yrs; Year of death 2002-2008 inclusive	**Fatality data up to 17yrs**: Includes Coroner's data, death registration, police report and other information specific to mechanism
Royal Life Saving Society of Australia (RLSSA) http://www.royallifesaving.com.au/contact-us	Fatal Queensland 0-19yrs	Drowning data for Queensland year of death 2002-2008 inclusive, 0-19yrs	**Fatality data:** Includes Coroner's data, ABS data; member reports, details of rescues, and media reports

†CCYPCG has transitioned to the Queensland Family and Child Commission (QFCC) from 1 July 2014.
‡eARF (Electronic Ambulance Report Form 2007-2008) and AIMS (Ambulance Integrated Management System 2002-2006)
(a) During the data collection period 20 hospitals contribute data to QISU which approximates 25% of the state. Note that QISU did not collect data from the same 20 hospitals throughout the data collection (e.g., some hospitals may have stopped contributing data for some time periods, and others may have started), and not all hospitals contributed data to QISU for the 7 year study period.)
(b) In 2008, there were 150 hospitals in Queensland with an average of 86,700 patient presentations per year. There were 101/150 in Queensland who operated with an electronic data system seeing an average of 76,300 patients per year. 12% of patients attend hospitals without electronic ED systems.
(c) Mater Health Services (MHS) data covers public and private hospitals in Brisbane and environs servicing approx.45,000 ED child presentations/year and 37,000 Adult presentations per year. Of 5 hospitals 2 are children's hospitals, and 3 adult (two private and one public). Mater Children's Hospital provided data for children 0-17yrs inclusive. Mater Adult Hospital provided data for adolescents 18 and 19yrs inclusive. Approximately 23% of child admissions are through ED, and 27% of adult admissions.
*QISU & MHS data were matched against three datasets – emergency, admitted and fatal.

3.4 ETHICS AND CUSTODIAN APPROVALS

Ethics approval for this research was obtained from the following human research ethics committees:

Children's Health Queensland (CHQ - (formerly Royal Children's Hospital) Human Research Ethics Committee HREC/09/QRCH/38
Institutional Approval from the Children's Health Services District at Royal Children's Hospital (RCH)
University of Queensland Medical Research Ethics Committee #2009001463
Mater Health Services Human Research Ethics Committee #1446E; Mater Adults Hospital and Mater Children's Hospital #1446E
National Coronial Information System #CF/07/13729 (2007-2010), #CF/10/25057 (2010-2013), #CF/13/19798 (2013-2016).

Approval was also required from the following data custodians:

Director General approval was granted for access, extraction and linkage of identified data without consent through Public Health Application (PHA), Queensland Health 16/3/2010 Ref RD002254 in consultation with custodians QHAPDC and QISU (Health Statistics Centre), and EDIS SATR (Health Access Unit).
Royal Life Saving Society Australia (RLSSA)
Commission for Children and Young People and Child Guardian (CCYPCG)
Queensland Injury Surveillance Unit (QISU)
Health Statistics Centre, Queensland Health (QHAPDC)
Hospital Access Unit, Queensland Health (EDIS, SATR)
Queensland Ambulance Service (QAS)

3.5 DATA LINKAGE

Data were received from custodians in Excel format, and linked manually using a number of variables from all data sources, principally name, address, date of birth, medical record number, sex, facility name, and date of incident/presentation/transfer (or any combination of these variables) using Excel and FileMaker. Using the identifiers described above, data were first collated into three separate datasets: Pre-hospital and Emergency; Hospital Admissions; and Fatality. Each of the fatality datasets was cross-matched, manually reviewed for

duplicates and merged; each of the Pre-hospital and Emergency datasets was cross-matched, duplicates removed, and merged. Finally, these two datasets (Pre-hospital & Emergency and Fatal) were cross-matched and merged with the Admitted Patients dataset to create one main data set. Data were then scrutinised to ensure that each individual row of data represented a unique presentation relating to one drowning incident. This means of collection allowed us to track at what point the person entered or left the patient system, and what services were utilised in the treatment of the drowning episode. This strategy for the data linkage is illustrated in **Figure 3-1**Figure 3-1 Strategy for data linkage (acronyms described in Table 3-1)**.**

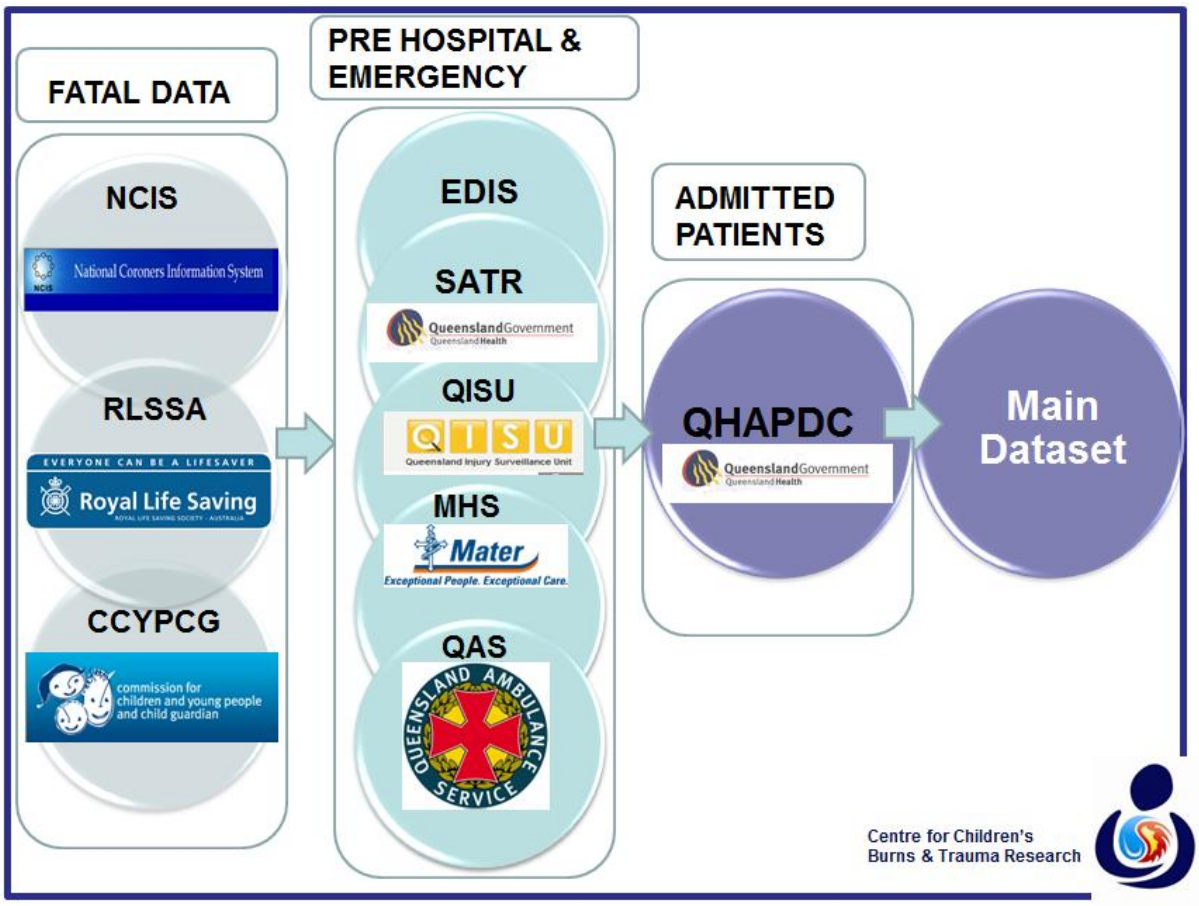

Figure 3-1 Strategy for data linkage (acronyms described in Table 3-1)

Identified data were linked manually for each unique drowning event over the time period to collate comprehensive detail across the continuum of care. Five researchers, were responsible for merging and linking the data using Excel and FileMaker.

Due to the urgency and relative rarity of a drowning event on any given day, a patient generally requires transportation for medical intervention immediately after the event. Consequently any disparity in time/date of presentation, facility, or any duplication of any these variables were highly unlikely and a match was not difficult to confirm. The manual data linkage process ensured that the other identifiers such as date of birth, address, medical record number, and sex were able to be linked where a name may have been spelled differently in the different data sets.

Few difficulties were encountered in linking and matching identified data with overlapping variables between datasets, and discrepancies between two entries with differing data (e.g. address and postcode) were resolved by allocating a hierarchy to databases. Each case did not necessarily appear in all datasets. A case was included if it appeared in any dataset, provided it met the search criteria and included age. Included cases were categorised as pre-hospital, emergency attendances or admissions if they were present in any of these databases, but were only included once (Figure 3-3). Transfers between hospital facilities were excluded. The final dataset comprised unique drowning events during the study period.

Narrative text was reviewed manually to extract additional information about the drowning event. It was beyond the scope of this study to validate coded data, (i.e., conduct analyses regarding the quality, completeness or consistency of variables), or to describe methods for

automated text extraction. The drawbacks and benefits of many other approaches to using linked data are reviewed elsewhere.[3] This approach was intentionally used to provide a more complete picture of drowning incidents, and through additional information show the way forward with informed injury prevention strategies.

Strengths and Limitations:

The drawback to data linkage was the time taken to gain access and acquire the data which for this project was 18 months in all, and a further six months to obtain all the data. This barrier is not unique to this project as other researchers have found.[4 5] Ethics approval from specific research committees was gained, however to acquire access to the data, approval of a Public Health Application was required by the Director General of Health. This process required negotiation with individual custodians, and further ethics, privacy and confidentiality procedures to be adhered to before data could be accessed. At the time of this project there was no data linkage unit in place in Queensland Health, so data were obtained and linked manually. There are now procedures in place through the Health Statistics Unit to acquire data (see Appendix 2).

Table 3-2 shows identified data collected. This included: name, address, date of birth, medical record number, sex, facility name, date of incident/presentation/transfer, mode of arrival, and discharge status. Each case did not necessarily appear in all data sets.

Studies using linked data have integrity if as many portals as possible are interrogated for case ascertainment. In this study seven data custodians were approached to access 12 different databases to extract data. This represents all relevant data sources that contain

information on child drowning events where medical attention was sought in Queensland during the study period. (Many custodians had two or more databases to interrogate).

Table 0-1 Linked data extract (showing overlap) from each custodian for demographics and treatment variables

Table 3.5.1: Linked data (showing overlap) from each custodian for Demographics and Treatment variables						
DEMOGRAPHICS						
QHAPDC_QH*	**SATR_QH**	**EDIS_QH**	**QISU_MHS_QH**	**MHS_(MCH & MAH)**	**QAS_(eARF & AIMS)**	**NCIS INC RLSSA**
SURNAME	SURNAME	Present Name Surname		PATIENT SURNAME	T_FAMILY_NAME	Name
	Given Names	Present Name First		PATIENT FIRST NAME	T_GIVEN_NAME	
					T_MIDDLE_INITIAL	
ADDRESS	Address	Present Street Address Line 1			T_STREET_NAME	
SUBURB	Suburb	Present Suburb		SUBURB	T_SUBURB_NAME	Residence Location
POSTCODE	Pcode	Present Postcode	POST_CODE	POSTCODE	T_POST_CODE	Post Code (UR)
UR	UR	MRN - Medical Record Number	UR_NUMBER	PATIENT UR	QAS_PIN	
DOB	DOB	Present Date Of Birth	DOB	DOB	D_BIRTH	
AGE AT ADM	Age	Present Age in Years	AGEYR		N_ACTUAL_AGE_YEARS	Age
			AGEMTH			Age Unit
			SEX-code			
SEX	Sex	Present Gender	SEX_DEF	GENDER	T_GENDER	Sex
INDIG STATUS CDE	Indig Status_code	Indigenous Status Code	INDIGENOUS_CODE			
INDIG STATUS	Indig Status_desc	Indigenous Status Desc.	INDIGENOUS_DEFINTION	ETHNICITY		Indigenous Origin
STHSEA_ISL						
COB CODE		Country Of Birth Code	COUNTRY_CODE			
COB	COB	Country Of Birth Desc.	COUNTRY_DEFINTION	COUNTRY OF BIRTH		Country (birth)
		Country of Residence Desc.				
MEDCR ELIG		Insurance Status Desc.				
SLA						
SLA NAME						
SLA VERSION						
ARIA	*Post code of location***	*Post code of location*	*Post code of location*	*Post code of location*	*Post code of location*	*Post code of location*
ARIA Desc	*Post code of location*	*Post code of location*	*Post code of location*	*Post code of location*	*Post code of location*	*Post code of location*
SEIFA Decile	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*
SEIFA Decile 06	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*	*Post code ur as above*
			LANGUAGE_CODE			
LANGUAGE			LANGUAGE_DEFINITION	LANGUAGE		
TREATMENT						
FACILITY ID(AD)		Facility Code	HOSPITAL_CODE			
FACILITY NAME(AD)		Campus Desc.	HOSPITAL_DEFINITION			
DISCHG_STATUS	Visit Type_code					
DISCHG_STATUS_DES	Visit Type_desc	Type of Visit Desc	MODE_OF_SEPERATION_DEFINITION (copy)	VISIT TYPE		
FnyrAdm			year	DATE SEEN	D_CASE(date)	*YeardeathDoIncident*
					D_RECEIVED(time date)	
TFR_TO_FCLTY_ID	Facility Code					
Tfr to name	Facility	Transfer Destn. Hospital Desc.(EDtoAD)		*(MCH)*	T_TO_PROPERTY_NAME	
					T_TO_STREET_NO	
					T_TO_STREET_NAME	
					T_TO_STREET_TYPE	
					T_TO_SUBURB_NAME	
					T_TO_POST_CODE	
ARRVL_CDE	Ref Source_code	Referred by Hospital Desc.				
ARRVL_DESC	Ref Source_desc	Referred by Desc.		REFERRED BY		
ADM SRCE	Arrival Method_code	Mode of Arrival Code		TRANSPORTATION	*(QAS)*	
ADM SRCE DESC	Arrival Method_desc	Mode of Arrival Desc.				
			INJURY_DATE			
			INJURY_TIME			
ADM DATE	Arrival Date	Arrival Date Time	ATTEND_DATE	ARRIVAL DATE	OFF_STRETCHER(date time)	
	Arrival Time	Admitted At (ADtoED inc SSU)	ATTEND_TIME	ARRIVAL TIME	AT_DEST(date time)	
				TIME SEEN	COMPLETED(date time)	
ADM TIME						
TFR_FROM_FCLTY_ID						
Tfr from name						
*Refer to Table 3.4.1 for Custodian acronyms **Italicised type refers to data generated in-house						
Note: Algorithm for interpretation - if any record existed the data were recorded;						
if two/multiple records existed but differed, (eg adress, postcode) a hierarchy of databases was used 1.NCIS/CCYPCG (if fatal) or QHAPDC (non-fatal) 2.EDIS 3.SATR 4.QISU 5.MHS						

3.6 CASE CAPTURE

3.6.1 FATALITY DATA

NCIS, RLSSA, CCYPCG [n = 120]

The initial search of the NCIS system located 88 cases. An additional 16 cases were obtained through CCYPCG, and 16 from RLSSA. Case information was extracted from the National Coronial Information System (NCIS) for the period Jan 2002 to December 2008 for children and young people aged 0-19yrs, for all open and closed cases, using the search criteria shown in Table 3.1. Electronic searching of police reports, findings and autopsy reports is not available in Queensland; however where available, autopsy reports were accessed under *bona fide* researcher status. Cases that involved drowning but were due to trauma from watercraft, motor vehicle crash, or injury from diving, were not included (there were five of these cases). Cases where no body was recovered were included where sufficient detail was recorded. Cases identified as self- inflicted harm or assault were included. Case information was sometimes incomplete or unknown because a) the case was open and enquiries were still proceeding (7 cases as at 30 Oct 2011); b) the person was alone at the time of drowning; c) the Coroner was unable to make a ruling on circumstances surrounding the death; d) the body was not recovered; or e) residential address was not able to be determined. RLSSA member reports and media monitoring were also used to obtain circumstantial information where relevant.

All identified cases were matched with information from the Royal Life Saving Society Australia (RLSSA) database for Queensland entries for the same years, and with data from the Commission for Children and Young People and Child Guardian for ages up to and

including 17 years of age. Crosschecking was possible through RLSSA which collect incidents from ABS, Coroner's reports, police reports, member reports, and the media.

It is impossible to know whether all drowning deaths have been certified and appear on the NCIS system. Whilst other data sources were used to fill gaps, it is possible that some drowning deaths occurred in 18 and 19 year olds between years 2002-2008 that have not yet been certified on the system.

3.6.2 PRE-HOSPITAL AND EMERGENCY DATA

QAS – [n= 835] - Data were extracted **(Table 3-1)** from the Ambulance Integrated Management System (AIMS) for cases from January 2002-December 2006, and from electronic Ambulance Report Form (eARF) for cases from January 2007-December 2008. There were 107 blank case rows where name was not provided or (occasionally) age or date of birth was not provided. Where this identifying information was not provided, call out date and time, location of pick up, date of birth, or incident number were used to match to other cases. In 47 cases more than one ambulance attended. In these cases, data from the primary transport vehicle was used because data recorded in the "backup transport" (second ambulance) entry contained duplicate data or no data. However, in all of these cases, entries were carefully compared to ensure that the most complete case information was obtained. If backup data contained information not included in the primary data, it was also merged. There were 43 inter-facility transfers where presentation (triage/ED) data were extracted.

In total, 40 cases were excluded. Two were non-drowning water incidents and for 38 cases, no identifying information was provided, and the available information could not be matched to date of birth or any other ED data for name, arrival date, gender; or against QHAPDC data

for name, date of arrival or hospital destination. If the age could not be determined, the case was excluded because it was not possible to be certain that the case fell within the required 0-19 yrs. Not all cases contained narrative text. Cases where patients died at the scene and not transported by QAS were not included in QAS data.

It is acknowledged that this method of ascertainment may not have captured all drowning cases transported or attended by QAS during the study period (i.e., it is possible that there are QAS records for some cases in the final dataset for which QAS data were not extracted because *drowning* was not recorded in the case nature field).

EDIS (n=335), **SATR/HBCIS** (n=616), **MHS** (n=119), **QISU** (n=206 35% ED) [**n=1276**]. Data extraction parameters are explained in **Table 3-1.** Raw data case ascertainment numbers and relevant cases are shown in **Table 3-3.**

Table 0-2 Case ascertainment by database

Custodian	Cases received from custodian[a]	All relevant cases	Matched unique cases
Pre-hospital			
QAS	1310	835	65
Emergency			
EDIS	335	335	
SATR/HBCIS	616	616	
MHS	222	119	372
QISU	228	206	
Total	1401	1276	
Hospital Admissions			
QHAPDC[c]	857	751	742
Fatalities			
NCIS/CCYPCG/RLSSA	125	120	120
TOTALS	3693[b]	2982[b]	1299

[a] Raw data case numbers as received - no exclusions. [b] Totals from separate databases do not tally to 1299, due to overlap in health service type use. A patient may have appeared on more than one database (e.g., QAS, EDIS, QHAPDC). c) Also includes Admitted cases from MHS and QISU.

QISU (n=206) (64% Admitted / 35% ED / 1% fatal) - QISU is a dedicated injury surveillance system, and collects injury information from emergency departments. In this study some emergency presentations were admitted to hospital or died so data were matched to these datasets as well. These data were not identified and were matched to the relevant datasets where possible. During the period 2002-2008, QISU collected data from 20 hospitals, and data from 14 of these hospitals is contained in the final drowning dataset. QISU did not collect data from the same 20 hospitals throughout the data collection (e.g., some hospitals may have stopped contributing data for some time periods, and others may have started), and not all hospitals contributed data to QISU for the seven year study period.

3.6.3 ADMITTED PATIENT DATA

QHAPDC [n=751] - There were 106 cases that involved re-presentation of the same child, either because of inter-hospital transfer or because of more than one episode of care for the same child (i.e., repeat presentations). In cases where the same child occurred twice in any dataset, each episode of care was carefully scrutinised to ensure that complete data were obtained. All dates (admission, discharge etc.) analysed for the final data set relate to primary episode of care. Additional variables were created for each case to document repeat episodes of care (dates, length of stay, primary procedures, and so on).

3.7 PATIENT FLOW & PATIENT CAPTURE

There are two outcomes from the linked data. Firstly, the capture of patients on each of the databases, and secondly, the patient flow as each case moves through the health care system. Together, **Figure 3-2** and **Figure 3-3** demonstrate the utility of linked data in relation to ascertaining drowning cases. Had data only been sought from the conventional data sources relating to hospital admissions and fatalities, the total number of cases would have been (751-46 deaths in hospital +120=) 825. That is, an additional 474 drowning incidents were captured by linking data across the continuum of care. This table also illustrates the importance of not relying solely on one data source relating to fatalities or (for example) emergency department presentations. Extracting data only from EDIS would have yielded 335 cases – this is approximately only a quarter (26.3%) of all drowning cases that presented to an emergency department in Queensland during the study period.

The pyramid on the right (Figure 3-2) is a typical injury pyramid showing the numbers of patients captured on each of the data bases and the duplication in record keeping of all data kept on drowning events, and how data would be skewed if episodes of care or linkage were not possible. However, when these episodes of care are linked to show individual cases and the highest level of care they received, the traditional pyramid gives way to an almost inverted shape with the largest burden being in admitted patients. It shows the health service usage that drowning episodes incur as patients move through the health system and receive various levels of care for drowning events. This is a good indicator of the severity of drowning, and the need for observation, hospitalisation, and medication. The pie chart shows the break-down of resource use for fatal drowning, with a high proportion of children dying at the scene or before reaching hospital admission.

The implications of fatal drowning being the least numbers of patients treated are significant in that this is all that is routinely collected in surveillance data. There has not previously been any indication of the burden on the health system of non-fatal drowning.

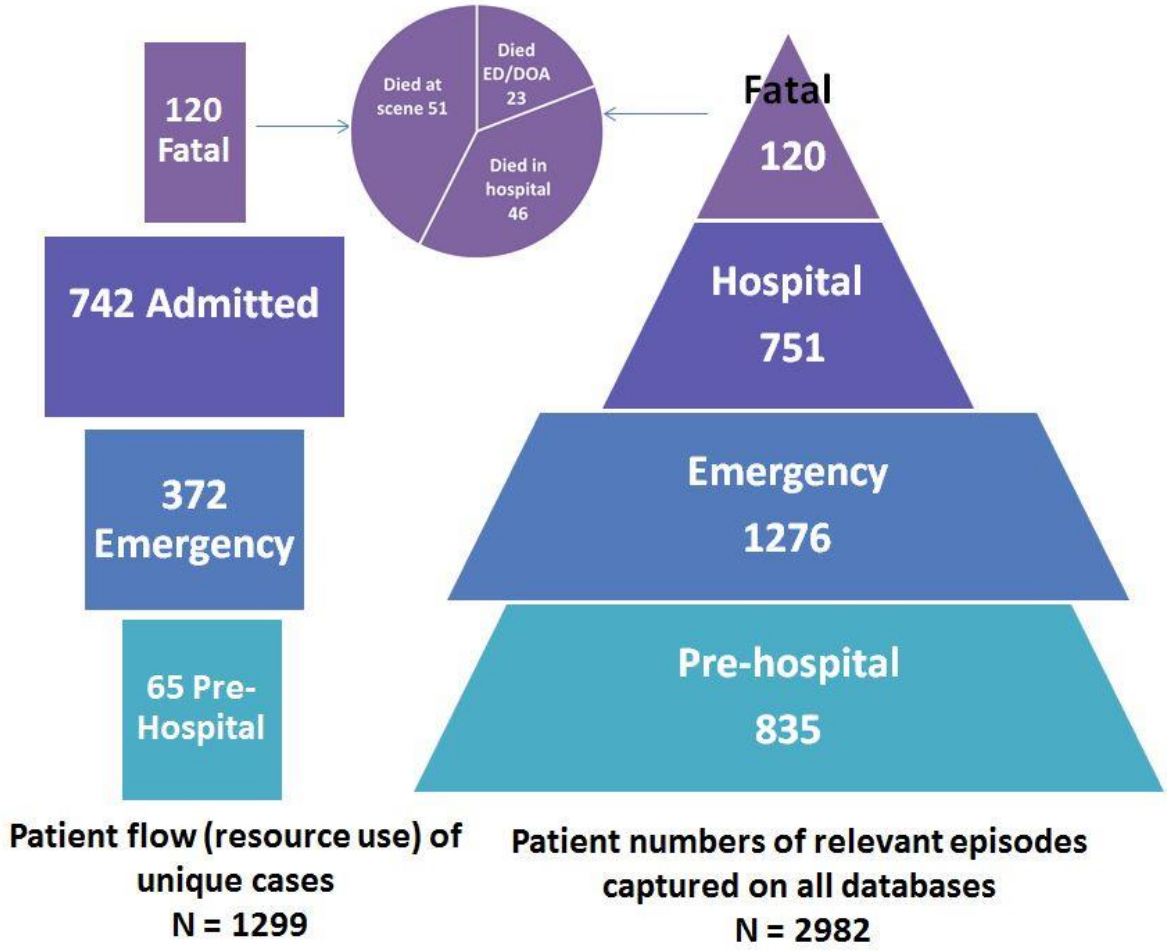

Figure 0-1 Drowning cases captured by each data source, and matched unique cases showing highest level of care Queensland, 2002-2008

Figure 3-3 illustrates the health service usage of patients from the point at which patients first came into contact with any form of medical treatment and how they transitioned through the various levels of care. This is a good indicator of the resources used for each of the 1299 drowning episodes who have generated 2522 episodes of care along the continuum. Fatalities have been included here as emergency services attendances are not always recorded. Attendance by police and transport provided by another service are not accounted for in these data.

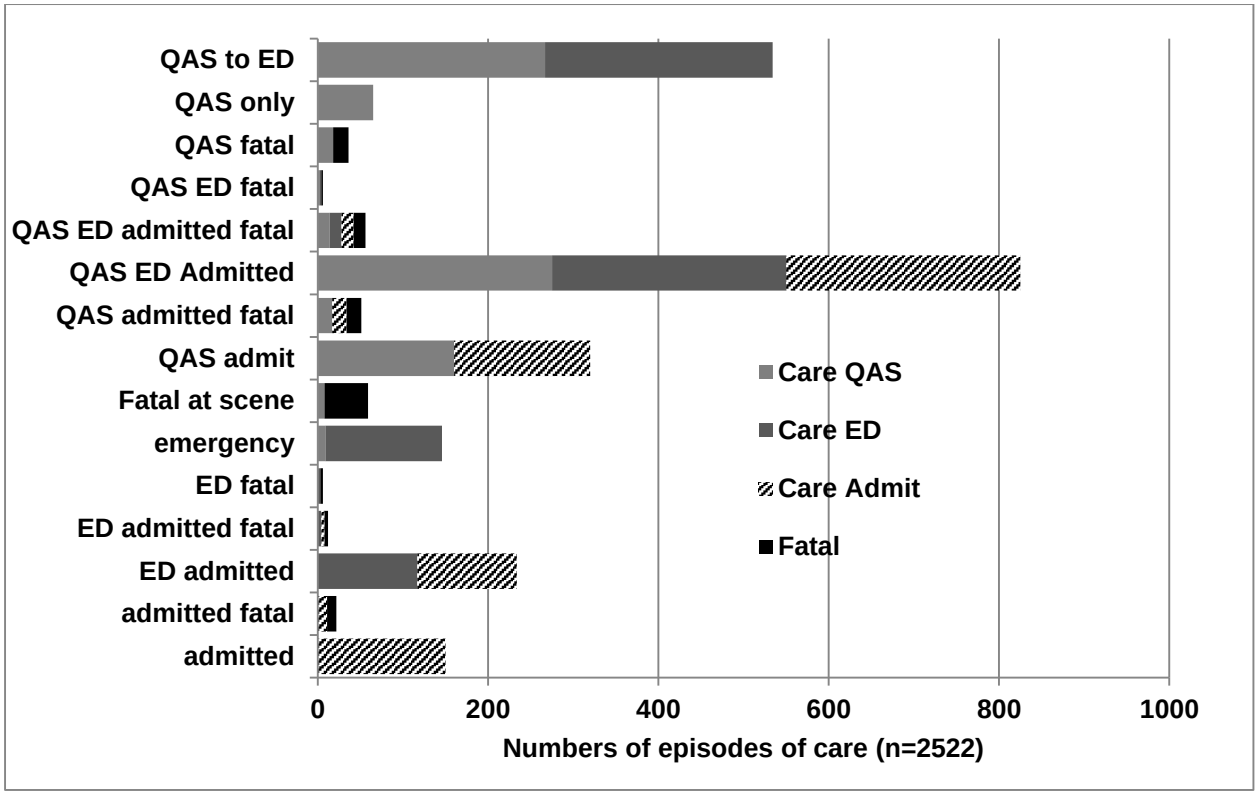

Figure 0-2 Health service usage (2522 episodes of care) for 1299 unique cases

3.8 DATA ANALYSES

Crude Incidence rates were calculated for fatal and non-fatal drowning incidents. The Australian Bureau of Statistics provides Queensland population data for each age year by calendar year, from 1901 onwards. This was the data source for the denominator in the calculation of Incidence Rates. Number of drowning events for a particular age and calendar year were divided by the corresponding population for that age year, for each year from 2002-2008. Calculation of incidence rates for fatal and non-fatal events (divided into hospital admission, and non-admission) was stratified by gender, age year, age group, and drowning location. Even though data on all drowning events that occurred in Queensland were

extracted, Incidence Rates were calculated for events among Queensland residents only, due to the lack of age-specific population data on non-Queensland residents (for the denominator). Incidence rates were also stratified by Indigenous status.

To calculate Incidence Rates (IRs) for Indigenous children in each age group, the estimated Indigenous population at 2006[14] for each age group was used as the population denominator for the specified age group for every year from 2002-2008. To facilitate comparison with the Non-Indigenous population, IRs for Non-Indigenous children were calculated using the same procedure, but with data relevant to the Non-Indigenous population contained in the same Australian Bureau of Statistics (ABS) report[14]. Queensland residents were identified by postcode of usual residence and crude IRs were calculated for fatal and non-fatal drowning events (total number of events divided by population). The denominator was sourced from Queensland estimated resident population using ABS population data for Indigenous and Non-Indigenous children, by age-group (0-4yrs; 5-9yrs; 10-14yrs; 15-19yrs), for the year 2006.[14]. While population data are provided for each age year for non-Indigenous children, from 1901 onwards, comparable data are only provided until 2006 for Indigenous children. The summary data from 2006 were compared with the population data per age year, for years up until 2006 and there were no marked differences for the age group of interest in this study (0-19yr olds). There are inaccuracies using this approach, however it was the most valid of all available approaches.

For all incidence rates, trends over time were analysed by chi-square test for trend using Epi Info (7.0). Relative Risk and 95% Confidence Intervals (CI) were also calculated using IBM SPSS Statistics 22.

Descriptive analyses were used to analyse the sample characteristics in relation to demographics (age, gender, socioeconomic status, geographical remoteness, Indigenous status, severity, incident characteristics (time of injury [month of year, day of week, time of day]); and injury characteristics (activity and location at time of injury). Descriptive analyses (i.e., t-tests, ANOVA, chi-square tests of independence or chi-square test for linear trend were used to investigate the association between demographics, health service usage / outcomes, injury characteristics, and event characteristics. When assumptions were violated, non-parametric alternatives were used (e.g., Fisher's Exact test for Chi-square test of independence, Mann-Whitney U tests for t-tests, Kruskal-Wallis for ANOVA, etc).

3.9 NARRATIVE TEXT CASE NOTES

Narrative text case notes were investigated manually, and by keyword-search to gain further attributes (or risk factors) and chain-of-event information on the drowning process.

Free text variables were provided in QHAPDC (External cause description); EDIS (Presenting problem); QISU (Injury description); MHS (Triage description, Triage Assessment); QAS (Comments, Final assessment) NCIS (Police reports, Coroner's reports). Appendix 3 shows extraction criteria and variables collected from each data custodian.

3.10 CONCLUSIONS

There are several implications arising from the data linkage process used in this study. Firstly, the significance of this multi-portal approach is illustrated by the fact that the number of cases captured was some 75% higher than if only relevant admitted patient data had been accessed. Secondly, it is a more accurate method to measure the true burden of drowning morbidity and mortality, and thirdly, an increased sample size will also be of benefit for statistical analyses. These data represent all relevant sources that contain information on child drowning events in Queensland and are a sound foundation for a population-based study.

The scope of this study was not to audit the consistency of collection, however, it is important to note that if a complete and accurate dataset for drowning is required, then as many databases as possible need to be interrogated. Cases were included if they appeared in any one of the datasets and the majority did not appear in all datasets. This is partly due to patients entering and leaving the system at many multiple points, however it does re-iterate the significance of linking the data and not relying on one or two databases.

Tracking the patient journey is a good indicator of severity and resource use of drowning - particularly non-fatal drowning which to date has been largely overlooked. The injury pyramid showed what would be expected from episodes of care with the numbers becoming gradually smaller in line with severity. The implications of resource use within the health system are self-evident from the high numbers. A further indicator of the burden on the health system is apparent when episodes of care are linked to individual patients. The severity of

drowning is accentuated where the highest level of care each patient received shows most patients are hospitalised. Again, this signifies the need for medical observation, medication and care of non-fatal drowning patients.

Significantly, the least numbers of patients were contained in the fatal data, and illustrates that counting the deaths is not necessarily a good measure of drowning events. Non-fatal drowning is the major proportion of service usage and is exceptionally worthy of surveillance for prevention efforts. Data linkage has revealed several benefits for the surveillance of drowning events; however, unless data are routinely linked preventable non-fatal drowning events will be overlooked as a burden on the public health system and families. The core data are routinely collected and with collaboration and political will could be readily linked to avoid the time taken to gain access and acquire data.

3.11 REFERENCES

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CH 4: CHARACTERISTICS OF DROWNING

CHAPTER 4. CHARACTERISTICS OF DROWNING – DEMOGRAPHIC, CLINICAL AND ENVIRONMENTAL

4.1 CHAPTER CONTEXT

The previous chapter described the process of acquiring and linking the data. Having established the 1299 unique cases, this chapter describes the next step which was to determine the epidemiology of the "who, what, when, where and why" of drowning that these enhanced data would reveal for both fatal and non-fatal drowning which addresses Objective 3 and describes the aetiology of drowning in Queensland. Overall sample characteristics including demographic, environmental and clinical characteristics are tabulated below **(Tables 4.1, 4-2 and 4-3).** In addition, the narrative text was scrutinised for chain of event information, and that process of analysis is provided in **Table 4-1**. These data relate to all fatal and non-fatal drowning events for which medical attention was sought in Queensland between 2002-2008, for children and adolescents 0-19yrs. Descriptive analyses are presented in the context of minimal interpretation as all data are explored further (incidence rates, trends over time, relative risks etc.) and discussed in the context of current literature in Chapters 5-8.

4.2 SAMPLE DEMOGRAPHICS

Demographic characteristics: There were 1299 (120 fatal and 1179 non-fatal) drowning cases of children 0-19yrs identified over the 7 years 2002-2008. This equates to 17 fatalities and 168 non-fatal drowning episodes every year in Queensland. Six percent (n=77) of fatal and non-fatal drowning events involved children who lived outside of Queensland but within Australia. The male to female ratio was 1.5:1. The most common age group for drowning was 0-4yrs (n=878, 68%). There were more drowning events (49%) for residents of Major Cities. Note that this is usual primary residence and does not necessarily reflect where the incident occurred. Children whose usual residence was in areas categorised as higher relative advantage according to the Index of Relative Socioeconomic Advantage and Disadvantage comprised the majority (n=878, 70%) of drowning events. Socio-economic status differed between fatal and non-fatal events (X^2=14.72 df=2 p<0.001) where twice the proportion of fatal events (14% vs 7%) occurred in families who resided in more disadvantaged areas (IRSAD 1-5). The majority of drowning incidents involved children not identified as Aboriginal and/or Torres Strait Islander (n= 966; 74.4%). Note that Indigenous status was not known for 246 cases.

Over the seven years, 41 (3.3%) of drowning events involved overseas tourists visiting Australia. Non-resident status (tourist status) was considered to be someone whose usual address was recorded as overseas. There were 10 cases where an Australian postcode was recorded however these children were born overseas, and/or were visiting on student visas and/or were not eligible for Medicare). There were two fatal events. Those born overseas made up 8% of fatal and non-fatal drowning. The highest numbers of tourists were from

Japan (n=14, 1.1%) followed by New Zealand (n=9, 0.7%). The locations of drowning events for overseas tourists are further described in Environmental Characteristics **Table 4-2.**

Drowning in rural and remote areas is a significant issue. Approximately two-thirds of fatal and almost half of non-fatal drowning events occurred outside of major populations areas categorised as Major City. Seventy percent of drowning events that occurred in remote/very remote Queensland were children aged 0-4yrs. Data on rural and remote drowning events are presented in further detail in Chapter 6, and in Appendix 4.

A further strength of linked data allowed postcode information to be extracted for both usual residence and the location of the drowning event itself. Data in **Table 4-1** is based on usual residence. Information for location of event was captured by postcode and narrative text through QAS, CCYPCG, and NCIS. This is presented in **Table 4-2**.

Table 4-1 Demographic characteristics of fatal and non-fatal drowning population 0-19yrs Queensland, 2002-2008

Variable		N (%)
Incident Type (n= 1299) **X^2=863.34 df=1 p<0.001**	Fatal Non-fatal	120 (9.2%) 1179 (90.8%)
Survival Ratio		1:10
Age Group (n= 1292) **X^2=1279.10 df=3 p<0.001**	0-4yrs 5-9yrs 10-14yrs 15-19yrs	878 (67.9%) 153 (11.8%) 98 (7.6%) 163 (12.6%)
Gender (n= 1288) **X^2=44.72 df=1 p<0.001**	Male Female	764 (58.8%) 524 (40.3%)
Location of Usual Residence (State) (n=1298)	Queensland NSW Victoria SA/NT/Tasmania Overseas	1179 (90.8%) 43 (3.4) 29 (2.1%) 6 (0.5%) 41 (3.3%)
Place of birth (n=1048) **(X^2=3.38 df=1 p=0.06)**	Australia Born Overseas	963 (91.9%) 85 (8.1%)
Geographical Location of Usual Residence (ARIA)[a] (n= 1298) **X^2=1740.03 df=6 p<0.001**	Major City Inner Regional Outer Regional Remote Very Remote Overseas Visitor	632 (48.7%) 281 (21.6%) 282 (21.7%) 37 (2.8%) 25 (1.9%) 41 (3.3%)
Geographical Location of Usual Residence (ARIA)[b] by Fatality (n=1259) **X^2=10.63 df=1 p<0.001**	**Non-fatal (n=1140)** Major Cities Rural & Remote **Fatal (n=119)** Major Cities Rural & Remote	 591 (51.8%) 549 (48.2%) 44 (36.9%) 75 (63.1%)
Indigenous Status (n= 1299) **X^2=1013.34 df=2 p<0.001**	Indigenous Not Indigenous Not stated	87 (6.7%) 966 (74.4%) 246 (18.9%)
Socioeconomic Status (IRSAD[c] – Index of Relative Advantage & Disadvantage) (n= 1255) **X^2=200.00 df=1 p<0.001**	Decile 1-5 Most Disadvantaged Decile 6-10 Most Advantaged	377 (30.0%) 878 (70.0%)

By Decile (n=1255) **X^2=267.23 df=9 p<0.001**	Decile 1	71 (5.7%)
	Decile 2	38 (3.0%)
	Decile 3	86 (6.9%)
	Decile 4	76 (6.1%)
	Decile 5	106 (8.4%)
	Decile 6	159 (12.7%)
	Decile 7	193 (15.4%)
	Decile 8	183 (14.6%)
	Decile 9	223 (17.8%)
	Decile 10	120 (9.6%)

Notes: ARIA: ASGC Remoteness classification 2001 cat no. 1216.0 Australian Bureau of Statistics

[a] ARIA- Accessibility and Remoteness Index of Australia; NSW – New South Wales; NT – Northern Territory; SA – South Australia. Location of usual residence (defined by postcode) was categorised using ARIA, which was developed by the National Centre for the Social Applications of Geographic Information Systems (GISCA). Each geographical area was allocated a score between 0 and 15, based on the (road) distance to nearby towns that provide services. Scores were then allocated to the following categories (OESR Queensland, 2011): Major city: 0.0-0.2; Inner Regional: 0.2-2.4; Outer Regional: 2.4-5.92, Remote: 5.92-10.53; Very Remote: 10.53+).

[b] ARIA categories: Metropolitan areas are represented by Major Cities. Inner and Outer Regional, Remote and Very Remote were grouped to form Rural and Remote and utilised usual residence postcode information.

[c] Socio-economic Index For Areas was used to estimate socioeconomic status in this study (ABS, 2008), based on postcode of usual residence. This was the Index of Relative Socioeconomic Advantage and Disadvantage. Higher deciles reflect higher relative advantage, and lower deciles reflect lower relative advantage. For analyses, these were collapsed into groups: Deciles 1-5; and Deciles 6-10. Data on collapsed SEIFA categories, as well as by Decile, are presented.

4.3 ENVIRONMENTAL CHARACTERISTICS

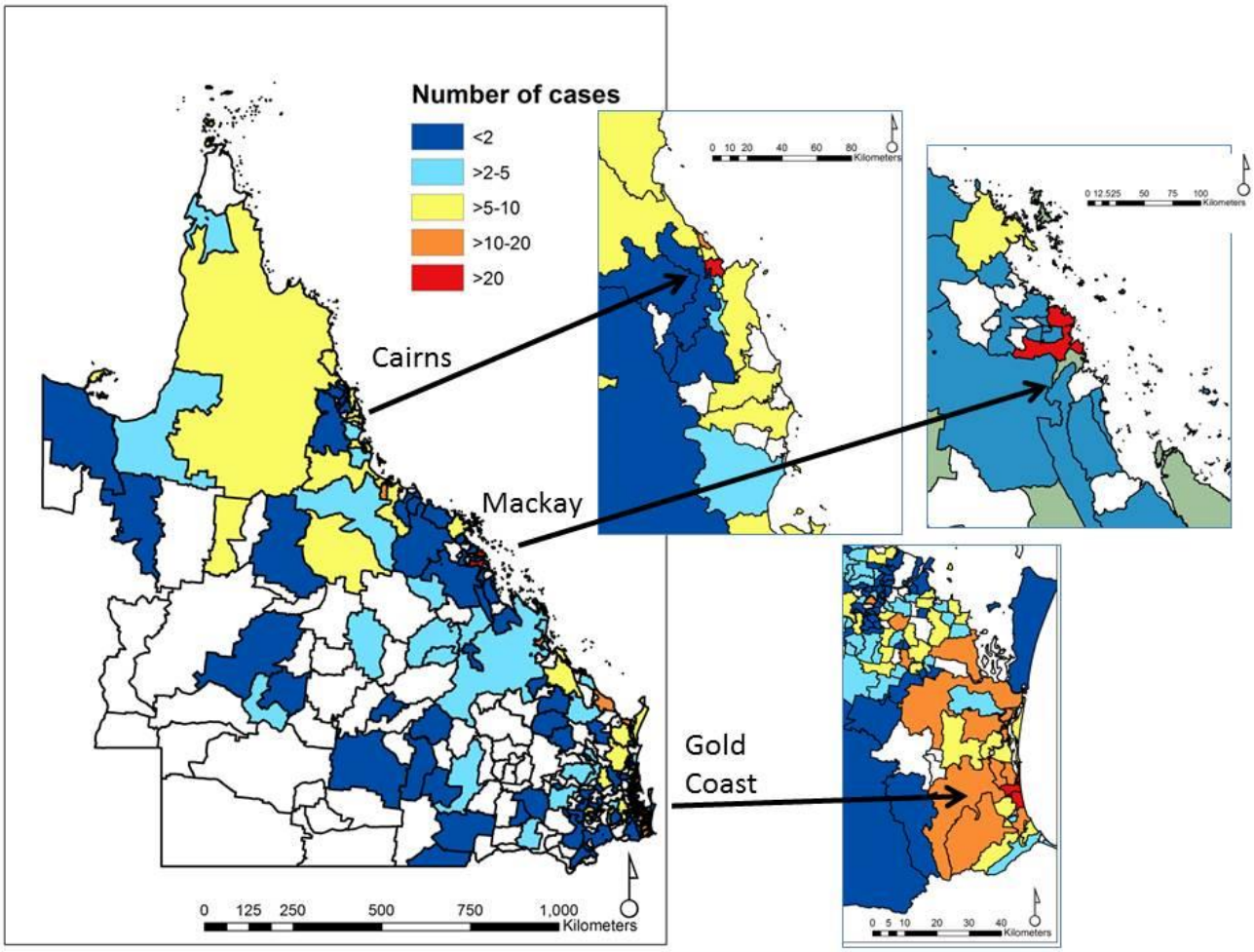
Environmental characteristics drowning events in Queensland over the 7 year study period are described in **Table 4-2**.

Pools made up more than half of all drowning locations (n=644, 59%), followed by inland water (n=146, 13.4%), bath (n=136, 12.5%), coastal (n=136, 12.5%) and other man-made water hazards (n=27, 2.5%). More often children got into difficulty while in the water rather than falling into water. The majority of water bodies were located on private property (43%). Commercially operated water bodies (predominantly pools and water parks) contributed 20% of drowning events. The least number of drowning events were in water bodies that were open to the public but had access restricted by opening times or patronage. Events occurred more frequently in Major Cities (50%; n=648). More than three quarters (77%) of drowning occurred in the warmer months between October-March. More drowning occurred on a weekend day (42%) than any day of the week which is consistent with children being involved in recreation activities on the weekends. Definite time of incident data was available for 109 of the 120 fatal events. For non-fatal drowning events, time of incident was determined through QAS, EDIS, SATR, QISU, or MHS for 1179 events. Where possible, time of the call to ambulance was used as a proxy measure for time of injury. For all drowning events, the most vulnerable period was between 12:00 noon and 18:00 (61.3%; n=790), and the majority of these events were between 3pm-6pm (57.9%; n= 456). Time of incident was different for fatal and non-fatal events ($X^{2=}$10.36; df=3; p=.016). Slightly more fatal drowning events occurred between 6am-midday (fatal: 21% n= 23 vs non-fatal 16%, n=194), whereas more non-fatal events occurred over night between 9pm-6am (8% n= 93vs fatal 1%; n=1). There were differences in relation to time of incident and age group (X^{2}=

83.31; df=9; p<0.00l). While midday till 6pm was the most common time of incident for all age groups, in children aged 0-4yrs, 5-9yrs and 10-14yrs, the next most common time of drowning event was 6am-midday, followed by 6-9pm. For adolescents aged 15-19yrs, one-quarter of incidents were between 9pm-6am (n=39).

Of 41 overseas tourist drowning events the location was known for 27 (65.8%). These events occurred at only three location types - pools, coastal water, and inland static water. This differed from Australian residents (X^2=14.078 df=4 p<0.001). Pools were still the most common location for drowning in tourists, (n = 21, 77.7%), and more of these events occurred in commercially run pools (70.1%). Almost double the proportion of overseas tourists (compared to Australian residents) had non-fatal drowning episodes in coastal water (22% vs 12%), and in inland static water (14% vs 7%). Swimming alone was a common risk factor for fatalities. Non-tourist drowning locations are explored in further detail in Chapter 6 "Where children and adolescents drown in Queensland".

Geographical Information System (GIS) mapping was undertaken using postcode data for location of drowning event and is presented for the first time. The distribution of drowning events across the state over the seven year period is shown graphically and has highlighted three areas with high drowning numbers. These areas are around Cairns, Mackay and the Gold Coast. As popular holiday destinations, there is a clear requirement for prevention input.



Notes: inset maps show postcode areas where drowning events were >20 cases across the 7 year study period.

Figure 4-1 Distribution of numbers of drowning events 0-19yrs by postcode of location of event (n=1299) 0-19yrs, Queensland, 2002-2008

Table 4-2 Environmental characteristics of fatal and non-fatal drowning 0-19yrs, Queensland, 2002-2008

Variable		N (%)
Location of incident (n= 1089) X^2**= 1086.27 df=4 p<0.001**	Pool	644 (59.1%)
	Inland water	146 (13.4%)
	Bath	136 (12.5%)
	Coast	136 (12.5%)
	Man-made water	27 (2.5%)
Location of Event for Non-resident tourists (n=38)	Pools	21 (68.4%)
	Coastal water	8 (21.0%)
	Inland water (static)	4 (10.5%)
Proximity to water (n=947)[a]	In water	593 (62.6%)
X^2**=60.32 df=1; p<0.001**	Fall in water	354 (37.4%)
Type of Place (n=986)	Public	421 (32.4%)
X^2**=21.03 df=1 p<0.001**	Private	565 (43.5%)
Owner / Operator (n= 986)[b]	Private	564 (57.2%)
X^2**=254.73 df=2 p<0.001**	Public	229 (23.2%)
	Commercial	193 (19.6%)
Access (n= 986)[c]	Public restricted	174 (17.6%)
X^2**=263.02 df=2 p<0.001**	Public unrestricted	247 (25.1%)
	Private residence	565 (57.3%)
Location of Event (ARIA)[d] (n=1299)	Major City	648 (49.9%)
	Inner Regional	284 (21.9%)
X^2**=530.48 df=3; p<0.001**	Outer Regional	298 (22.9%)
	Remote/Very Remote	69 (5.3%)
Month of incident (n=1299)	January	200 (15.4%)
X^2**=507.77 df=11 p<0.001**	February	155 (11.9%)
	March	103 (7.9%)
	April	72 (5.5%)
	May	41 (3.2%)
	June	31 (2.4%)
	July	37 (2.8%)
	August	44 (3.4%)
	September	77 (9.8%)
	October	127 (9.8%)
	November	168 (12.9%)
	December	244 (18.8%)
Season of incident (n=1299)	Warm Oct-March	997 (76.8%)
X^2**=371.84 df=1 p<0.001**	Cool April-Sept	302 (23.2%)
Day of week (n=1299)	Saturday	276 (21.2%)
X^2**=111.6 df=6 p<0.001**	Sunday	266 (20.5%)
	Monday	159 (12.2%)
	Tuesday	154 (11.9%)
	Wednesday	139 (10.7%)
	Thursday	151 (11.6%)
	Friday	154 (11.2%)
Time of Incident (n=1288)[e]	06:00-11:59	217 (16.8%)

X^2=932.48 df=3 p<0.001	12:00-18:00	790 (61.3%)
	18:00-21:00	187 (14.5%)
	21:00-05:59	94 (7.3%)

Notes:
[a] Activity codes from QISU, NCIS and CCYPCG and narrative text were used to establish whether the person was in the water or fell in the water. Intentional drowning and assault was grouped with missing.
[b and c] Public water settings were categorised on two levels of access: Public restricted access: Commercial/municipal operated (or developed) settings where access is restricted by opening or closing times, or to patrons who may have paid for holiday accommodation or to use the facility, (eg. water theme parks, school pools, hotels, resorts, caravan or holiday parks; and Public unrestricted access: where there is no fencing, or open and close times (beach, rivers, creeks, waterholes, and tidal pools).
[d]ARIA- Accessibility and Remoteness Index of Australia; Location of drowning event was determined from information obtained from narrative text in QAS, EDIS, SATR, QISU, MHS, CCYPCG, and NCIS police reports. Postcode of drowning event was categorised using ARIA, which was developed by the National Centre for the Social Applications of Geographic Information Systems (GISCA). Each geographical area was allocated a score between 0 and 15, based on the (road) distance to nearby towns that provide services. Scores were then allocated to the following categories (OESR Queensland, 2011): Major city: 0.0-0.2; Inner Regional: 0.2-2.4; Outer Regional: 2.4-5.92, Remote: 5.92-10.53; Very Remote: 10.53+).
[e] Definite time of incident data were available for most fatal events (n=108), (missing persons or open cases (n=12)) via CYCPCG or NCIS. For non-fatal events, time recorded by QISU, recorded triage time (MHS, SATR, EDIS), or QAS call-out time was used as a proxy.

4.4 CLINICAL CHARACTERISTICS – THOSE WHO SURVIVE

Clinical characteristics: Information regarding the clinical characteristics of those involved in fatal and non-fatal drowning events is shown in **Table 4-3.**

Over half of drowning cases were admitted to hospital (n=742, 57.1%) and almost half stayed 24hrs or less (47.9%). Time of death (or the closest estimate in cases where the body was missing) was recorded for 108 incidents. The majority of children who died succumbed to their injuries on the day of the incident (n=110, 91.7%). Of those, 51 (42.5%) died at the scene, 23 (19.2%) were declared dead on arrival at emergency and 30 (25.0%) died within 24 hours of arriving at hospital. Six (5%) died in the following 24-48hrs. An additional eight (6.7%) died in the ensuing weeks, and two (1.7%) died more than two weeks later.

Almost two-thirds of all non-fatal events (62.9%, n=742) were admitted to hospital. The mean length of stay in hospital for the primary admission was 1.85 days (SD=5.07 days; SEM=.192 days; minimum: 1 day; maximum: 120 days). The majority of children (79.5%; n=590) were admitted to hospital for one day, and nearly all children who were involved in a non-fatal drowning event stayed in hospital for one week or less (96.9%; n=719). Over one quarter (n=372; 28.6%) of drowning events involved presentation to an Emergency Department only (with no admission to hospital), which represents almost one-third (31.5%) of non-fatal events. Sixty-five events involved attendance by ambulance only (with no subsequent transportation to any medical facility).

Fatalities are only a small percentage (4.7%) of all health service usage, with non-fatal drowning taking up the other 95.3%. Two thirds of health system service usage was pre-hospital and emergency department (33% respectively).

Table 4-3 – Clinical characteristics of drowning events 0-19yrs in Queensland 2002-2008

Variable		N (%)
Severity (Definitive Level of Care) (n= 1299)[a] **X^2= 879.82 df=3 p<0.001**	Fatal Admitted Emergency Pre-hospital	120 (9.2%) 742 (57.1%) 372 (28.6%) 65 (5.05%)
Transported to Hospital[b] (n=1299)	QAS only (inc 21 fatal) Emergency Dept only Less than 24hrs (inc 30 fatal) 24-47hrs (inc 6 fatal) 48-71hrs (inc 2 fatal) 3-7 days (inc 5 fatal) 8-14 days (inc 1 fatal) >2 weeks (15-120 days) (inc 2 fatal) Admitted for unknown time Fatal at scene	86 (6.7%) 372 (28.6%) 160 (12.6%) 464 (35.7%) 58 (4.5%) 37 (2.8%) 12 (0.9%) 11 (0.8%) 46 (3.5%) 53 (4.1%) 1299
Health Service Usage (n=2522)[c]	QAS Emergency department Admitted Fatal to hospital Fatal at scene	835 (33.1%) 819 (32.5%) 748 (29.7%) 69 (2.7%) 51 (2.0%) 2522 (100.0%)
Time of death (n= 120) **X^2= 64.47 df=5 p<0.001**	Died at scene Death on arrival ED Died in hospital Death within 24-48hrs Death >48hrs	53 (42.5%) 23 (19.2%) 46 (38.3%) 120 (100%) 110 (91.7%) 10 (8.3%)
Glasgow Coma Score (n=273 GCS 3-14) **X^2= 162.57 df=2 p<0.001**	GCS <=5 (inc 51 fatalities) GCS 6-8 GCS 9-14 GCS 15	76 (27.8%) 41 (15.0%) 156 (57.2%) 273 (100%) 493 (64.4% of total 766 cases with GCS recorded)
CPR attempts (n=1299)	CPR attempted Not recorded	405 (31.2%) 894 (68.8)

[a] For this study definitive level of care was used as a proxy measure of injury severity. Patients attended by Queensland Ambulance Service (QAS) reflected the least serious type of drowning incident. Those treated at the Emergency Department only (and who required no further treatment) were considered the next most serious, and those who were admitted to hospital as a consequence of their drowning incident were considered the next most serious. Fatalities were the most serious type of drowning incident.

[b] Data presented here are for 1299 cases who were attended and transported to hospital (including fatalities (n=120) and emergency treatment.

[c] Episodes of care generated by 1299 patients are calculated by adding each level of care that each patient is given as they transition through the hospital system. These figures include fatalities as each fatality is also treated within the system prior to death.

The Glasgow Coma Scale (GCS) 1-15 is used to assess the consciousness level of a patient, with 15 considered to be a normal level. At GCS 8 or less patients are comatose and routinely intubated and this was the case for 43% (n=117) of cases. A total of 766 cases recorded a GCS, and two thirds (n=493) were GCS 15. For those with a GCS≤15 (n=273; see **Figure 4-2** almost all were non-fatal. There were 76 children recorded with a GCS≤5. Fifty one of these children died (76%), and all but one of these had a GCS of 3. This leaves thirty percent (n=23) with GCS≤5 who survived the drowning event. GCS was recorded by ambulance officers at the scene of the drowning event, and it is important to note that a low GCS in the initial stages of a drowning event may not necessarily mean a poor outcome, but a low GCS score on day three is likely to be an indicator of poor long term outcomes. It was beyond the scope of this research to examine long term outcomes of drowning events, however the outcome for these children would be considered clinically poor. Further research is required in this area. There is no research as to the length of survival after the drowning event, the cost to families and the relevant health services, or if these children have drowning recorded as an underlying cause of death.

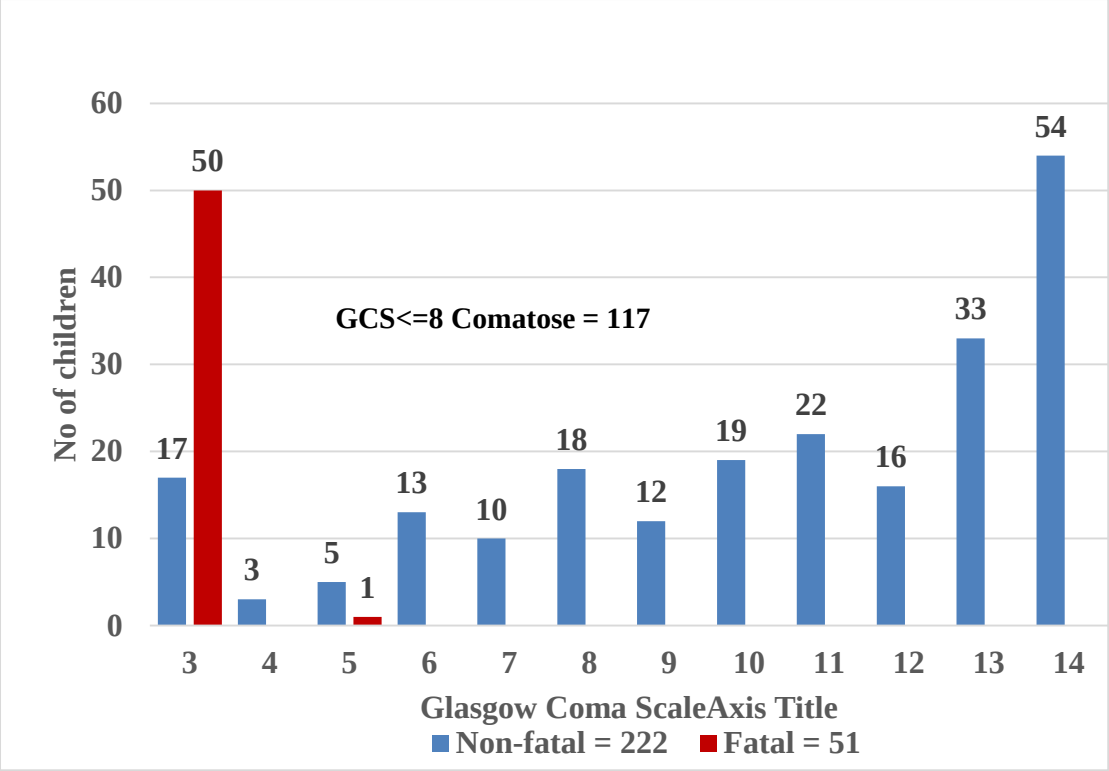


Figure 4-2 Glasgow Coma Scale for patients with GCS<=14 (n=273)

Cardiopulmonary Resuscitation (CPR) was attempted in 405 cases – this inlcuded bystander CPR as recorded by police, or CPR administered by a paramedic at the scene. CPR was attempted for 70% (n=84) of fatal cases, and 27% of non fatal cases (n=321). Non-fatal cases were assumed to have been found unresponsive and in respiratory arrest if they sought medical attention. A recording of less than 30% attempts at CPR indicates improvement could be made with uptake levels of this important intervention. It should be noted that in 10% of fatalities, CPR was not able to be attempted because the child involved was missing for some period of time. **(Figure 4-3)**

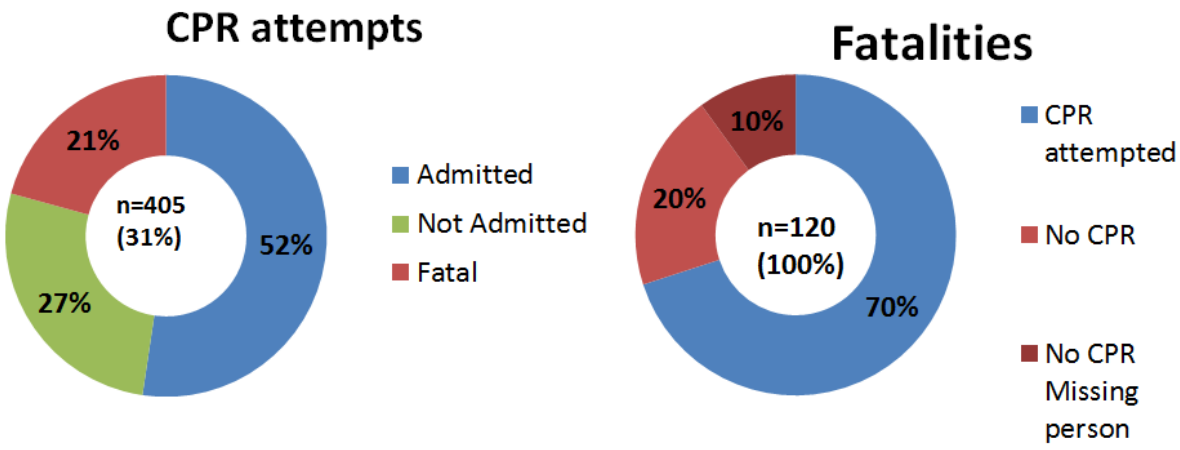


Figure 4-3 CPR attempts by severity and fatality

Table 4-4 Time lapse for fatal drowning cases, Queensland, 2002-2008

	Time between last seen and noticed missing (n=85)	Time between last seen and found (n=90)
0 minutes	15	1
1-2 minutes	2	1
3-4 minutes	3	3
5 minutes	20	14
6-10 minutes	15	9
11-20 minutes	15	16
21-30 minutes	5	9
31-60 minutes	3	8
60 minutes+	7	4
1-12 hours	-	11
13-24 hours	-	6
>24 hours	-	8

Fatality data for 85 children aged between 0-17yrs included information regarding time between when the child was last seen and noticed missing, and for 90 cases, time between when the child was last seen and when they were discovered was recorded **(Table 4-4)**. As

can be seen, in 25 of the 85 cases, the child's absence was noticed within 5 minutes, and in an additional 15 cases, the child's absence was noticed between 6-10 minutes.

4.5 NARRATIVE TEXT CASE NOTES

How narrative text was extracted and analysed

Drowning is a complex injury mechanism and often has multiple causes. Narrative text was utilised in this study to extract additional information about the drowning event to add value to coded data. It is common practice in medical notes to use abbreviations and short forms for common conditions which makes automated text and keyword searches difficult to conduct.

Therefore, attributes were extracted manually, and these were categorised as shown by the sample of entries in **Table 4-5**. More specifically, the first column lists the injury prevention elements as defined by Haddon: the *host* refers to the person at risk of injury where the *agent* of injury is the environmental entity whose action (or energy) is necessary to cause the damage.[1] The energy is transferred to the host through a *vector* (person or animal) or another inanimate vehicle. This process of analyses enables an understanding of whether there are specific causal factors for part of a group, or whether one factor could account for the entire group.

The rationale for the design and inclusion of this framework is to provide a tool which will facilitate the extraction of the drowning prevention information from narrative text. This framework can be used to extract multiple factors from the same text and provides a simple way of categorising the data. Additionally, once the factors are extracted, Haddon's matrix enables a means of translating the data to practice by suggesting where in the event phase prevention efforts might be applied. It should be noted that in this thesis, data regarding location of incident was determined using this framework. This is only one example of the type of information that can be extracted from the data in the future. Further work could be achieved from this data including information on clinical outcome measures, and CPR. An upcoming study on supervision is planned, and this framework will be invaluable in extracting the supervision information.

I report here only a sample of these causal *factors* (column 2 of **Table 4-4**) to show how descriptive analyses were undertaken for the drowning location results presented in Chapter 6 (Where children and adolescents drown in Queensland). Factors associated with the *host* included *cognitive ability*, *underlying medical conditions,* and *child carelessness /disobedience. Agent* (or energy transference or interruption) factors include *physiological homeostasis* associated with asphyxia, and water properties such as *static* or *dynamic*, or *assault*. *Vectors* were grouped under headings such as *furniture, structural failure,* or *recreational equipment. Environmental* factors were considered to be physical and are grouped as *weather events, access to water*, or *delay in rescue*; and social factors which include *activity* of the child, *alcohol*, *direct supervision* or *indirect supervision,* and *swimming alone or at night.*

An additional element "other consequences" has been adapted from a descriptive framework for injury data.[1] [2] Factors included here are not easily categorised elsewhere but give good information about the consequences and the severity of harm via measures such as how *spontaneous respiration* was regained (whether by removing the child from water, or whether *resuscitation* was required), and an outcome measure of *Glasgow Coma Scale*.

It is important to note that many of these factors as revealed from narrative text occurred together, or occurred in a discrete age-related portion of the population. As a result these data will require further scrutiny and analyses, as the data can be further applied to the three dimensional matrix which introduces pre-event, event, and post-event phases as an aid for choosing a means for intervention. The third dimension is the application of weighted value criteria, which assesses the cost (or value) of conducting the intervention compared with the potential effectiveness of the intervention[3] and has the potential for further research.

Table 4-5 Categories of additional drowning attributes derived from narrative text

Injury Prevention Elements[1]	Factors - Additional drowning attributes extracted from narrative text[2]	Example from text
HOST Person at risk		
	Cognitive/or physical ability	global delay; young child 0-36mths; pram fell in water
		patient in wheelchair
	Underlying medical condition	autism/ epilepsy
	Carer carelessness (lack of supervision)	baby's face in water while being bathed; left in care of sibling parent involved in other task (farm/house work)
	Child carelessness /disobedience	Jumped in on top of sibling; Removed "floaties"

AGENT Energy interruption/transferred to person via vector		
	Loss of physiological homeostasis	Drowning event
	Other potential energy transfer	Jumped off bridge and failed to emerge
		Panic / exhaustion; fall in water where no supervisor is present
	Static water	Found submerged in dam
	Dynamic water	Near weir wall and sucked over Strong current (rip or river);
	Assault	Child held under water by another
VECTOR **(person/animal or object)**		
	Detail on the water body type	Pool; river; bath; dam; pond
	Furniture	Climbed chair to gain access to pool/gate
	Structural failure	Child swept away when dam failed; fell into underground tank
	Recreation equipment	Failed to emerge after falling off flying fox; Slipped through float ring
ENVIRONMENT Physical and social site characteristics[a]		
Physical	Access to water	Gate not self-closing left open; 3 sided fencing only; unfenced
	Weather events	Rough surf; minor flooding; or strong currents.
	Natural disasters (cyclones, major floods or tsunami)	Boat overturned in storm at sea
	Delay in rescue	Missing for 30 minutes search found child submerged in dam
Social	Alcohol	Drank 6 beers went swimming
	Activity	Sitting on edge of pool when fell; Playing in shallow end then fell in deep end
	Supervision: Direct/Indirect[b]	dichotomy of care
	Swimming at night	Failed to emerge from surf at night
	Swimming alone	Found at bottom of swimming pool
	Owner / Operator	Public; Private; Commercial[c]
OTHER CONSEQUENCES Severity of harm		
	Responsive (Apnoeic or cyanosed or pulseless) Spontaneous respiration (no	Yes/No Began breathing when retrieved

	CPR/EAR)	from water
	Submerged/immersed <=1min	Y/N
	Submerged /immersed>1-5mins	Y/N
	Missing	Y/N
	Submerged	Y/N
	Floating face up	Y/N
	Floating face down	Y/N
	CPR1 (ROSR within a few compressions)	Y/N
	CPR2 (ROSR >1 min-5mins)	Y/N
	EAR (ROSR within a few breaths)	EAR
	GCS reading	3-15

a)Social environments include legal norms and accepted practices in the culture (such as norms about child discipline or alcohol consumption).
b)Direct supervision (visual and constant – ability to act quickly) and Indirect supervision (close by but not necessarily visual, aural reliance for assistance)
c)Owner /operator: Private access: water body for private use of residents; Public restricted access: commercial/municipal operated (or developed) where access is restricted by opening or closing times, or to patrons who may have paid for holiday accommodation to use the facility; Public: unrestricted access (no fencing, or open or close times).
Abbreviations: CPR: Cardiopulmonary resuscitation; EAR: Expired air resuscitation; GCS: Glasgow Coma Score; ROSR: Return of spontaneous respiration.

4.6 PREVENTION OUTCOMES - CONCLUSION

Fatal drowning is a relatively rare event compared to the non-fatal event with a 1:10 ratio of death to survival. Characteristics of drowning were extracted from the data and provide important insights into the demographic, environmental, and clinical characteristics of the population most involved in fatal and non-fatal drowning. These characteristics were briefly described in this chapter, and are further elaborated in Chapter 5 (Incidence and Severity Rates).

The linked data facilitated detailed information about drowning location for the first time, which again was only briefly presented here and is presented in more detail in Chapter 6 (Where children and adolescents drown in Queensland). Pools made up more than half of all drowning locations (59%), followed by inland water, bath, coastal and man-made water hazards. Targeted prevention strategies are required for children in the water (rather than falling into water), privately owned water bodies, and commercially operated water bodies. Geographically, interventions would have most effect if pitched at people living in major cities, with heightened awareness for the warmer months, and times between 12:00 and 18:00.

The international consensus for the definition of drowning, (Chapter 3) emphasises the importance of drowning as a process, and that prevention must incorporate an understanding of the physiological processes along that continuum. Using linked data in this study facilitated collection of information along that continuum of the drowning patient. This chain of event information is otherwise not routinely available.

Case narrative text was investigated manually and by keyword search to gain clarity about further attributes, including chain-of-event for the data. More information about the complex chain-of-events leading to the drowning event are revealed in simply providing a few written words rather than trying to fit a scenario to a pre-determined drop down box category. Contributing factors can be fitted to pre-event, event, and post-event points along the continuum providing multiple points to apply prevention stratagems.

Demographic, environmental and clinical characteristics of fatal and non-fatal drowning events in children and adolescents 0-19yrs in Queensland between 2002-2008 are presented here, in conjunction with a summary of data extracted from narrative text provided in case notes from various sources relating to these events. Data are summarised briefly with the intent of providing context, and are explored in further detail in subsequent Chapters 5-8.

4.7 REFERENCES

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CH 5: DROWNING INCIDENCE RATES

CHAPTER 5. DROWNING INCIDENCE RATES: MORTALITY AND MORBIDITY RATES IN CHILDREN AND ADOLESCENTS 0-19YRS

5.1 CHAPTER CONTEXT

This current chapter presents the incidence analyses undertaken for this thesis to address Objective 4. Including non-fatal drowning in the total drowning figures allowed more accurate analyses for calculating crude incidence rates and a previously unidentified 1:10 survival ratio. Two out of three of those survivors were admitted to hospital. These are the first population-level incidence rates produced for fatal and non-fatal drowning in Queensland children and adolescents and indicates that Queensland has made gains in preventing fatal drowning, though not with the same magnitude as the increased trends in non-fatal events. Admissions to hospital as a proxy for severity point to increased numbers of survivors who presented to hospital for treatment, but the numbers who were not admitted more than doubled over the seven years. Males were a large part of the rises in rates.

Continued efforts to prevent drowning among 0-4yr-olds with respect to access to water and supervision, particularly those aged 1-3yrs should prevail, as this group had the highest fatality, survival and admission rates and are higher than national data. These analyses have been published in PLOS One (citation below) and the published article follows.

Citation: Wallis BA, Watt K, Franklin RC, Nixon JW, Kimble RM. Drowning mortality and morbidity rates in children and adolescents 0-19yrs: a population-based study in Queensland, Australia. 2015 ***PLOS One*** 25 Feb 2015; 10(2):E0117948 http://www.plosone.org/article/fetchObject.action?uri=info:doi/10.1371/journal.pone.0117948&representation=PDF

5.2 ABSTRACT

Drowning mortality and morbidity rates in children and adolescents 0-19yrs: a population-based study in Queensland, Australia

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Keywords: drown*child*, paediatric, adolescent, morbidity, mortality, severity, incidence

OBJECTIVE

To redress the lack of Queensland population incidence mortality and morbidity data associated with drowning in those aged 0-19yrs, and to understand survival and patient care.

DESIGN, SETTING AND PARTICIPANTS

Retrospective population–based study used data linkage to capture both fatal and non-fatal drowning cases (N=1299) among children aged 0-19years in Queensland, from 2002-2008 inclusive. Patient data were accessed from pre-hospital, emergency department, hospital admission and death data, and linked manually to collate data across the continuum of care.

MAIN OUTCOME MEASURES

Incidence rates were calculated separately by age group and gender for events resulting in death, hospital admission, and non-admission. Trends over time were analysed.

RESULTS

Drowning death to survival ratio was 1:10, and two out of three of those who survived were admitted to hospital. Incidence rates for fatal and non-fatal drowning increased over time, primarily due to an increase in non-fatal drowning. There were non-significant reductions in fatal and admission rates. Rates for non-fatal drowning that did not result in hospitalisation more than doubled over the seven years. Children aged 5-9yrs and 10-14yrs incurred the lowest incidence rates 6.38 and 4.62 (expressed as per 100,000), and the highest rates were among children aged 0-4yrs (all drowning events 43.90; fatal 4.04; non-fatal 39.85 – comprising admission 26.69 and non-admission 13.16). Males were over-represented in all age groups except 10-14yrs. Total male drowning events increased 44% over the seven years ($P<0.001$).

CONCLUSION

This state-wide data collection has revealed previously unknown incidence and survival ratios. Increased trends in drowning survival rates may be viewed as both positive and challenging for drowning prevention and the health system. Males are over-represented, and although infants and toddlers did not have increased fatality rates, they had the greatest drowning burden demonstrating the need for continued drowning prevention efforts.

5.3 INTRODUCTION

Drowning is preventable, yet in most countries drowning ranks among the top three causes of injury death(1,2) The estimated drowning mortality rate of 6.8/100,000, translates to approximately 400,000 deaths annually.(3) Almost half of those deaths worldwide are children and adolescents aged 0-19yrs, accounting for 175,000 lives lost in a single year.(1) Drowning in children and adolescents is second only to road traffic trauma as a principal cause of unintentional injury death.(1) Furthermore, the magnitude is greater than these figures reveal, because global numbers do not include drowning due to floods, cataclysms, transport incidents and intentional drowning.(2)

Drowning is an injury with particular etiological patterns which change according to age group, aquatic setting and activity.(4) Many studies focus on either mortality or hospital admissions, with very few publishing combined figures. Reporting across these various categories makes a uniform measure of drowning difficult to define and consequently it is difficult to compare findings across studies, or conduct meta-analyses in order to implement preventative strategies. Additionally, countries categorised by income such as high income countries (HIC) or low and middle income countries (LMIC) have broadly varying death rates.(1) The greatest burden occurs in the youngest children and global rates for 0-4yrs at 18.9/100,000 and for 5-14yrs at 9.5/100,000 confirm this.(5) Among children aged less than 15yrs in the Western Pacific region (which includes Australia), rates range from 1.2-13.9/100,000. The rates for the most vulnerable children aged 1-4yrs varied from 2.0-10.2/100,000.(6)

The state of Queensland has the second highest number of drowning deaths comprising 22% of drowning deaths Australia-wide.(4, 7) The most recently available data show downward trends for Australian drowning mortality and hospitalisation from 1999-00 to 2003-04. However, the drowning mortality rate in Queensland (IR=2.2/100,000), is significantly higher than for Australia (IR=1.9/100,000), as is the hospitalisation rate (4.2/100,000 Queensland vs 3.0/100,000 Australia).(8) The National Water Safety Strategy, the Annual Report of Deaths of Children and Young People, and state government departments of Health and Local Government have all indicated that prevention of drowning is a high priority,(9) (10) with drowning fatalities among children 0-17yrs increasing over the five years up to 2008-09.(10) Furthermore, state-wide non-fatal data on the outcomes of drowning events are not collected, so the true morbidity burden from this injury on particular sectors of the population is unknown.

A population-based study of deaths and survivors of drowning episodes has not previously been conducted across Queensland, nor across the age spectrum 0-19 yrs. It is at least three decades since Pearn & Nixon,(11) and Pitt & Balanda(12) conducted their review of 0-14yr old child drowning incidents in the City of Brisbane Drowning Study. In these studies the rates for fatal and non-fatal freshwater drowning for ages 0-14yrs were reported as more than doubling from 10.4/100,000 to 26.8/100,000 in the decade 1976 to 1986.(13, 14) Rates for 0-4yrs increased from 26.6 to 70.2, and for all of Queensland were reported as 32.55/100,000 in 1997.(15) It is therefore timely for a detailed review that encompasses children of all ages, including the lesser-studied adolescent group who to date have been overlooked in Queensland studies. These data will assist in understanding of drowning incidents for prevention efforts, and will allow comparisons across national and international boundaries.

This study redresses the lack of a Queensland population-based study in those aged up to 20yrs, and presents analyses of fatal as well as non-fatal drowning data collected using data linkage. This method achieved the best possible case capture to report both fatal and non-fatal cases of drowning as defined internationally.(16, 17) Data from across the patient journey affords vital detailed information of the drowning environment and patient care prior to, during, and after the incident.

5.4 METHODS

In this population-based study, data linkage was used to ascertain cases of fatal and non-fatal drowning events among children and young people aged 0-19yrs inclusive, residing in Queensland between January 2002 and December 2008. Data were accessed from multiple portals including pre-hospital, emergency, hospital admission and death data, using the most appropriate data extraction criteria **(Table 5-1).**

Table 5-1 Data custodians, scope and extraction criteria – "7 year review of drowning in children and adolescents 0-19yrs in Queensland 2002-2008"interventions and risk factors discussed in studies that did not meet eligibility criteria

Pre-hospital, Hospital Emergency and Hospital Admission	**Data Scope**	**Criteria for data extraction Jan 2002 – Dec 2008**	**Data coverage**
Queensland Ambulance Service (QAS) https://ambulance.qld.gov.au/research.html (Accessed Oct 2014)	Fatal and Non-fatal Pre-hospital Queensland	Case nature = drowning; eARF=0-19yrs; AIMS=all ages†	Information regarding all patients attended by QAS; data includes clinical information (vital signs) treatment administered by QAS or bystanders (e.g. CPR), facility and transfer details, and details of incident (location, events leading to)
Queensland Injury Surveillance Unit (QISU) http://www.qisu.org.au/ModCoreFrontEnd/index.asp?pageid=109 (Accessed Oct 2014)	Fatal and Non-fatal Emergency Admissions 25% of Queensland (a)	Nature of main injury = drowning and submersion; age=0-19yrs	Emergency presentations to 20 hospitals (a)
Emergency Department Information System (EDIS) Hospital Access Unit, Queensland Health http://www.health.qld.gov.au/research-reports/data-requests/default.asp (Accessed Oct 2014)	Fatal and Non-fatal Emergency 63% of Queensland (b)	ICD10 T751 Drowning and non-fatal submersion and ICD10 W65-W74; age=0-19yrs	**Emergency presentations** to 101 hospitals with average 18,200 patients per year(b)
Surgical and Retrieval Team (SATR) Hospital Access Unit, Queensland Health http://www.health.qld.gov.au/research-reports/data-requests/default.asp (Accessed Oct 2014)		ICD10 T751 Drowning and non-fatal submersion and ICD10 W65-W74; age=0-19yrs	
Queensland Health Admitted Patients Data collection (QHAPDC) Health Statistics Centre http://www.health.qld.gov.au/research-reports/data/	Fatal and Non-fatal Admission Queensland	Principle Diagnosis/Other Diagnosis = ICD10 T75.1 Drowning and non-fatal submersion; age-0=19yrs OR where external cause code included V90, V92, W65-W70, W73-W74, X37-X38, X71, X92.	**Admitted patients** from all public and private hospitals in Queensland
Mater Health Services (MHS) (children and adults) Business Practice Improvement http://www.mater.org.au/Home/Services (Accessed Oct 2014)	Fatal and Non-fatal Emergency Admission Queensland (c)	Diagnosis description = Injury or Trauma including non-venomous bites drowning or near drowning 994.1; or Diagnosis = ICD10 T751; Drowning and non-fatal submersion); age=0-19yrs	**Emergency presentations** to Mater Children's and Adults Hospitals

Fatal drowning data	Data Scope	Criteria for data extraction	Data coverage
National Coronial Information System (NCIS) http://www.ncis.org.au/how-to-access-data-on-the-ncis/ (Accessed Oct 2014)	Fatal Queensland 0-19yrs	Queensland jurisdiction; "Threat to breathing and downing and immersion" and string searches "drown*" and "immersion" and various truncations and misspellings ("dorn" "dron" "imer"; year of death 2002-2008 inclusive	Includes coroner's findings, police investigation reports and toxicology
Commission for Children and Young People and Child Guardian Child Death Review Unit (CCYPCG)‡ http://www.qfcc.qld.gov.au/contact-us info@qfcc.qld.gov.au	Fatal Queensland 0-17yrs only	Death registered as drowning; 0-17yrs; Year of death 2002-2008 inclusive	**Fatality data up to 17yrs**: Includes Coroner's data, death registration, police report and other information specific to mechanism
Royal Life Saving Society of Australia (RLSSA) http://www.royallifesaving.com.au/contact-us	Fatal Queensland 0-19yrs	Drowning data for Queensland year of death 2002-2008 inclusive, 0-19yrs	**Fatality data:** Includes Coroner's data, ABS data; member reports, details of rescues, and media reports

†CCYPCG has transitioned to the Queensland Family and Child Commission (QFCC) from 1 July 2014.
‡eARF (Electronic Ambulance Report Form 2007-2008) and AIMS (Ambulance Integrated Management System 2002-2006)
(a) 20 hospitals contribute data to QISU which approximates 25% of the state.
(b) In 2008, 150 hospitals in Queensland see an average of 86,700 patients per year. There were 101/150 in Queensland who operated with an electronic data system seeing an average of 76,300 patients per year. 12% of patients attend hospitals without electronic ED systems.
(c) Mater Health Services (MHS) data covers public and private hospitals in Brisbane and environs servicing approx.45,000 ED child presentations/year and 37,000 Adult presentations per year. Of 5 hospitals 2 are children's hospitals, and 3 adult (two private and one public). Mater Children's Hospital provided data for children 0-17yrs inclusive. Mater Adult Hospital provided data for adolescents 18 and 19yrs inclusive. Approximately 23% of child admissions are through ED, and 27% of adult admissions.

Identified data were linked manually for each unique drowning event over the time period to collate comprehensive detail across the continuum of care. Drowning is a relatively unusual event which generally requires a patient to be transported for medical intervention immediately after the event. Consequently any disparity in time/date of presentation, and facility, or any duplication of any of these variables was highly unlikely. Identified data collected included: name, address, date of birth, medical record number, sex, facility name,

date of incident/presentation/transfer, and mode of arrival and discharge status. BW and KW and three research assistants (MT, CM and HW) were responsible for merging and linking the data using Excel and FileMaker. BW & KW scrutinised data for consensus as to a correct match on a case by case basis. Identifiers such as date of birth, address, medical record number, or sex were able to be linked where names were spelled differently. Few difficulties were encountered in linking and matching identified data with overlapping variables between datasets, and discrepancies between two entries with differing data (e.g. address and postcode) were resolved by allocating a hierarchy to databases. Each case did not necessarily appear in all datasets. A case was included if it appeared in any dataset, provided it met the search criteria and included age. Included cases were categorised as pre-hospital, emergency attendances or admissions if they were present in any of these databases, but were only included once. Transfers between hospital facilities were excluded. The final dataset comprised unique drowning events during the study period. Further detail on data linkage is available from the corresponding author on request and is the subject of a forthcoming paper.

This study used the internationally agreed terminology for the drowning process outcome being either fatal or non-fatal drowning.(16, 17) The scope of the data collected was deliberately broad to capture as many cases of non-fatal drowning as possible. Respiratory impairment (which excludes water rescue) is not readily extracted without further data mining, and the authors have assumed that if medical attention was not sought that respiratory impairment was unlikely. The authors have no way of knowing how many cases go unreported. The terms “all drowning events” or “total events” are used when referring to combined figures for both fatal and non-fatal drowning.

Crude incidence rates (IRs) were calculated for drowning events for each calendar year using population data from the Australian Bureau of Statistics (ABS) and are quoted as per 100,000 population. Rates were calculated separately for all drowning events; fatal events; and non-fatal events (hospital admission and non-admission were also calculated separately); by age group and gender.

Even though data for every drowning event that occurred in Queensland were extracted, IRs were calculated for events among Queensland residents only, due to the lack of age-specific population data on non-Queensland residents (for the denominator). Trends over time were analysed by chi-square test for trend using Epi Info (7.0). Relative Risk and 95% Confidence Intervals (CI) were also calculated using IBM SPSS Statistics 22.

Ethics and approvals were sought and granted from Children's Health Services District (Royal Children's Hospital Human Research Ethics Committee HREC/09/QRCH/38; Royal Children's Hospital Institutional Approval; University of Queensland Medical Research Ethics Committee #2009001463; Mater Health Services Human Research Ethics Committee #1446E; and National Coronial Information System #CF/07/13729 (2007-2010), #CF/10/25057 (2010-2013), #CF/13/19798 (2013-2016). Director General approval was granted for access to identified data without consent through Public Health Application, Queensland Health 16/3/2010 Ref RD002254. Custodian approvals were granted from Royal Life Saving Society Australia, Commission for Children and Young People and Child Guardian, Queensland Ambulance Service.

5.5 RESULTS

5.5.1 OVERALL DROWNING 0-19YRS

Between January 2002 and December 2008 there were 120 fatal and 1179 non-fatal drowning incidents (total=1299) among 0-19yr-olds in Queensland. This equates to approximately three incidents per week. The ratio of fatal to non-fatal drowning events was 1:10, and for non-fatal events the ratio of hospital admission (n=742) to non-admission (n=437) was 1.7:1. Indigenous status was recorded for 80% of drowning incidents, and of those 7% of incidents involved children and adolescents who identified themselves as Aboriginal and/or Torres Strait Islander.

The remaining analyses for IRs relate only to Queensland residents (n=1168). There were 116 fatal and 1052 non-fatal events among 0-19yr old Queensland residents yielding an overall total drowning incidence rate of 15.12/100,000 **(Figure 5-1).** Incidence rates (IRs) for all drowning events increased by 28% during the study period (X^2= 9.02; P<0.01) and during 2006-2008 rates increased by 44%. There was a non-significant reduction in fatal IRs over the seven years (X^2=0.44; P=0.509), and non-fatal IRs increased by 33% (X^2=8.41; P<0.01).

		Crude Incidence Rates/100,000				
		Female	Male	RR† (CI 95%)	Total	Total Trends 2002-2008
0-19yrs	Total	12.86	17.28↑***	1.34 (1.20-1.51)	15.12	↑**
	Fatal	1.06	1.92		1.50	↓
	Non-fatal	11.79	15.36↑***		13.62	↑**
	Admitted	7.49	9.42	1.26 (1.08-1.47)	8.48	↓
	Not Admitted	4.3	5.94↑***		5.14	↑***
0-4yrs	Total	37.28	50.16	1.35 (1.17-1.55)	43.9	↔
	Fatal	3	5.04		4.04	↓
	Non-fatal	34.28	45.12		39.85	↑
	Admitted	23.74↓*	29.49	1.24 (1.04-1.48)	26.69	↓*
	Not Admitted	10.54	15.64↑***		13.16	↑***
5-9yrs	Total	4.61	8.05↑*	1.75 (1.20-2.53)	6.38	↑**
	Fatal	0.54	1.02		0.78	↑
	Non-fatal	4.08	7.03		5.59	↑*
	Admitted	2.58↑*	3.67	1.42 (0.85-2.39)	3.14	↑
	Not Admitted	1.5	3.36		2.46	↑
10-14yrs	Total	5.05	4.21	0.83 (0.55-1.26)	4.62	↑
	Fatal	0.52	0.29		0.4	↓
	Non-Fatal	4.53	3.91		4.22	↑
	Admitted	1.96	2.06↑*	1.05 (0.56- 1.95)	2.01	↑
	Not Admitted	2.58	1.86		2.21	↑
15-19yrs	Total	5.73	8.07↑**	1.41 (1.00-1.99)	6.93	↑**
	Fatal	0.31	1.5		0.92	↑
	Non-Fatal	5.41	6.58↑**		6.01	↑*
	Admitted	2.6	3.39	1.30 (0.77-2.18)	3	↔
	Not Admitted	2.81	3.19↑**		3	↑***
0-14yrs‡	Total	15.26	20.30↑***	1.34 (1.20-1.51)	17.85	↑*

*P<0.05, **P<0.01, ***P<0.001 (↑)increase (↓) decrease (↔) no change in drowning over time; RR† ref category for each age category is females; 0-19yrs n= 1168

†Reference group Female ‡0-14yrs reported to facilitate comparison with other paediatric studies.

Figure 5-1 Incidence rates for all drowning, admitted, and not admitted drowning events by age group, gender and trends over time for 2002-2008

Sixty two percent (n=655) of children involved in non-fatal drowning events were admitted to hospital, and of those (n=408) who were not admitted 84% attended the emergency department (ED) and the remaining 16% (65) received emergency pre-hospital care only. **Figure 5-2** shows the rates for non-fatal drowning. The rates for survivors who sought medical help but were not admitted to hospital increased significantly, more than doubling to

the end of the study period by a factor of 2.34, (IR=5.14/100,000; X^2=30.48; P<0.001) while hospital admissions reduced slightly (IR=8.48/100,000; X^2=0.40; P=0.530).

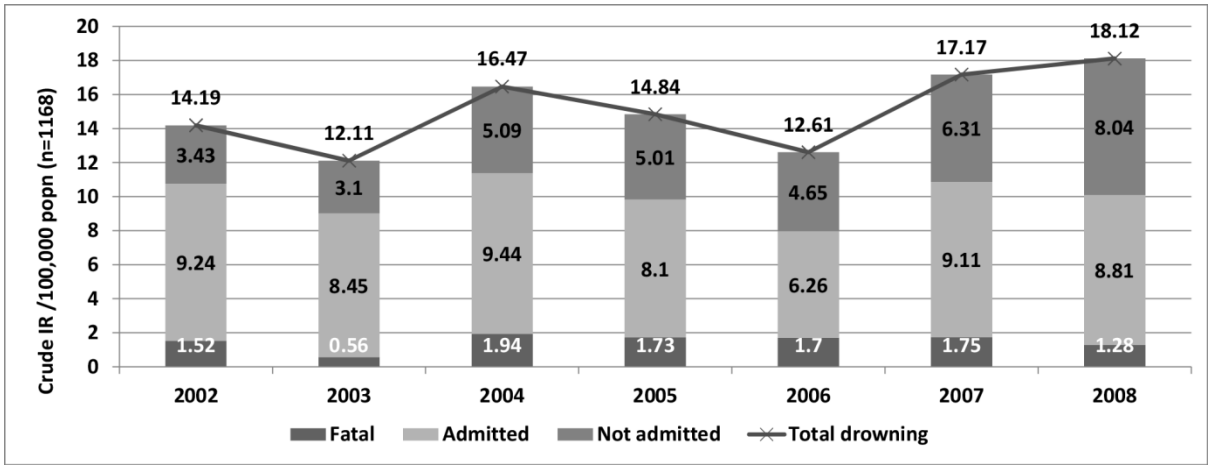

Figure 5-2 Drowning incidence rates in 0-19yr old Queensland residents by calendar year 2002-2008 stratified by severity

Males were involved in just over half (59%) of all drowning events (M:F 1.3) and were 1.3 times more likely than females to be involved in a drowning incident (RR=1.34; 95%CI=1.20-1.51) (Figure 5.1). During the study period there were very small non-significant reductions in both male and female drowning deaths. The incidence of drowning events increased by 44% over the seven year study period among males (X^2=10.90; P<0.001), and this was primarily due to a 55% increase in non-fatal events (X^2=10.96; P<0.001). For females, rates of drowning resulting in death, admission (X^2=0.499; P=0.480) or non-admission (X^2=3.251 P=0.071) reduced slightly, but not significantly. In contrast, there was a significant rate increase in males (174%) in drowning events that did not result in admission (X^2=24.64; P<0.001). Most commonly patients spent 24-48 hours (62%) in hospital before discharge. A stay of less than 24 hours (24%) was the second most common time period.

5.5.2 AGE GROUP AND SEX

Table 5.1 shows the IRs for the duration of the study stratified by age group and gender, all drowning separately, trends over time and relative risk of drowning for males.

0-4yrs: The majority (70%) of drowning events and the highest incidence rates consistently occurred in this age group regardless of severity**.** There were no significant changes in fatal or non-fatal rates. Admission rates reduced (X^2=0.4.4; P<0.05) and non-admission rates more than doubled (X^2=17.73; P<0.001). Of the children and adolescents who were hospitalised for 24-48 hours or less than 24 hours, 82% and 69% were 0-4yrs olds.

Males in this age group incurred the highest incidence rates for the entire study (IR=50.16) and the risk of young males being involved in a drowning event was 1.3 times greater than for females of the same age (RR=1.35 95%CI=1.17-1.55). Male non-admission incidence rates increased (X^2=15.34; P<0.001) whereas female hospital admission rates decreased over the time (X^2=4.72; P<0.05).

5-9yrs: Children 5-9yrs made up only 10% of total drowning incidents overall however rates almost trebled (X^2=7.96; P<0.01) over the study period. Deaths were few in this age group (maximum six in 2007) and in four of the seven study years there were either no recorded male fatalities or female fatalities (data not shown). Increased events were mostly non-fatal (X^2=5.83; P<0.05).

For this age group the highest incidence in total drowning events occurred in males (X^2=4.86; P<0.05) who also had a greater risk of drowning than their female counterparts of the same

age (RR=1.75 95%CI=1.20-2.53). Male total drowning rates increased over the time of the study by a factor of 3.14 (X^2=4.86; P<0.05). The Incidence of hospital admissions in females increased by a factor of 5.63 (X^2=4.00; P<0.05).

10-14yrs: The lowest incidence rates of the entire study were in young adolescents who also had the lowest risk of drowning. Admission rates increased significantly over time among males (X^2=3.99; P<0.05).

There were three years of the study where no fatalities were recorded at all, and a further two years where there were no male fatalities. This was the only age group where numbers of non-fatal incidents in males were fewer than females. (RR=0.834; 95%CI= 0.55-1.26).

15-19yrs: Older adolescents were involved in 12% of incidents overall. Total drowning incidence rates almost trebled over the study (X^2=6.96; P>0.01) primarily due to non-fatal events (X^2=5.31; P<0.05). Although the rates for hospital admissions and non-admissions were similar, the non-admission rate increased by a factor of 2.3 (X^2=11.12; P>0.001) over the study.

For male adolescents total drowning rates almost doubled ($X^{2=}$7.06; P<0.01), and non-fatal and non-admission rates more than doubled (X^2=6.13; P<0.01; X^2=8.72; P<0.01) respectively. Mortality rates for females were the lowest rates in this age group; no fatalities were recorded for four years of the study. The risk of a male drowning was 1.4 times that of a female (95%CI=1.00-1.99).

5.5.3 RELATIVE RISK BY AGE GROUP

(Table 5-2) 0-4yrs: Children under 4yrs were the most vulnerable to a drowning event, though the risk of them being involved in a non-fatal event was higher than a fatal event. Children aged 0-4yrs were seven times more likely to be involved in a drowning event than children aged 5-19yrs and an almost 10-fold risk of being admitted to hospital.

Table 5-2 Relative risk of drowning by age for total drowning and hospital admission, Queensland residents 2002-2008

Age (yrs)	IR total drowning (n)	RR† drowning event compared with 5-19yrs (95%CI)	IR Admission (n)	RR† hospital admission compared with 5-19yrs (95%CI)	RR‡ non-fatal drowning compared with fatal drowning (95%CI)
<1	35.84 (134)	6.01 (4.93 - 7.34)	18.46 (69)	6.81 (5.14 - 9.04)	15.75 (7.71 - 32.18)
1	67.6 (250)	11.34 (9.64 - 13.33)	41.37 (153)	15.27 (12.23 - 19.07)	9.00 (5.95 - 13.60)
2	56.56 (209)	9.49 (7.99 - 11.26)	34.37 (127)	12.69 (10.05 - 16.02)	8.95 (5.70 - 14.05)
3	40.83 (151)	6.85 (5.66 - 8.29)	25.96 (96)	9.58 (7.44 - 12.34)	7.39 (4.52 - 12.08)
4	18.86 (70)	3.16 (2.45 - 4.09)	13.47 (50)	4.97 (3.62 - 6.83)	22.33 (7.03 - 71.02)
0 to 4	43.9 (814)	7.36 (6.50 - 8.34)	26.69 (495)	9.86 (8.24 - 11.78)	1.82 (1.78 - 1.86)
5 to 19	5.96 (350)	1	2.71 (159)	1	7.54 (5.44 - 10.44)

RR† - Relative Risk reference group 5-19yrs; RR‡ - Relative Risk reference group Fatal (non-fatal is any drowning event – pre-hospital and admitted); IR – Incidence Rates quoted per 100,000 population per annum

Compared with 5-19yr olds, the risk of a drowning event for the youngest children aged 0-4yrs peaked at age 1yr, and remained elevated until the age of 4yrs before it fell to a 3-fold risk. The incidence of admission to hospital following a non-fatal drowning event was almost ten times higher among children 0-4yrs than older children and adolescents aged 5-19yrs.

The most vulnerable age was 1yr with the highest incidence for all drowning events, admission to hospital, and a ten-fold risk of being involved in a fatal drowning event compared with 5-19yr olds (RR=9.68 95%CI= 5.89-15.91). Children aged either <1yr or 4yrs had the highest risk of being involved in a non-fatal drowning compared with a fatal drowning. For each year of age less than 5yrs, the risk pattern for those admitted to hospital is the same as for children involved in any drowning event.

5.6 DISCUSSION

5.6.1 OVERVIEW 0-19YRS

Drowning prevention requires an understanding of all drowning scenarios, however there is no one database in Queensland which allows analysis of drowning deaths and survivals. This study linked data from ten databases to form a picture of fatal and non-fatal drowning in Queensland and demonstrates that fatal drowning is only a small part of the drowning problem.

On average, there were three drowning episodes each week in Queensland, and for every child or adolescent fatality, ten others were rescued, potentially resuscitated and survived. Two out of three of those survivors were admitted to hospital. Trends over the time of the study indicate that fatal drowning decreased slightly, but not with the same magnitude that non-fatal drowning rates increased.

The survival ratio for Brisbane City was 1:1 in 1976 for children aged 0-15yrs(13, 18), and 1:3 a decade later for Brisbane City.(14) A figure of 1:9 for Queensland(15) in the mid-1990s was thought to be under-estimated as only hospital admissions were included. In line with national figures(7) fatalities did reduce slightly over the study period however, the overall drowning rate increased.

The over-representation of male involvement in our data is supported in national data,(19, 20) and is evident across all years of the study and all types of drowning with two minor

exceptions (10-14yrs fatal and non-fatal) where female rates marginally exceeded males. Non-fatal rates for males increased 55% which is of concern. On the one hand it is positive that these increased events did not result in fatalities, but does warrant further investigation as to whether increases were associated with better supervision or resuscitation response, medical management or continuing or persistent morbidity.

A modest but non-significant reduction in admission rates over the seven years is also a positive finding, however, numbers of drowning survivors who sought medical assistance, but were not admitted more than doubled. This previously unknown burden of non-fatal drowning shows more than 62% of drowning survivors being admitted to hospital and most staying for one or two days. The impost on the health system has yet to be explored.

Total drowning events among Aboriginal and Torres Strait Islanders in Queensland has not been previously documented. Seven per cent of all drowning incidents involved children and adolescents self-identified as Aboriginal and/or Torres Strait Islander. This population is proportionately 6.5% of the Queensland population and is therefore not over-represented.(21)

0-4yrs: Although 0-4yr infant and toddler fatality rates decreased, this group still bore the greatest mortality and morbidity burden from drowning. Non-fatal rates were seven times that of children and adolescents aged 5-19yrs. While fatality rates are much lower than reported in 1973 (IR=15.69)(15, 22, 23) it is concerning that drowning in this age group has not decreased significantly over the period of the study. Compared with national data, the

drowning fatality rate for Queensland toddlers was more than double(24) (1.8 vs 4.04) and admission rates were 48% higher.(8)

Total drowning rates for toddlers have continued to increase. Brisbane City increased 164% the decade following 1975 from 26.62 to 70.2.(13, 14) The Queensland rate of 43.9 for this study is 65% higher than in 1997(IR=32.55).(15)

The most vulnerable remains children aged one year as earlier studies have shown,(11-13) however it is encouraging that children <1yr and 4yrs had a reduced risk of being involved in a fatal event compared with a non-fatal. The high risks of drowning associated with the early developmental years need to be examined in the context of access to water and supervision. Pool fencing as a drowning prevention strategy for young children has been shown to be effective (12, 25) and was mandated in Queensland in 1991(26). Regulatory control by individual local councils across the state led to inconsistencies in enforcement so it is difficult to say definitively that this has reduced fatality on its own, however as the only statutory intervention promoted since 1991, this is a positive sign toward reducing drowning in this age group. Continued action is required to reduce drowning in toddlers 0-4yrs(27), and analyses indicate a high need for vigilance and continued intervention as the risk of drowning and admission to hospital for young children compared with that of older children was almost 10-fold.

5-19yrs*:* Numbers were small for fatal and non-fatal drowning and events fluctuated yearly over the study. Older adolescents incurred no deaths over several years of the study. Low fatality rates and reduced admission rates in older adolescents must be weighed against

significant increases in non-fatal drowning and non-admissions as an impost on the health system. International data show similar patterns of drowning rates by age group, however, rates for Queensland are more than double those of the USA.(28)

Further investigation is required to determine why adolescents 10-14yrs had the fewest drowning incidents, hospital admissions and non-admissions. All Queensland children are taught to swim at school from about age six, and this along with some level of supervision for this age group, may account for the lower rates in children 5-14yrs. Also further investigation is warranted for the 10-14yr group where females had higher drowning rates than males (M:F 1:1.2). The male predominance was found in other Australian studies (27,29) and indicates a specific injury prevention need. The low rates in 10-14yrs drowning are reflected in similar patterns in Australian fatal drowning(4) and comparable rates of hospitalisation (3.0 for 15-24yrs vs 2.7 15-19yrs).(8)

5.6.2 DATA SCOPE

In this study as many databases as possible were accessed for case capture, and we believe this is a sound foundation for a population-based study. This is the first study on drowning to comprehensively link datasets across the continuum of care (pre-hospital to fatality), to allow mapping of the patient journey for a drowning event. The inherent value of this approach is evidenced by the previously unexplored magnitude of non-fatal drowning which proved larger than expected, and the impact on health services is therefore apparent. Including morbidity data has enhanced the quality of data in relation to statistical analyses and age groups most at risk, and will inform injury prevention strategies.

The current drowning definition(16,17) encompasses the fact that drowning can result in either death or survival from respiratory impairment. Further detailed data mining would be required to determine if respiratory impairment (which excludes water rescue) had occurred. These data would support an investigation to determine if this is achievable using the definition in its current form. For this paper, drowning survival where medical attention was sought was an attempt to exclude those who did not suffer respiratory impairment. Sixteen percent of non-admitted patients were treated by paramedics (pre-hospital) and were not transported to hospital, and there are a number (at this point unknown) who presented to the emergency department for precautionary care and who potentially may not have suffered respiratory impairment. Limitations in this study relate to the time involved in accessing and linking data, and the associated privacy issues which unnecessarily dates the data. Real time data collection inherently has a lag as Coroners can take several years to definitively confirm cause of death and close cases. Mortality figures available through the Australian Bureau of Statistics are underestimated for the same reason.(24) As data linkage continues to improve in Queensland it is hoped that future studies will allow for more effective and timely linked data.

5.6.3 WHAT THIS STUDY ADDS

- An understanding of all drowning events that require care in Queensland for children 0-19yrs is gained by using data linkage (previously not undertaken for drowning).
- Previously unreported incidence of fatal and non-fatal drowning (IR=15.12/100,000 pa), survival ratio 1:10 and ratio of hospital admission compared with non-admission 1:2.
- Overall there was a significant increase in 0-19yrs non-fatal drowning. Fatalities and admissions reduced however, not with the same magnitude.
- The rate of drowning survivors who sought medical assistance, but were not admitted to hospital, more than doubled.
- The highest incidence rates occurred in the 0-4yrs age group. This group recorded the highest rates for fatality, survival and admission and are higher than national data. Survivals and non-admissions increased, while fatalities and admissions to hospital decreased over the study period.
- Children aged 10-14yrs had the lowest incidence rates for all drowning events.
- Males were over-represented in all age groups except 10-14yrs.
- Significant increases were observed in male non-fatal drowning episodes presenting to hospital.

5.6.4 PREVENTION IMPLICATIONS

Most gains for prevention efforts should focus on:

- Children 0-4yrs; access to water and supervision, with particular attention on critical ages 1-3yrs.
- The reasons children and adolescents 10-14yrs had the lowest rates and the over-representation of males in all age groups except 10-14yrs.
- Whether there is any association between resuscitation response, medical management, or continuing morbidity with increased survival rates.

5.7 CONCLUSION

For every child or adolescent drowning fatality in Queensland, ten others were rescued, revived and survived. Two out of three of those survivors were admitted to hospital. Queensland appears to have made gains in preventing fatal drowning, though not with the same magnitude as the increased trends in non-fatal events. Admissions to hospital as a proxy for severity point to increased numbers of survivors who presented to hospital for treatment, but the numbers who were not admitted more than doubled over the seven years. Males were a large part of the rises in rates. Such increased events should be viewed as both positive and challenging for drowning prevention, warranting additional investigation to explore whether survival is associated with resuscitation response, medical management, improved parental supervision, and continuing or persistent morbidity.

Prevention strategies should continue to target 0-4yr-olds with respect to access to water and supervision, particularly those aged 1-3yrs as this group had the highest fatality, survival and admission rates and are higher than national data. To arrest increased drowning requires closer scrutiny of those who survive drowning events for insights as to why children and adolescents 10-14yrs had the lowest drowning rates and why males are over-represented in all age groups except 10-14yr olds.

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CH 6: LOCATIONS OF FATAL & NON-FATAL DROWNING

CHAPTER 6: WHERE CHILDREN AND ADOLESCENTS DROWN IN QUEENSLAND: A POPULATION-BASED STUDY

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6.1 CHAPTER CONTEXT

This current chapter most importantly identifies the locations of non-fatal drowning as well as fatal drowning. As stated in Objective 5 locations of drowning events in Queensland are identified and the magnitude of drowning at particular sites is quantified, and differences in relation to drowning location in terms of age, severity, and trends over time for the duration of the study period (2002-2008) are examined. The narrative text (rather than codes provided in routinely collected data) revealed contributing factors to the drowning event, which are also presented to inform prevention

strategies. The chapter is inserted as a manuscript, as submitted for publication review with BMJ Open in June 2015.

6.2 ABSTRACT

OBJECT

This retrospective population-based study examined drowning location by the site of immersion for both fatal and non-fatal drowning events in Queensland. Drowning location is not routinely collected, and this study used data linkage to identify drowning sites. The resulting enhanced quality data quantifies drowning incidence for specific locations by geographic region, age group and by severity for the first time.

DESIGN

Linked data were accessed from the continuum of care (pre-hospital, emergency, hospital admission and death data) on fatal and non-fatal drowning episodes in children aged 0-19yrs in Queensland for the years 2002-2008 inclusive.

RESULTS

Drowning locations ranked in order of overall incidence were pools, inland water, coastal water, baths and other man-made water hazards. Swimming pools produced the highest incidence rates (7.31/100,000) for overall drowning events and were more often privately owned pools and in affluent neighbourhoods.

Toddlers 0-4yrs were most at risk around pools (23.94/100,000), and static water bodies such as dams and buckets – the fatality ratios were highest at these two locations for this age group.

Children 5-14yrs incurred the lowest incidence rates regardless of drowning location. Adolescents 15-19yrs were more frequently involved in a drowning incident on the coast shoreline, followed by inland dynamic water bodies.

CONCLUSION

Linked data has resulted in the most comprehensive data collection on drowning location and severity to date for the state of Queensland. Most mortality and morbidity will be prevented by improving water safety through engaged supervision around pools and bath time, and a heightened awareness of buckets and man-made water hazards around the farm home for young children. These data provide a different approach to inform prevention strategies.

6.3 ARTICLE SUMMARY

Strengths and Limitations of this study

- Data linkage with case notes provided enhanced detail on non-fatal drowning locations and contributing factors associated with the environment of those locations.
- Incidence related to drowning locations and the effects of age on rates are reported for the first time.
- A breakdown of pool operators, static and dynamic water bodies, coastal waters, and geographic and socio-economic information provides new perspectives for drowning locations to inform prevention strategies.
- Locations in order of incidence overall were pools, inland water, coastal water, baths and other man-made water hazards.
- Heightened supervision and prevention efforts directed at developmental prevention strategies for all static water hazards close to home are required to reduce the drowning burden for toddlers 0-4yrs who have the largest drowning burden, regardless of the location. Adolescents are more likely to have drowning incidents in coastal water or inland dynamic water.

6.4 INTRODUCTION

Approximately every three minutes somewhere in the world a child aged between 0-19yrs drowns.(1) These young people account for almost half of the worldwide annual total deaths, and those under the age of 5yrs are disproportionately affected.(2, 3) These numbers are believed to be underestimated by 39-50% because drowning due to natural disasters, transport incidents and intentional drowning are not included.(4) These data also do not provide a measure of morbidity associated with drowning survival, nor do they provide information about where the drowning occurred.(5) Current data from Queensland for children 0-19yrs established a fatal rate of 1.5/100,000, yet the non-fatal drowning rate was 13.6/100,000 pa. For every fatality ten other children were retrieved from the water and sought medical assistance.(6)

The circumstances leading to drowning can vary widely, and drowning location, age of the child and the child's activity are inevitably linked.(7-10) Differences in geographical and cultural factors between high income countries (HIC) and low and middle income countries (LMIC) also exist.(10, 11) In HIC, among children up to the age of one year, most drowning deaths occur in bathtubs.(4, 7, 8, 12, 13). After the first year of life, swimming pools and man-made ponds (dams) or reservoirs are more frequently involved.(4, 14, 15) The World Health Organisation (WHO) recognised that poor quality drowning data have contributed to a neglect of drowning as an important public health issue, and that if prevention strategies are to be successful, they need to be tailored to the local context.(4) This emphasises, the importance of good quality local data such as this which identifies drowning locations.

Currently administrative data bases worldwide collect drowning information according to the International Classification of Diseases (ICD-10)(16) at only three locations: baths (W65-66) pools (W67-68), and natural water (W69-70). All other drowning locations are grouped under "specified" or "unspecified" (W73-74), which hinders drowning prevention. Presently there is no international aquatic standard for the classification of water body types which makes comparisons of locations and contributing factors almost impossible between countries. In this study water type has been analysed as five categories to produce data and encourage prevention strategies that may be useful to other countries.

A further challenge to comprehending drowning is the difficulty in obtaining an accurate measure of actual exposure to water. By this we mean using a child-risk measure; that is, children who are likely to access, enter or be near water, rather than children from within a population-based group (some of whom may not necessarily be exposed to water).(17) An Australian study demonstrated that when explored by actual exposure, drowning risk was under-estimated and was higher than road traffic risk.(18) This exposure measure reflects temporal fluctuations, lifestyle and regional characteristics, however, obtaining such data is usually done by telephone survey, is labour-intensive, expensive and logistically only possible in High Income Countries (HIC).

Since the seminal work of Pearn and Nixon,(19) and Pitt et al(20) exposed unfenced backyard swimming pools and bathtubs as high risk locations,(12, 21, 22) the 0-4yr old pool immersion rate trebled in Brisbane to 70.2 in 1986,(23) and then reduced to 20.7 in in 2002.(24) Therefore this is a timely detailed review that encompasses all locations (e.g. pools, dams, bathtubs, creeks and rivers) and an exploration of any contributing factors in the chain of events leading to drowning. These data assist in an understanding of drowning incidents for prevention efforts, which must take into

account child developmental factors, the characteristics of the water body, and the physical and socio-economic environments.(1, 15)

The overarching aims of this paper were to identify locations of drowning events in Queensland children and adolescents, and to quantify the magnitude of fatal and non-fatal drowning at particular sites. Prevention strategies can be adopted for identified drowning sites beyond ICD-10 coding and characteristics associated with reoccurring locations and particular age groups were explored where available. This study fills a crucial gap in reporting locational incidence rates for Queensland children, and presents analyses of fatal and non-fatal drowning location data collected using data linkage. This method achieved the best possible case capture to report all drowning cases as defined internationally.(25, 26) We report for the first time incidence rates for drowning locations which frequently reoccurred in Queensland, along with the severity of events and contributing factors for particular drowning environments.

6.5 METHODS

Data were obtained for all drowning episodes in Queensland where medical assistance was sought for children and adolescents aged 0-19yrs inclusive, between 1 January 2002 and 31 December 2008. For simplicity of reading, we will refer to this entire age group as children. This paper describes all drowning events, and specific drowning groups (for example those who died), as fatal drowning or non-fatal drowning, as per the internationally agreed definition,(25, 26) and respiratory impairment was considered to have occurred if medical assistance had been sought.

Data custodians, extraction criteria and linkage methods are described elsewhere.(6) However in summary, identified data were manually linked to create a comprehensive dataset across the continuum of care. Cases were included once only if a patient appeared in any of the databases accessed, (patient transfers between hospital facilities were excluded) and were categorised as pre-hospital or emergency department (ED) treatment, hospital admission or death. Additionally, cases were included if the patient died at the scene or subsequently without discharge from hospital. Briefly, data on age, gender, drowning location of event, geographical event location (Accessibility/ Remoteness Index of Australia (ARIA) based on event postcode), event time, and day of week were collected. Residential postcode was used to calculate Socioeconomic Index for Areas (SEIFA) and drowning event postcodes were used to determine Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD).(27)

Data on non-fatal drowning locations were obtained from pre-hospital and emergency department case notes, Queensland Injury Surveillance Unit, or ICD-10 codes for hospitalised cases. These notes were also used to obtain information on other circumstances leading to the drowning event.

Descriptive analyses used six categories for drowning locations: 1. Swimming pools (referred to as pools) were considered to be any manufactured structure for swimming in public, private (including wading pools) and commercial spaces. Included in this group were spas where water is not emptied at the end of each use (as opposed to spa baths which are typically emptied after use); 2. Baths were nominated as such and included shower baths and laundry tubs where children were being bathed; 3. Coastal water included beach, surf, and rip currents (where people enter the water from the shoreline) and has been separated from inland water when it was specifically nominated as such in the text. For the purposes of analyses the coastal water category includes ocean and sea where entry to the water was from a boat or jetty, as the number of events were small (6%); 4. Inland dynamic water included creeks, rivers, weirs, streams of water, and flood water; 5. Inland static water is usually naturally occurring water bodies such as lakes, however due to their size, water storage reservoirs (dams) are included as well as those categorised as "inland water bodies" and "large area of water" or "still water" in the data. 6. Locations classified as "other" included manufactured (or man-made) hazards around the home such as buckets, tanks, ornamental ponds, drains and culverts, or animal water storage (such as troughs or dips). These generally involve smaller quantities of water and have been referred to as "other man-made water hazards".

Private and public pool settings were classified by levels of access. Private settings were considered to be a domestic pool (or water body) for private use of the residents (included single and multi-dwelling pools, wading pools, and outdoor spas). Public pool settings categorised on two levels of access: Public restricted access: Commercial/municipal operated (or developed) settings where access is restricted by opening or closing times, or to patrons who may have paid for holiday accommodation or to use the facility, (eg. water theme parks, school pools, hotels, resorts, caravan

or holiday parks; and Public unrestricted access: where there is no fencing, or open and close times (eg. tidal pools constructed on the beach).

Drowning locations were further collapsed into four categories for the purpose of calculating Incidence Rates (IRs). Inland water includes static and dynamic water, and due to small numbers "other man-made hazards" was grouped with missing. The drowning locations were stratified by Accessibility and Remoteness Index for Australia (ARIA)(27) and severity (death, admission to hospital, or not admitted).

Fatality ratios were the number of fatal events over the number of non-fatal events. Crude IRs were calculated for each calendar year, using population data from the Australian Bureau of Statistics(28) and are expressed as per 100,000 per population. Descriptive analyses used data on all drowning events that occurred in Queensland, and IRs were calculated for events among Queensland residents only due to the lack of age-specific population data on non-Queensland residents (for the denominator). Calculation of incidence rates for fatal and non-fatal events was stratified by age, drowning location and severity. Chi square test for trends over time were computed using Centers for Disease Control and Prevention Epi Info ™ 7.1.2.0. Relative Risks (RR) and 95% Confidence Intervals were calculated using IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp released 2013. Descriptive analyses (primarily chi-square tests) were also conducted to determine whether there were variations in characteristics of drowning events. Fisher's Exact was used where assumptions of chi-square tests were violated.

Ethics and approvals were sought and granted from Children's Health Services District (Royal Children's Hospital Human Research Ethics Committee HREC/09/QRCH/38; Royal Children's

Hospital Institutional Approval; University of Queensland Medical Research Ethics Committee #2009001463; Mater Health Services Human Research Ethics Committee #1446E; and National Coronial Information System #CF/07/13729 (2007-2010), #CF/10/25057 (2010-2013), #CF/13/19798 (2013-2016). Director General approval was granted through Public Health Application, Queensland Health 16/3/2010 Ref RD002254.

Custodian approvals were granted from Royal Life Saving Society Australia, Commission for Children and Young People and Child Guardian, Queensland Ambulance Service.

6.6 RESULTS

6.6.1 DESCRIPTIVE DROWNING LOCATION ANALYSES 0-19YRS

A total of 1299 (120 fatal and 1179 non-fatal) drowning incidents among 0-19yr olds in Queensland occurred between Jan 2002 and December 2008. Drowning location could be identified for 1088 (84%) of drowning incidents. Differences in drowning location and age groups are shown in **Table 6-1** (X^2=352.13 df=8 p=<0.001) and indicate that more than half (59%) of all drowning occurred in pools, followed by inland water (13.4%), baths and coastal waters (12.5% respectively), and other man-made water hazards (2.5%). There were significant differences in drowning location by age group. The 0-4yr age group had the highest frequency of drowning in sites in close proximity to home with more than two thirds of drowning events occurring in pools (68%), and 18% in baths. For adolescents 10-19yrs more drowning events occurred at locations further from home in coastal water, followed by inland water and pools. The highest fatality ratio (0.69) for 0-19yrs was associated with other man-made water hazards; and a breakdown of these sites showed buckets as being most predominant (32%). Inland water incurred the second highest fatality ratio (dams stand out in this group with a fatality ratio of 2.67), and pools and baths the lowest. Pools generated the lowest fatality ratio indicating that children were more likely to be rescued from a pool and survive the event than any other locations. Males were over-represented in all sites except bathtubs (X^2=13.21 df=3 p=0.004). More males were involved in events in dynamic water was 1.9:1 rather than static water 1.4:1.

Table 6-1 Drowning location for all drowning by age group, gender and fatality ratios (n=1088)

Location	0-4yrs (%)	5-9yrs (%)	10-19yrs (%)	All drowning (%)	M:F ratio	Fatality ratio†
Pool	489 (67.5)	94 (69.1)	60(26.6)	643 (59.1)	1.6:1	0.09
Public				196		
Private				367‡		
Inland Water	60 (6.3)	24 (17.6)	61(27.1)	146 (13.4)	1.6:1	0.32
Static water				68	1.41:1	0.35
Dynamic water				78	1.9:1	0.30
Bath	128 (17.7)	np (2.2)	5(2.2)	136 (12.5)	0.84:1	0.09
Coastal	22 (3.0)	15 (11.0)	97(43.1)	136 (12.5)	1.3:1	0.10
Shoreline				127		
Offshore				9		
Other man-made water hazards	25 (3.5)	0	2(8.8)	27 (2.5)	2:1	0.69

(%) within location; †Fatality ratio = number of fatal events/number of non-fatal events; ‡80 pools were not able to be identified as public or private; np = not publishable due to small numbers. Data on frequency of Other man-made water hazards are presented in this table but for analyses this category was collapsed into missing. Drowning location was not able to be identified for 211 drowning events (16%).

Eighty eight percent of pools were identified as being operated for public or private use. The frequency of occurrence of particular drowning sites is presented in **Table 6-2** and the top three sites for each age group are ranked for fatal and non-fatal events. The majority of pool drowning events 367 (65%) occurred in privately owned pools and a further 161 (29%) were in public (commercially operated) pools where access was restricted to patrons. There were no fatalities at public unrestricted access pools 35 (6%). Most children who got into difficulty in pools (60%) were in the water rather having fallen in at the time of the incident. However, the inverse was true for 0-4yrs olds as they were most likely (85%) to have fallen in (X^2=15.88 df=4 p<0.01). There were 68 incidents that could be identified as inland static, and 78 as dynamic water incidents.

Table 6-2 Leading fatal and non-fatal drowning locations by age group, Queensland 2002-2008

	FATAL	NON-FATAL
	Ranked location by % of drowning events (n=120)	Ranked location by % of drowning events (n=965)
0-19yrs	1. Pool 43% *(84% private, 16% public restricted access)* 2. Inland water 29% *(static 51%)* 3. Coast 10% *(offshore 50%)*	1. Pool 61% *(63% private, 30% public restricted access)* 2. Bath 13% 3. Coast 13%
AGE GROUP	Ranked locations % of drowning events within age group	
0 to 4yrs (n=724)	1. Pool 56% 2. Inland water 16% *(static 75%)* 3. Man-made 15% *(pond 33%)*	1. Pool 69% 2. Bath 18% 3. Inland water 7% *(static 60%)*
<1yrs	1. Bath 63% 2. Man-made 25% *(bucket 100%)* 3. Pool 12%	1. Bath 71% 2. Pool 20% 3 Man-made 4% *(bucket 75%)*
1 to 4yrs	1. Pool 61% 2. Inland water 18% *(dam 66%)* 3. Man-made hazards 13%	1. Pool 77% 2. Bath 9% 3. Inland water 8% *(static 64%)*
5 to 9yrs (n=118)	1. Inland water 53% *(static 63%)* 2. Coast 20% *(watercraft 60%)* Pools 20% (np) 3. Bath (np)	1. Pool 75% 2. Inland Water 13% *(dynamic 69%)* 3. Coast 10% *(Beach 100%)*
10 to 14yrs (n=58)	1. Inland 44% *(dynamic 100%)* 2. Coast 33% (np) 3. Pool 22%	1. Pool 41% 2. Coast 31% *(shoreline 100%)* 3. Inland water 27% *(71% dynamic)*
15 to 19yrs (n=138)	1. Inland water 52% *(82% dynamic)* 2. Coast 24% *(60% shoreline)* 3. Pool 19%	1. Coast 56% *(94% shoreline)* 2. Inland water 21% *(dynamic 100%)* 3. Pool 19%
Note for sub-categories: Pools (private, restricted access or unrestricted access); Inland water (static or dynamic); Coast (entry to water shoreline or offshore); np=not publishable		

***Remoteness*: Figure 6-1** Figure 6-1 Drowning location by remoteness (ARIA)* of geographic location of event, Queensland 2002-2008 (n=1088)shows the proportion of drowning events that occurred at specific sites in the state of Queensland by remoteness (ARIA). Pools were the most frequent drowning location for all geographic regions, with the majority occurring in Major Cities (33%), Regional (24%) and Remote (2%) (X^2=28.23 df=6 p<0.001). All other drowning occurred at sites in similar proportions across the geographic regions.

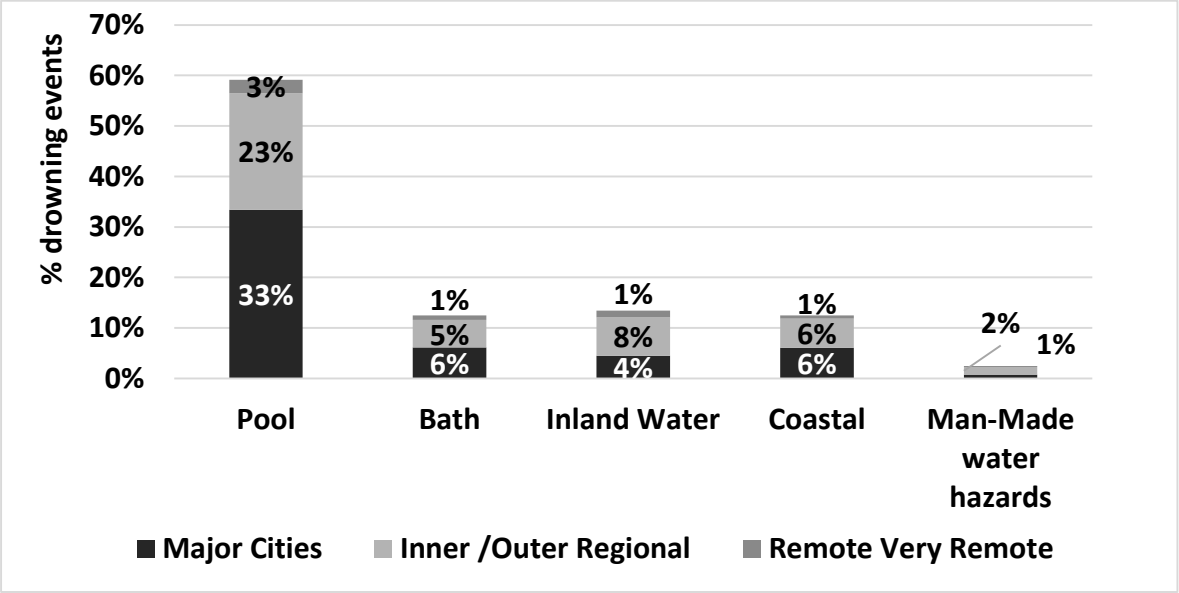

Figure 6-1 Drowning location by remoteness (ARIA)* of geographic location of event, Queensland 2002-2008 (n=1088)

*Note: * ARIA (Accessibility / Remoteness Index of Australia) utilised postcode of the location of the drowning event. Data on man-made water hazards presented in this figure but for analyses this category was collapsed into missing.*

***Socio-economic status*:** Drowning locations varied between areas in the highest 50% of IRSAD (decile 6-10 indicating a relative advantage) compared to those in the lower 50% (decile 1-5 indicating relative disadvantage) (X^2=22.61 df=3 p<0.001). The highest frequency downing locations in most advantaged areas were pools (64%), followed by baths (13%) and coastal waters (12%). In areas with a relative lack of advantage twice as many drowning events occurred in inland water (22% vs 11%) and other man-made hazards (4% vs 2%) than areas of advantage. Disadvantaged areas also incurred higher proportions of fatal drowning events than disadvantaged areas (14% vs 7%), and higher proportions of fatal drowning events compared with non-fatal events (43% vs 28%). (X^2=14.717 df=1 p<0.001).

6.6.2 OVERALL DROWNING LOCATION INCIDENCE RATES 0-19 YEARS

There were 1179 Queensland residents involved in drowning events and 981 (83%) where a drowning location was identified **(Figure 6-2**Figure **)**.

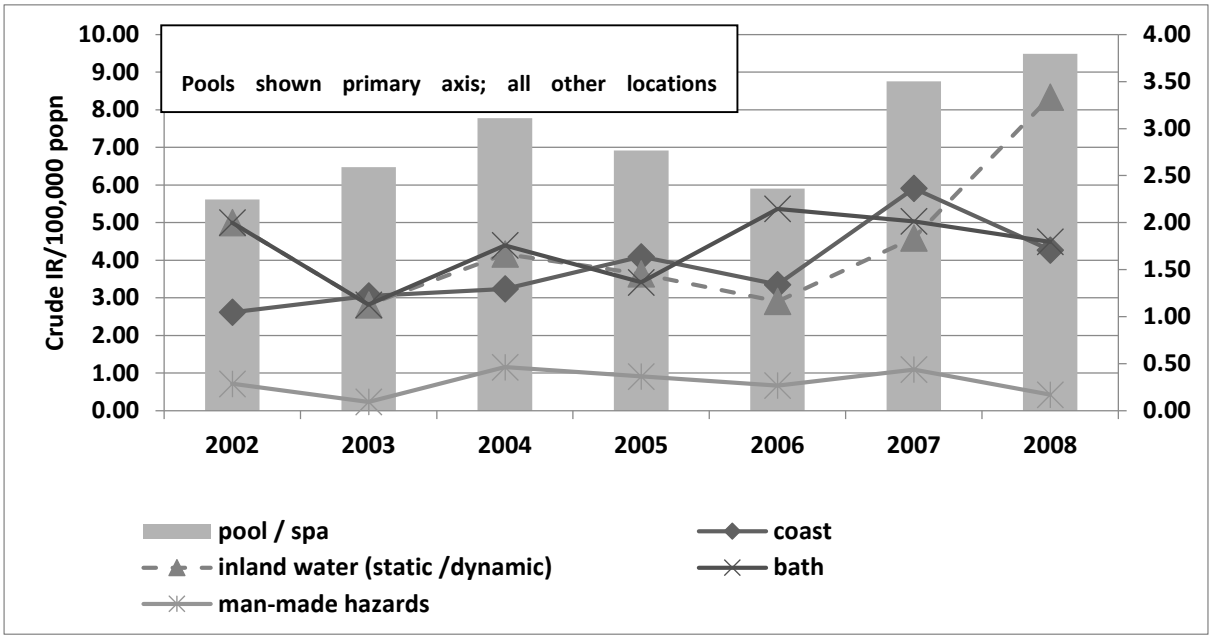

Figure 6-2 Total drowning incidence rates by drowning location, Queensland residents 0-19yrs, 2002-2008

Overall, the highest drowning incidence rates for 0-19yr olds over the study period were in pools. This was followed by inland water, coastal water, baths and man-made water hazards.

Table 6-3 Drowning Incidence rates by location, severity and gender Queensland residents 0-19yrs, 2002-2008

	Fatal	Admitted	Not-Admitted †	Fatal and Non-Fatal IR			
				Total	Female	Male	RR‡ (CI 95%)
Pool	0.65	5.04	1.63	7.31*** ↑	5.76	8.74	1.52 (1.28-1.80)
Inland Water	0.45	0.97	0.39	1.81** ↑	1.41	2.25	1.60 (1.14-2.24)
Bath	0.14	1.14	0.47	1.75↓	1.97	1.54	0.78 (0.56-1.10)
Coastal	0.13	0.56	0.84	1.53*↑	1.41	2.25	1.04 (0.72-1.50)
Other man-made water	0.13	0.09	0.08	0.30↓	0.21	0.38	1.78 (0.76-4.20)

*p<0.05; **p<0.01; ***p<0.001; Increases (↑); decreases (↓), or no change (←→) in drowning incidence over time; † Non-fatal = admissions and emergency presentations; ‡ Reference category females.

Pools had the highest IRs for all types of drowning events **(Table 6-3).** Total drowning rates (fatal and non-fatal combined) for 0-19yr olds significantly increased over the study period for pools (69%), inland water (67%), and in coastal waters (63%), whereas there were small (non-significant) decreases in rates for bath and man-made water locations. Non-fatal drowning events were a significant proportion of these increases - pools (87%), inland water (85%) and the coast (63%). There were no significant changes over time in fatal rates for any location.

The male to female ratio for all drowning events where location could be identified was 1.5:1 which varied by location (X^2=13.21 df=3 p=0.004). Males had a greater risk of drowning than females at any location, but particularly pools and inland water. The only exception was baths where a risk of drowning was 22% lower in males than females though this was not significant (RR=0.78 0.56-1.10).

6.6.3 LOCATION BY AGE GROUP AND SEVERITY

Trends over time: There were no significant changes over the seven years in fatal rates at any of the locations in any age group. Where total incidence rates increased this was primarily due to increases in non-fatal drowning events **(Table 6-4).** Pool rates increased in every age group except for those aged less than 12 months however significant increases over time were observed in pool drowning rates for children 0-4yrs, 1-4yrs and 5-9yr olds. Increased rates were seen in inland water drowning for 10-14yr non-fatal drowning, and coastal drowning in 5-9yr olds. For children over 2yrs bath drowning is a rare event. The highest percentage (74%) of unknown locations was in the 0-4yr age group.

Table 6-4 Trends over time in drowning location incidence rates by severity and age, Queensland, 2002-2008

Age yrs	POOL (n=565)		BATH (n=135)		INLAND WATER (n=140)		COAST (n=118)	
	Non-Fatal	Total	Non-Fatal	Total	Non-Fatal	Total	Non-Fatal	Total
0-4	21.68**↑	23.94*↑	6.36	6.85↓	2.48	3.18↑	0.80	1.13↑
<1	4.55	4.81↓	18.19	19.53↓	1.07	1.07↓	np	np
1-4	26.01**↑	28.78*↑	3.38	3.65↓	2.84	3.72↑	1.28	1.35↑
5-9	3.40**↑	3.55**↑	0.10	0.16↔	0.78	1.20↑	0.47*↑	0.63*↑
10-14	1.51	1.56↑	np	np	1.00***↑	1.20↑	1.15	1.30↑
15-19	0.87	1.07↑	0.15	0.20↑	1.17	1.68↑	2.75	2.90↔

***p<0.05; **p<0.01; ***p<0.001 increases (↑); decreases (↓), or no change (←→) in drowning incidence over time; trends only shown for Total drowning or where significant; np=not publishable due to small numbers being potentially identifiable.**

Analyses for the separate locations stratified by age and severity are shown in Figure and **Table .** Information on contributing factors where they were able to be identified is presented in the following text.

Pool Drowning: Swimming pools **(Figure 6-3Figure)** incurred high drowning rates in the 1-4yr age group for fatalities, admissions, and non-admissions than any of the other age groups.

The highest rates of pool drowning occurred in children aged one, two and 3yrs for total drowning events, hospital admissions and fatal events. Two year olds were the most vulnerable in terms of risk of pool drowning (IR=37.34).

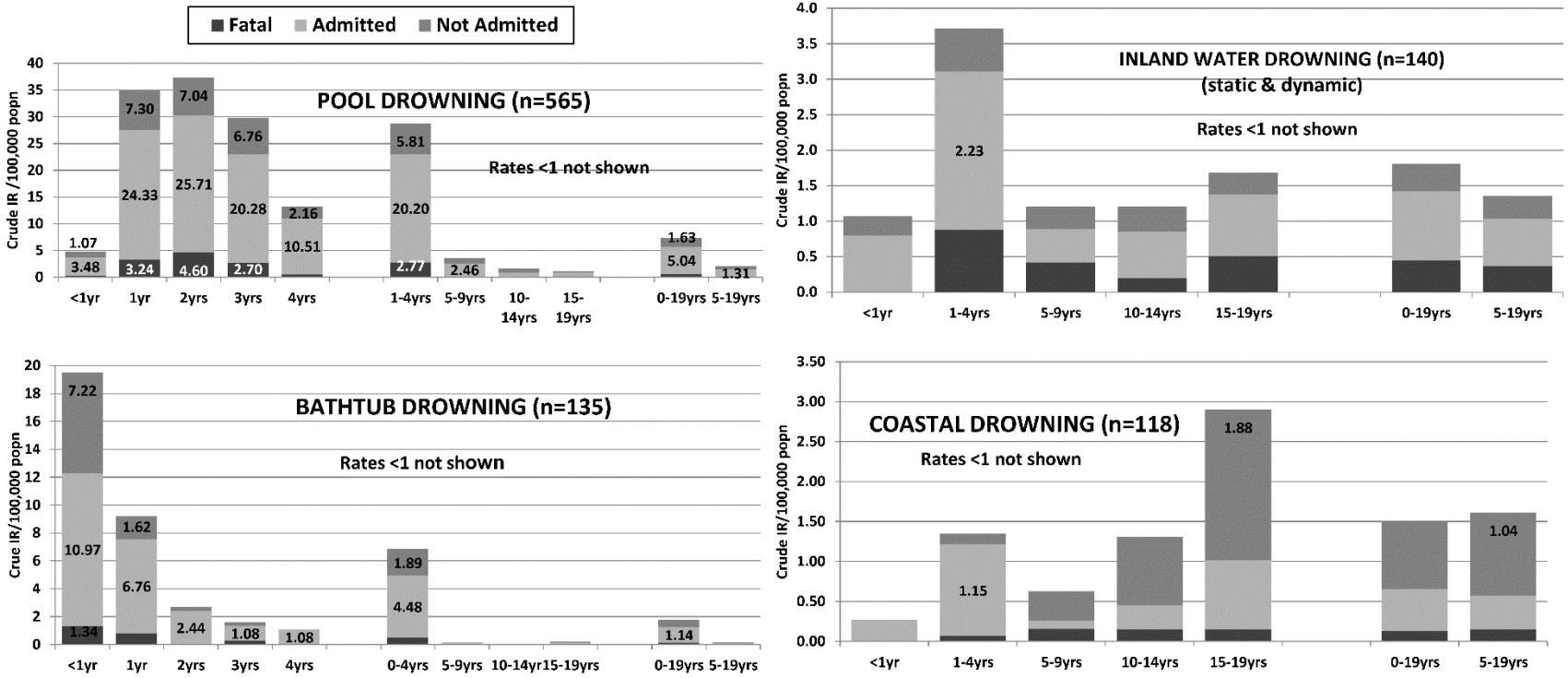

Figure 6-3 Drowning locations incidence rates by severity and age, Queensland, 2002-2008

Table 6-5 Drowning location incidence rates and relative risk of any drowning event by severity, stratified by year of age, Queensland, 2002-2008

Age (yrs)	IR total drowning	RR† of drowning event compared with 5-19yrs (95%CI)	RR† of hospital admission after drowning compared with 5-19yrs (95%CI)	RR‡ of fatal drowning compared with non-fatal drowning (95%CI)	M:F ratio
POOL DROWNING (public & private))					
<1	4.81	2.36 (1.44-3.87)	2.65 (1.47-4.77)	0.59 (0.01.044)	1:1.7
1	34.88	17.07 (13.31-21.88)	18.55 (13.68-25.15)	0.10 (.06-.019)	1.4:1
2	37.34	18.26 (14.30-23.32)	19.60 (14.51-26.48)	0.14 (0.09-0.23)	1.7:1
3	29.74	14.55 (11.23-18.84)	15.46 (11.25-21.24)	0.10 (0.05-0.19)	2.1:1
4	13.20	6.46 (4.63-9.00)	8.01 (5.45-11.77)	0.04 (0.01- 0.18)	1.8:1
1 to 4	28.78	29.12 (22.14-38.31)	15.40 (11.99-19.78)	0.11 (0.08-0.14)	1.6:1
5 to 19	2.04	1	1	0.7 (0.04-0.15)	1.7:1
INLAND WATER (static & dynamic)					
<1yr	1.07	0.78(0.29-2.14)	0.92(0.28-2.97)		np
1-4yrs	3.72	2.73 (1.93-3.84)	3.35 (2.11-5.33)	0.31 (0.17-0.58)	1.5:1
0 to 4	3.18	2.34 (1.67-3.27)	2.92 (1.86-4.60)	np	1.6:1
5 to 19	1.36	1	1	0.38 (0.23-0.62)	1.2:1
BATH DROWNING					
<1	19.53	143.26 (69.04-297.26)	128.74 (50.17-325.78)	0.07 (0.03–0.18)	1:1
1	9.19	67.45(31.23-145.70)	79.35(30.38-207.28)	0.10 (0.03-0.32)	1:1.3
2-4	-	13.21(5.82-30.0029.	17.97(6.63-48.71)	0.05 (.01-0.39)	1:1
0 to 4	6.85	50.25(24.60-102.67)	52.55(21.31-129.57)	0.08 (0.4-0.15)	1:1.1
5 to 19	0.14	1	1	0.33 (0.07-1.65)	1:7
COASTAL DROWNING (shoreline & offshore)					
1 to 4	1.35	0.84 (0.52-1.35)	8.81 (4.01-19.35)	0.05 (0.01-040)	1:1
5 to 19	1.62	1	1	0.33 (0.07-1.65)	1.3:1

RR† - Relative Risk reference group 5-19yrs; RR‡ - Relative Risk reference group Fatal (non-fatal is any drowning event – pre-hospital and admitted); IR – Incidence Rates quoted per 100,000 population per annum; np not publishable due to small numbers

Inland Water: Fatal drowning occurred at this location across all age groups, **(Figure 6-3)** however no infant <1yr fatally drowned in inland water bodies. Dams were the most common location in this category for the 1-4yr age group. Toddlers aged 1-4yrs were 2.7 times more likely to drown than their counterparts aged 5-19yrs in bodies of inland water Error!

Reference source not found.. Admission rates for inland drowning were highest for 1-4yrs (IR=2.23) and <1.0 for all other ages.

Bath Drowning: Bath drowning was more frequent and severe in children under five years (**Figure 6-3)**. The male to female ratio for bath drowning was the same for <1yr and 2-4yrs, but the bath drowning rate was 1.1 times higher for females than males aged 1yr old, and seven times higher for females 5-19yrs (compared with males) (**Table 6-5)**. Ranked fourth in drowning locations overall, bath drowning incidence was the greatest for infants aged 0-1yr. The risk of a bathtub drowning event for an infant aged <1yr is 143 times that of children 5-19yrs.

Examination of case notes showed that the majority (67%) of bath drowning events occurred when there was no supervisor in the room (the child was knowingly left alone in the water even for a short time ranging from 1s to 30mins). Seven percent were left with a sibling (aged between 3-5yrs) where the sibling either did not respond to, or contributed to the drowning in some way, or alternatively alerted the parent (usually that the water was overflowing). A small percentage (5%) was the result of a seizure or intentional harm. None of the 18 cases who had direct supervision were fatal and all but one were aged <1yr.

Coastal Drowning: Fatalities from drowning at the coast were rare (IR<1) but occurred in all age groups. There were no coastal drowning fatalities for infants aged less than 1yr **(Figure 6-3).** Drowning in coastal waters incurred the lowest total drowning rates for all children 0-19yrs. Admission rates were highest for 1-4yrs, and were <1.0 for all other age brackets.

Almost half of fatal coastal events were related to offshore watercraft, swimming alone or at night, or in rough unpatrolled surf. Almost half of all fatal offshore watercraft victims were not wearing a life jacket. Coastal drowning events were more common I older children these events were 16% less likely for those aged 1-4yrs than 5-19yrs **(Table 6-5**Table **).**

Other man-made water hazards: (data not shown due to small numbers). This category had the lowest numbers of drowning events of all, yet the highest proportion of fatalities (41%). All fatalities occurred among 0-4yrs. There were no drowning events (fatal or non-fatal) in 5-9yrs, or 10-14yrs and non-fatal events were rare in 15-19yrs. Incidence was highest incidence in children 0-4yrs (IR=3.18) and 96% of all cases were in this age group. Admission rates for <1yr and 1-4yrs were approximately equal (IR=0.53 and IR=0.54). The majority of these locations involved static water, and buckets were the most common drowning danger (33%). Hazards such as ornamental ponds, tanks, stock troughs and stock dips presented the greatest risks for toddler drowning especially for those under one year (IR=1.34) and a risk of drowning in such water hazards was 78 times that of older children 5-19yrs (RR=78.50 95%CI 9.171-671.90). Males were twice as likely as females to drown in these types of water bodies, but this was not significant.

6.7 DISCUSSION

Drowning locations ranked in order of overall incidence were pools, inland water, coastal water, baths and lastly other man-made water hazards. The magnitude of drowning at these sites was much greater in Queensland than previously reported for the rest of Australia or the USA.(29-32)

Young children aged 0-4yrs had a seven-fold risk of a drowning event over 5-19yr olds,(6) signifying that the high risks for drowning associated with the early developmental years need to be examined in the context of pools, baths, and inland water - particularly water storage dams and other man-made water hazards close to the home. Mortality case series have previously provided the only data on hazardous locations such as dams or buckets,(33) (34-37) whereas, these detailed locations provide insights for national hospitalisation data(32) which lacks location detail beyond ICD-10 coding of pools, baths and natural water. Coding for more than one quarter of the 0-4yr cohort was "unspecified" and yet this age group constitutes 43% of the total all-age drowning hospitalisation in Australia.(32) The detail contained in this non-fatal data points to locations around the home that are not unique to Queensland, and are eminently preventable at a national level with appropriate interventions.

The discussion which follows is presented in the context of location (or water type), the predominant age of the child affected, and any prevalent contributing factors. The results reinforce the necessity for better drowning location definitions (an aquatic standard) for the classification of water body types in coded data enabling prevention strategies to be targeted

by drowning location as well as geographic regions. Such multi-level approaches can target an appropriate audience for the age group at risk, and promote specific interventions observed to have promising outcomes.(10, 38) (39)

Pools

Overall, more than half of all Queensland childhood drowning occurred in pools and predominantly among males. Encouraging signs of fatality prevention are that the swimming pool fatality rate is much lower than reported in 1976 (IR=0.65 vs IR=22.55),(40) and pools incurred the lowest fatality ratio of all sites. However, the highest admission rates, and significant increases in non-fatal pool drowning rates over the reporting period, along with higher rates than previously reported in 1976 (IR=9.49 vs IR=6.2)(40), indicate the potential for morbidity and further fatalities,(10) and highlight that there is no room for complacency if this significant ben is to be reduced. Pool drowning occurs predominantly in privately owned pools, which are more often than not located in areas of relative high socioeconomic advantage. It occurs more often in the city, but also in inner and outer regional areas as well as remote areas across Queensland.

Pool density has been shown to affect drowning(20, 41, 42) although the methods to calculate it differ between pools/population-at-risk and pools/number of dwellings. An estimate of 311,000[1] pools and spas registered in Queensland homes(43) per 1,660,750 dwellings(44) gives density ratio of 1:5 which is similar to an earlier Brisbane City study.(20) To some

[1] *(G Hemmings, A/Principal Advisor DLGP, personal email communication, March 28, 2012)

extent this high density of pools would explain the over-representation of this location in drowning episodes, however, this higher exposure will also require consolidation of political will and public acceptance for ever-strengthening interventions to be implemented. The Queensland Pool Registry (operating since 2010) is anticipated to not only confirm the number of pools in Queensland, but also verify the presence of pool fencing which complies with current legislation. More importantly, with an aging stock of pools in Queensland, ensuring that fences and self-closing gates are maintained and operating is a priority.(45)

It is equally important to prevent young children from getting into the pool alone, but also to protect them while they are in the water. The majority of children got into difficulty while they were known to be in or around water however, 0-4yr olds were most likely to have fallen in. Pool fencing was mandated in Queensland in 1991 and has been shown to be an effective drowning countermeasure for such lapses in supervision of young children.(20, 46) Over the long term, pool fatality in this age group has reduced in Queensland and this has been linked to ever-strengthening legislation implementing standards related to pool fencing.(47, 48) Regulatory control by individual local councils from 1992 led to inconsistencies in enforcement so it is difficult to say definitively that this has reduced fatality on its own, however as the only intervention promoted consistently over the time this is a positive sign toward reducing drowning in this age group.

Obligatory CPR courses for all registered pool owners could provide an opportunity to append other pool safety information about pool toys and flotation devices; the necessity for close, constant and visual supervision.(49, 50) This is particularly critical for the vulnerable ages 1-3yrs. In this study dimensions of supervision ranged from “direct” (constant visual

where physical proximity to the child allowed a quick response) to "indirect" supervision (where the supervisor knows the child is in or near water but is unable to take immediate protective action).(51) Common risk factors were reliance on siblings as caregivers, or a misguided belief that carers would hear if trouble occurred. In the majority of these lapses (over 64%) caregivers knowingly left the child in or near water for just a short time to tend to laundry, food preparation or the phone.

The older age groups incurred the least pool immersions and it is not clear why they were involved in fewer events, but may be related to better swim ability, some level of supervision and/or a developing concept of water safety. Nonetheless, this was the location with the highest frequency for 5-9yr olds, leaving no room for complacency.

Inland water

Ranked second as a drowning location overall, this was the leading location for fatalities in children 5-19yrs. In younger children 1-4yrs more than half (55%) of drowning locations were dams with an astonishing fatality ratio of 2.66. In rural settings a safe fenced house yard/play area is the best way to prevent young children from wandering alone long distances(33) to water hazards that they may have visited regularly. For adolescents 10-19yrs these settings more often involved dynamic water and was more frequently chosen for recreation than pools. Inland water settings have been targeted nationally(52) and this may go some way to reducing the significant increase in drowning at this type of location. Behaviour change interventions which tackle common risk factors such as over- or under-estimating ability or current strength; swimming alone or at night, or after consuming alcohol.(53, 54)

These kinds of water settings were more often found in areas of relative low socioeconomic advantage.

Baths

Hospital admission following a bath drowning was second only to pool drowning in children 0-19yrs. and may be related to the young age of most bath immersions. A further breakdown of ages within the 0-4yr group indicated engaged direct supervision as lacking in the bathroom for infants <1yr. Although bathtubs ranked as the fourth location in overall drowning, a very high risk was indicated for infants <1yr (143 times 5-19yr olds). Bathtub drowning interventions are best targeted at parents of very young children as immersions are unusual above 2yrs. Parents and carers should be reminded to never leave young children alone in the bath (even for short periods) or in the care of a sibling. Baths were the sole location where significantly more females than males had drowning events. The other age group of concern for bath drowning is adolescents 15-19yrs where intent, and the involvement of other substance use played a role.

Coastal water

Non-fatal drowning rates increased over the study period and the coastal shoreline was the second most frequent location for intervention activities for 5-9yrs. Unfortunately, it is not always recorded if coastal drowning events were at beaches patrolled by lifeguards, albeit a sound drowning prevention intervention to address the significantly increasing burden. It is law that children 1-12yrs require a life jacket (PFD) when in small boats.(55) Small watercraft incidents offshore resulting in fatality show that children not wearing life jackets

can and do drown. Water recreation incidents for adolescents 15-19yrs at the surf beach involved rip currents, exhaustion and alcohol. Interventions and risk factors suggested were similar for Inland water drowning (see above).

Other man-made water hazards

These more unusual water bodies produced the highest fatality ratio and mostly occurred in children 0-4yrs (96%). Strengthened efforts are required to educate new parents that buckets left partly filled after use resulted in one third (32%) of drowning events. They are a lesser known but universal threat(35, 37, 56, 57) as are man-made water hazards such as troughs, in-ground tanks, and drains or culverts. There is scope to mitigate access at the time these water bodies are created. These were more common in areas of relatively low socioeconomics generally in line with more rural settings.

Strengths and limitations: This is the first study on drowning locations to comprehensively utilise linked data across the continuum of care (pre-hospital to fatality), and effectively map the 'patient journey' from the moment of retrieval from the water to definitive care. Drowning is a process which is the outcome of a chain of events(58), and data that capture patterns within that chain of events has an inherent value. The value in collecting text narratives is validated by the previously unexplored magnitude of non-fatal drowning locations that frequently reoccur. Data linkage limitations have been published previously.(6)

This linked data is a major strength of this study and allowed identification of detailed information on drowning location. A substantial proportion of data on drowning location were obtained from case notes prepared by paramedics (eARF) who attended the scene, or text entered in the "presenting complaint" field in the emergency department. This was true even for cases resulting in hospitalisation following the drowning event, as information on these events is limited by the available ICD10 codes to the following categories: bathtub (W65-W66), swimming pool (W6-68), natural water (W69-70, with no differentiation between lake, open sea, river and stream); Other specified drowning and submersion (W73); and unspecified drowning locations (W71, a very frequently occurring code indicating it used as a garbage code). Including the pre-hospital and emergency case notes allowed calculation of incidence rates and analyses at a much more detailed level than has previously published. The utility of the consequent linked data is great, and also allowed identification of factors that contributed to the drowning event such as supervision, swimming alone and similar other risk factors. Data on supervision and contributing factors were not analysed in detail in this paper but are planned for the future.

The authors acknowledge that coastal drowning events may be underestimated where it has been categorised as "large area of water" or "natural water". These, along with "natural still water" have been categorised as inland static water. Age-specific population data used to calculate rates for immersion sites may underestimate risk of drowning, however water exposure data(18) and pool data(42) were not available for Queensland. Further work is required in improving the collection and description of aquatic locations. It may be that some parents sought medical care for their children as a precautionary measure after the event, and this is noted when known.

In 2010 further legislation that post-dates these data introduced a register in Queensland where pool owners are obligated to register their pools, and ensure pool fencing complies with Australian standards before sale or rental of the property. Owners who don't sell or rent had a five year window to ensure that their pool fencing complied. Certification requires updating every two years. The register utilises hospital presentation data, and any pool where a child had a drowning event and seeks medical assistance is investigated for contributing causes. We look forward to findings of these inspections to provide contributing factors to morbidity and improved fencing compliance.(45)

6.8 CONCLUSION

This is the first study in Australia to link data for drowning events and explore the differences between fatal and non-fatal drowning locations by incidence, age and severity. This enhanced quality data have identified target populations, socio-economic groups, geographic regions along with contributing factors specifically related to drowning locations in Queensland. This is a different perspective to inform injury prevention strategies.

Swimming pools yielded the highest incidence rates for overall drowning events and pose the largest burden across all age groups. Swimming pools dominate the drowning burden for 0-4yrs and produced the most fatalities, admissions and affect more age groups than any other location. Older children were more frequently involved in a drowning incident at the coast, followed by inland water bodies. Bath drowning requires intervention for infants less than one year. Swimming alone, or for young children, being in the water unsupervised even for a short time was the most prevalent contributing factor. Mortality and morbidity incidence will be reduced by ensuring engaged supervision around pools and at bath time, improved water safety barriers between the house and pools and dams; and a heightened awareness of buckets and man-made farm water hazards.

CONTRIBUTORSHIP

BAW conceptualised and designed the study, carried out the analysis, drafted the initial manuscript and approved the final manuscript as submitted. KW assisted in the design of the study, carried out quality control of analysis, reviewed and revised the manuscript and approved the final manuscript submitted. JN assisted in the design of the study and approved the final manuscript as submitted. RCF reviewed and revised the manuscript and approved the final manuscript. RMK assisted in conceptualisation of the study, reviewed and revised the manuscript and approved the final manuscript as submitted.

COMPETING INTERESTS

None declared

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DATA SHARING

All the data are from the Queensland drowning study titled "7-year Review of drowning in children and adolescents 0-19yrs, Queensland, 2002-2008", and were obtained from third party data custodians with strict ethical guidelines protecting privacy covered under Legislation. Ethics committees, data custodians and Approval from Director General under the Public Health Act all

have specific conditions and requirements relating to access to these data which we cannot breach. Due to the ethical restrictions, the data cannot be sent to a public repository. However, aggregate and non-identifiable data are provided in the tables, and requests for the original data can be sent to the data custodians. The contact details for each data custodian can be provided by contacting any of the following authors:

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CH 7: DROWNING IN ABORIGINAL AND TORRES STRAIT ISLANDER CHILDREN AND ADOLESCENTS

CHAPTER 7: DROWNING IN ABORIGINAL AND TORRES STRAIT ISLANDER CHILDREN AND ADOLESCENTS IN QUEENSLAND (AUSTRALIA)

7.1 CHAPTER CONTEXT

Objective 6 of this thesis was to determine whether the incidence of drowning events, characteristics of children involved in these events, or injury characteristics differed with respect to Indigenous status. It is known that Indigenous children are at greater risk of injury, and that this is a worldwide phenomenon not unique to Australia. It is often difficult to identify Indigenous people within data, and smaller numbers can skew results or make definitive analyses problematic. One of the strengths of additional non-fatal data in this thesis was to increase the sample size and alleviate this problem. Indigenous status was recorded in emergency and hospital admission data making these figures as accurate as possible. These data allow the examination of Indigenous drowning events with Non-Indigenous events to gauge differences by Indigenous status, age, location, and geographic regions.

Preliminary results were presented as an oral presentation at the Australian Injury Prevention Network (AIPN) Aboriginal and Torres Strait Islander Injury Prevention Symposium, at The George Institute, Sydney, July 2013. The conference abstract is in Appendices. The results of this

study were submitted to BMC Public Health March 2015 and the manuscript is inserted below as submitted to the journal.

7.2 ABSTRACT

Drowning in Aboriginal and Torres Strait Islander Children and Adolescents in Queensland (Australia)

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BACKGROUND

Indigenous children are at greater risk of drowning than other children, however there is little known about this group. This study identifies the previously unpublished incidence and characteristics of fatal and non-fatal drowning in Indigenous children and adolescents.

METHODS

Retrospective data (Jan 2002-Dec 2008) on fatal and non-fatal drowning events among Indigenous and Non-Indigenous Queensland residents aged 0-19yrs were obtained from multiple sources across the continuum of care (pre-hospital; emergency department; admitted patients; fatality) and manually linked. Crude incidence rates for fatal and non-fatal events were calculated using population data from Australian Bureau of Statistics.

RESULTS

There were 87 (6.7% of all events) fatal and non-fatal (combined) Indigenous drowning events yielding a crude Incidence Rate of 16.8/100000/annum. This is 44% higher than the incidence rate for Non-Indigenous children. For every fatality, nine others were rescued and sought medical treatment (average 12 per year). There were no significant changes in Indigenous drowning

incidents over the study period. Drowning rates were higher for Indigenous females than males. Overall incidence was higher among Indigenous children and adolescents than Non-Indigenous children for every calendar year and age-group (0-4yrs; 5-9yrs; 10-14yrs) except those aged 15-19yrs where no drowning events were recorded for males.

Location of drowning sites was similar in both populations 0-19yrs, however there were slight differences in frequency at each of the locations. The three leading drowning locations for Indigenous 0-19yr olds were pool 948%), bath (21%) and natural water (16%), and for non-Indigenous 0-19yrs the leading locations were pool (66%), natural water (13%) bath (12%) ($p<.01$). Except for pool drowning, Indigenous drowning occurred more often in geographic ares of relative disadvantage. Among Indigenous children drowning location varied with age ($p<.001$). Most frequent locations by age were: <1yr bath (71%); 1-4yrs pools (80%); 5-9yrs pools (75%); and adolescents 10-19yrs beach/ocean (36%). Severity of event differed statistically with Indigenous status and by remoteness with all fatal drowning events occurring in Regional or Remote areas, and none in Major Cities.

CONCLUSION

For every fatal drowning among Indigenous children in Queensland aged 0-19yrs there are nine non-fatal events. This previously unreported survival ratio of 9:1 indicates the non-fatal injury burden in Indigenous children aged 0-19yrs. Although higher Indigenous drowning rates prevailed, no significant changes over time are concerning. Equally the apparent over-representation of Indigenous adolescent females should be weighed against the absence of drowning among Indigenous male adolescents in the same age group in consecutive years of the study. Further investigation around behaviour and culture may highlight protective factors. Culturally specific prevention strategies which take into account social and demographic indicators identified in this

study should be delivered to carers and peers of vulnerable age groups who frequent specific locations. Females, swim ability, supervision and the young are areas which need to be incorporated into Indigenous-specific interventions for drowning prevention.

7.3 BACKGROUND

Drowning is among the 10 leading causes of death of children and young people in every region of the world.(1) Drowning varies by age group, but for children and adolescents aged 1-24yrs it ranks within the first five causes of death for the Western Pacific Region (which includes Australia).(1) Indigenous Australians have been found to have a drowning risk 3.6 times that of Non-Indigenous Australians.(2) In Australia drowning is the third leading cause of unintentional injury death(2) and drowning hospitalisation rates are higher for Indigenous people of all ages compared with Non-Indigenous.(3)

While it is recognised that Indigenous children suffer a significantly higher burden of morbidity and mortality worldwide(4), in Australia one quarter of all deaths among Indigenous children are due to injury - this is three times the rate for Non-Indigenous children aged 0-17yrs.(5) For the same age group in 2003-2007 the drowning rate was nearly double that of Non-Indigenous adolescents (2.8/100,000 vs 1.7/100,000 respectively.(5)

National Indigenous drowning data has not been published consistently in the past due to poor documentation of Indigenous status and privacy problems encountered when reporting on sub-groups of populations.(4, 6) Small numbers cause fluctuations in trends and results often require cautious interpretation. For example drowning survivors were thought to be underestimated because of poorly documented Indigenous status where hospitalisation and death rates were reported at the same rate (4.3/100,000). (2, 6) In particular, variations in ages and reporting deaths or hospitalisations by region make comparisons difficult.

Notwithstanding the state of Queensland having the second largest Indigenous population (146,429 is 6% of the state) in Australia with almost half are aged less than 20yrs(7), there has been no previous study on Indigenous drowning in young people in Queensland. This is the first population-based study on drowning where data from multiple datasets have been linked to acquire the most comprehensive identification of Indigenous status, and to capture as many cases as possible of fatal as well as non-fatal drowning among this age group. This study addresses the absence of Indigenous data, identifies the incidence and socio-demographics of drowning mortality and morbidity and describes the characteristics for all age groups including aquatic locations. Comparisons are drawn with the Non-Indigenous population in some instances to better inform prevention strategies.

7.4 METHODS

Patient data from multiple portals across the continuum of care were manually linked to collate detailed data on fatal and non-fatal drowning episodes in children and adolescents aged 0-19yrs in Queensland from January 2002-December 2008. For simplicity of reading we refer to Aboriginal and Torres Strait Islander people as Indigenous and Non-Indigenous for those who did not identify as Indigenous. All people 0-19yrs are referred to as “children” and “adolescents” where appropriate. The definition of drowning used in this study is an internationally agreed designation where drowning is acknowledged as a process of respiratory impairment from immersion or submersion in liquid, which can result in death or survival.(8) These analyses used fatal and non-fatal drowning events combined, to avoid the numbers of fatal drowning alone in the Indigenous population being potentially identifying (a requirement of ethics)(9, 10). “All drowning events” and “total drowning” are terms used to describe fatal and non-fatal drowning events combined.

Data were sourced from hospital based reporting systems Queensland Health Admitted Patients Data Collection (QHAPDC), Emergency Department Information System (EDIS); Surgical and Retrieval Team (SATR); Queensland Injury Surveillance Unit (QISU), Mater Health Services (paediatric and adult), and Queensland Ambulance Service (QAS); Fatal data were provided by National Coronial Information System (NCIS); the Commission for Children and Young People and Child Guardian Child Death Review Unit (CCYPCG); and the Royal Life Saving Society Australia (RLSSA). Details on data linkage and data extraction have been reported elsewhere.(11) Briefly, data on age, gender, severity, (deaths, hospital admission and pre-hospital/emergency presentation), drowning location of event, geographical event location, event time, and day of week, Socioeconomic Index for Areas (SEIFA)(12) (based on residential postcode) and Accessibility/ Remoteness Index of Australia (ARIA)(13) (based on event postcode) were collected.

Self-identified Indigenous status is recorded routinely in all datasets accessed for this study except QAS. Country of birth and Medicare eligibility were also checked. For the purposes of this study Indigenous status was allocated using adapted algorithms (14) where Indigenous status was allocated based on the number of times the status values were recorded in individual datasets. If non-Indigenous is greater than Indigenous, status = Non-Indigenous; if Non-Indigenous is less than Indigenous, status = Indigenous; if Non-Indigenous = Indigenous, status = Non-Indigenous; if Non-Indigenous is missing or unknown and Indigenous is missing or unknown, status = unknown. Where two records indicated Non-Indigenous and Indigenous = Indigenous (only two cases). The term “Non-Indigenous” applies to those who identified as not being Aboriginal and/or Torres Islander, and following published guidelines(15), 246 patients were excluded from analyses where Indigenous status was not recorded in any dataset. Site of immersion data were ascertained from police and coroners’ reports (for deaths), and for non-fatal drowning, mined from variables such as

triage text, presenting problem, place/location definitions, activity description, major injury factor descriptions, and the pick-up location where an ambulance attended.

To calculate Incidence Rates (IRs) for Indigenous and Non-Indigenous children in each age group, the estimated Indigenous and Non-Indigenous population at 2006(16) for each age group was used as the population denominator for the specified age group for every year from 2002-2008. This is because while population data for each year of age are available for each calendar year for Non-Indigenous Queensland residents, these data are not available for Indigenous children.(16) Queensland residents were identified by postcode of usual residence and crude IRs were calculated for fatal and non-fatal drowning events (total number of events divided by population). The denominator was sourced from Queensland resident population using Australian Bureau of Statistics (ABS) population data which are provided for each age year, from 1901 onwards.(17) The same data are provided for the Indigenous population, but only until 2006. The ABS provides estimated summary population data for Indigenous and Non-Indigenous children, by age-group (0-4yrs; 5-9yrs; 10-14yrs; 15-19yrs), for the year 2006.(16) The summary data from 2006 were compared with the population data per age year, for years up until 2006 and there were no marked differences for the age group of interest in this study (0-19yr olds). The authors believe that this was the most valid of all available approaches.

IRs are presented per 100,000 population together with 95% Confidence Intervals, stratified by age group and gender for every calendar year from 2002-2008, for total drowning events, fatal events and non-fatal events. Chi square test for trends over time were computed using Centers for Disease Control and Prevention Epi Info ™ 7.1.2.0. Relative Risks (RR) and 95% Confidence Intervals were calculated using IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp

released 2013. Descriptive analyses (primarily chi-square tests) were also conducted to determine whether there were cultural variations in characteristics of drowning events. Fisher's Exact test was used where assumptions of chi-square tests were violated.

Ethics and approvals were sought and granted from Children's Health Services District (Royal Children's Hospital Human Research Ethics Committee HREC/09/QRCH/38; Royal Children's Hospital Institutional Approval; University of Queensland Medical Research Ethics Committee #2009001463; Mater Health Services Human Research Ethics Committee #1446E; and National Coronial Information System #CF/07/13729 (2007-2010), #CF/10/25057 (2010-2013), #CF/13/19798 (2013-2016). Director General approval was granted through Public Health Application, Queensland Health 16/3/2010 Ref RD002254.

Custodian approvals were granted from Royal Life Saving Society Australia, Commission for Children and Young People and Child Guardian, Queensland Ambulance Service.

7.5 RESULTS

7.5.1 DESCRIPTIVE CHARACTERISTICS

A total of 1299 cases of fatal and non-fatal drowning aged between 0-19yrs were identified in the seven years 2002-2008 in Queensland. Indigenous status was recorded for 81% (N=1053) of cases. Results are presented only for cases for which data on Indigenous status was recorded. Nineteen per cent (n=246) of cases were excluded from analyses on this basis. Where Indigenous status was known, there were 87 Indigenous and 966 Non-Indigenous drowning events over the seven years of the study, yielding an annual average of 12 and 138 drowning incidents respectively. Indigenous children represented 6.7% of the total drowning events. The survival to death ratio for Indigenous drowning in children is 9:1.

Severity and Cardiopulmonary Resuscitation (CPR): Comparative data for severity and CPR are described in **Table 7-1.** Overall, Indigenous children constituted 7% of presentations not admitted, 9% of admitted patients and 8% of fatalities. Approximately 30% of cases had first responder attempts at CPR. Proportionately, CPR was attempted in both populations at the same frequency (Indigenous 29% and Non-Indigenous populations 30%).

Table 7-1 - Drowning by Australian Indigenous status showing severity and gender, 0-19yrs Queensland, 2002-2008

	0-19yrs Non-Indigenous (n=966)	0-19yrs Indigenous (n=87)	P value
	%	%	
Fatal	11% (110)	10% (9)	
Non-Fatal	90% (856)	90% (78)	X^2=0.42 df2 p=0.810
Admitted	68% (656)	71% (62)	
Not Admitted	21% (200)	19% (16)	
Male:Female	1.6:1	1:1	X^2=4.78 df1 p=0.029
Received CPR	30% (29)	29% (25)	

Location: Location could not be identified for 116 (11%) drowning events where Indigenous status was known. **(Table 7-2)** Even though the top three ranked locations were similar sites for both Indigenous and Non-Indigenous populations, the proportion by drowning location varied significantly with Indigenous status (X^2=11.31 df4 p=0.026), with most variation observed in the 0-4yr old group. The adolescent age groups 10-14yrs and 15-19yrs each had drowning events at only two locations.

Table 7-2 - Drowning location by Australian Indigenous status and age group 0-19yrs, Queensland 2002-2008 (N =1053)

	NON-INDIGENOUS	INDIGENOUS	
	Ranked location by % of drowning events (n) (n=859)	Ranked location by % of drowning events (n) (n=79)	P value*
0-19yrs	Pools 64% (549) Natural Water 13% (109) Bath 12% (103)	Pools 47% (37) Bath 21% (16) Natural Water 17% (13)	X^2=11.31 df4 p=.026
AGE GROUP	Leading locations by % of drowning events within age group (n) (n=859)	Leading locations by % of drowning events within age group (n) (n=78)	
0 to 4yrs (n=670)	1.Pool 70% (426) 2.Bath 16% 3.Natural Water 8%	1. Pool 52% (30) 2.Bath 26% 3.Natural Water 12%	X^2=14.73 df4 p=.008
<1yrs	1.Bath 67% (55) 2.Pool 21% 3.Other 6%	1.Bath 80% (8) 2.Pool 10% / Other 10%	
1 to 4yrs	1.Pool 77% (409) 2.Natural Water 9% 3.Bath 8%	1.Pool 60% (29) 2.Bath 15% 3.Nat water / Beach or Ocean 12%	
5 to 9yrs (n=118)	1.Pool 75% (80) 2.Natural water 15% 3.Beach or Ocean 9%	1.Pool 55% (6) 2.Beach or Ocean / Natural Water 18%	X^2=5.37 df3 p=.324
10 to 14yrs (n=58)	1.Pool 46% (24) 2.Natural water 31% 3.Beach or Ocean 21%	1.Beach or Ocean 67%(np) 2.Natural water 33%	X^2=7.44 df3 p=.035
15 to 19yrs (n=92)	1.Beach or Ocean 44% (39) 2.Natural water 29% 3.Pool 21%	1.Natural water 67% (np) 2.Pool 33%	X^2=5.24 df4 p=.394
np<5; *frequency of specific age group at five locations (Beach / Ocean, Pools, Natural water, Baths and Other) comparing Indigenous status. Note: Location was unknown in 116 (11%) of cases where indigenous status was known.			

Gender differences were observed for drowning location in Indigenous children, but these were not significant (X^2=7.55 df3 p=.056). Compared to all other locations, for males the most frequent place was pools (62%) (X^2=5.51 df1 p=.019), whereas for females, the most frequent location was baths (75%) (X^2=4.30 df1 p=.038). Pool related drowning events were more common at private residences (54% Indigenous and 68% Non-Indigenous) compared to public pools (27% and 17% for

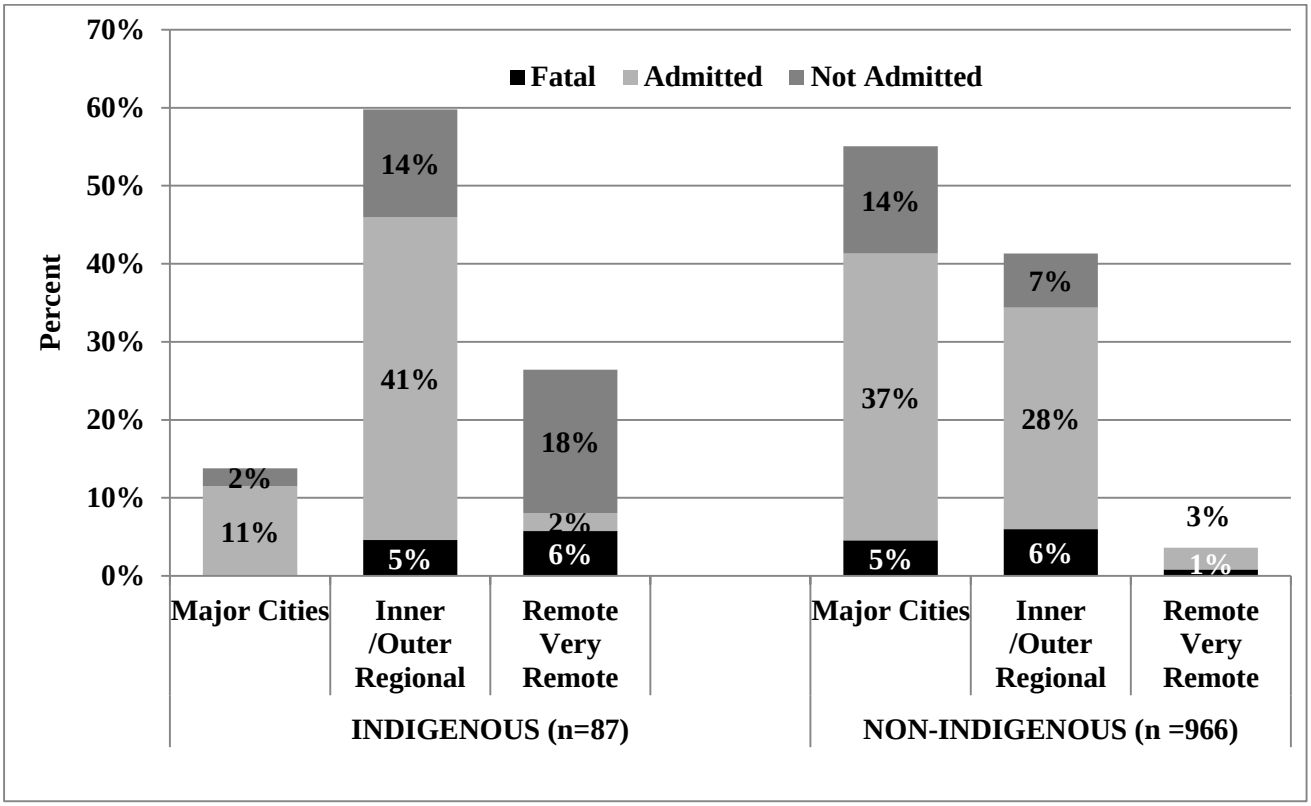
both Indigenous and Non-Indigenous children respectively). While the proportions were different this was not significant, (X^2=2.86 df1 p=.091).

Indigenous and Non-Indigenous drowning by age group: The proportions of each age group involved in drowning were similar between the two populations (X^2=4.69 df3 p=.196). The majority of drowning events occurred in toddlers aged 0-4yrs who made up 76% and 72% of Indigenous and Non-Indigenous drowning incidents respectively. Proportionally fewer Indigenous 15-19yr olds were involved in drowning incidents than their Non-Indigenous counterparts (3% vs 11%). Drowning locations were similar between the two populations although Indigenous children 0-4yrs (52%) had fewer events in pools than Non-Indigenous children (70%) of the same age, and more drowning episodes in baths (26% vs 17%) (X^2=18.02 df4 p=.001).

Indigenous drowning location by age group: There were significant differences for location by age group among Indigenous children. (X^2=31.07 df6 p<.001). Those aged 0-4yrs were more likely to have suffered a bathtub drowning than their older counterparts 5-19yrs (25% vs 5%). All but one bathtub drowning occurred in 0-4yrs and most (50%) were aged <1yr. Just over half (52%) of drowning events for younger children 0-4yrs occurred in pools compared with 35% for 5-19yrs. Natural water and the beach or ocean (30% each) were next the most likely locations for children 5-19yrs.

Remoteness: The geographical location of drowning event (defined by ARIA) is shown in **Figure 7-1** (stratified by Indigenous status and severity). Drowning differed significantly by Remoteness (ARIA) of event and Indigenous status (X^2=108.10 df2 p<.001), with proportionally more Non-Indigenous events occurring in Major Cities (98%) and Regional areas (89%). Drowning severity

also differed by Remoteness with all fatal drowning events occurring in Regional or in Remote areas for Indigenous children, compared with the majority of Non-Indigenous drowning occurring in Major Cities (X^2=85.09 df2 p<.001). For the Indigenous population over half of fatalities (56%) occurred in remote areas (notably, there were none in Major Cities) whereas the majority of non-fatal drowning occurred in regional areas (X^2=4.395 df2 p=0.052.). The inverse was seen in non-Indigenous children. The majority of drowning events for the Indigenous population occurred in pools in Major Cities (75%) and Regional (52%) areas, but in Remote (30%) areas the beach or ocean was the most frequent location. For Non-Indigenous children, pools were the most frequent drowning location for all geographic regions.



ARIA Accessibility / Remoteness Index of Australia utilised postcode of drowning event

Figure 7-1 - Geographical location of drowning events by Indigenous status and severity 0-19yrs, Queensland, 2002-2008 (n =1053)

Season, Weekday and Time: The warmer months from October through February showed consistently higher frequency patterns of drowning for both Indigenous (81%) and Non-Indigenous

populations (77%) (X^2=.450 df1 p=.502). Sunday, Monday and Friday were the days that drowning events most commonly occurred for Indigenous children, but this was not significantly different to Non-Indigenous children (X^2=8.86 df6 p=0.182). **(Table 7-3)** The most critical times for drowning among the Indigenous population were between 12:00-15:00 (28%) and 15:00-18:00 (38%). The location of drowning event varied by time of day for Indigenous children (X^2=13.68 df9 p=.050). The most frequent time of day for all locations was between 12:00-18:00 for both populations, but 20% of Indigenous bath drowning events occurred between 06:00-12:00 (vs 6% of pool drowning) and 17% of pool drowning occurred between 18:00-21:00 (vs 7% of bath drowning).

Table 7-3 – Season, Day of week and time of incident by Indigenous status, Queensland, 2002-2008 (N=1053)

	Day of Incident		
Season	Indigenous	Non-Indigenous	Total
Warm / Wet Oct-March	20% (17)	23% (219)	22%
Cool / Dry Apr - Sept	80% (70)	77% (747)	78%
Day of Week			
Sunday	22.8%	20.7%	20.8%
Monday	18.4%	11.2%	11.8%
Tuesday	9.2%	12.1%	11.9%
Wednesday	12.6%	10.6%	10.7%
Thursday	6.9%	11.0%	10.6%
Friday	16.1%	12.0%	12.3%
Saturday	14.9%	22.5%	21.8%
Time of Day			
06:00-11.59	9.2% (8)	16.9% (164)	16.4%
12:00-14:59	27.9% (24)	25.2% (243)	25.4%
15:00-17:59	37.9% (33)	25.2% (340)	35.4%
18:00-20:59	13.8% (12)	15.0% (145)	14.9%
21:00-00:00	6.9% (67)	6.8% (6)	7.0%
There were 11 events where time was unknown			

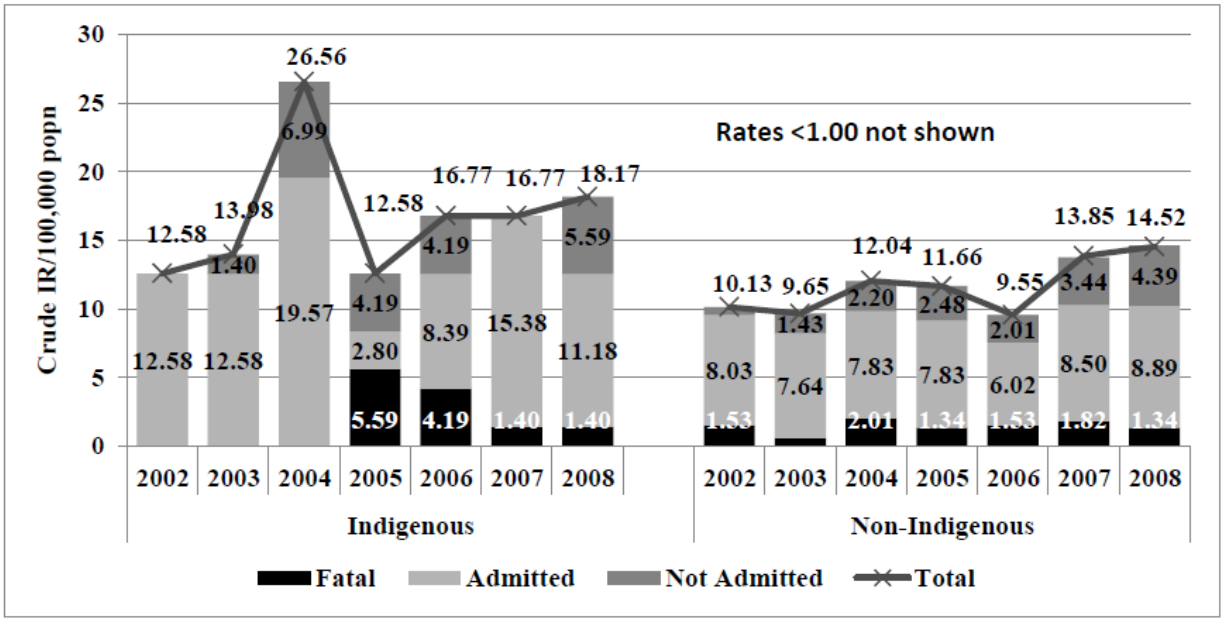
IRSAD: Against the Index of Relative Socioeconomic Advantage and Disadvantage (IRSAD)(12) the majority (58%) of Indigenous children involved in drowning events resided in areas categorised

as being more disadvantaged (IRSAD 1-5[50]). This true for only 28% of Non-Indigenous children (X^2=32.09 df1 p<.001).

More than three quarters (77%) of all drowning incidents that occurred in pools were at residents where households were in the highest 50% of IRSAD (decile 6-10) indicating a relative lack of disadvantage and greater advantage in general. For Indigenous children drowning location differed by IRSAD (X^2=13.77 df3 p=.003), where the 62% of events that occurred in pools were the only drowning site that was located in most advantaged regions (IRSAD 6-10). All other drowning locations for Indigenous children were in regions with a relative lack of advantage (IRSAD 1-5): beach 92%; natural water 77%; and baths 63%.

7.5.2 INCIDENCE RATES

IRs stratified by severity of drowning events **(Figure 7-2)** for 0-19 year olds show Indigenous drowning rates were higher for all types of drowning episodes for every year of the study. The highest number (19) of Indigenous drowning events was in 2004 and varied between 9 and 13 incidents for the other years. The highest number of Non-Indigenous drowning events was 152 in 2008. The non-fatal drowning rates were 47% higher among Indigenous children than Non-Indigenous children and a risk of any drowning events was 1.44 times that of their Non-Indigenous counterparts (RR=1.44 95%CI=1.15-1.81).

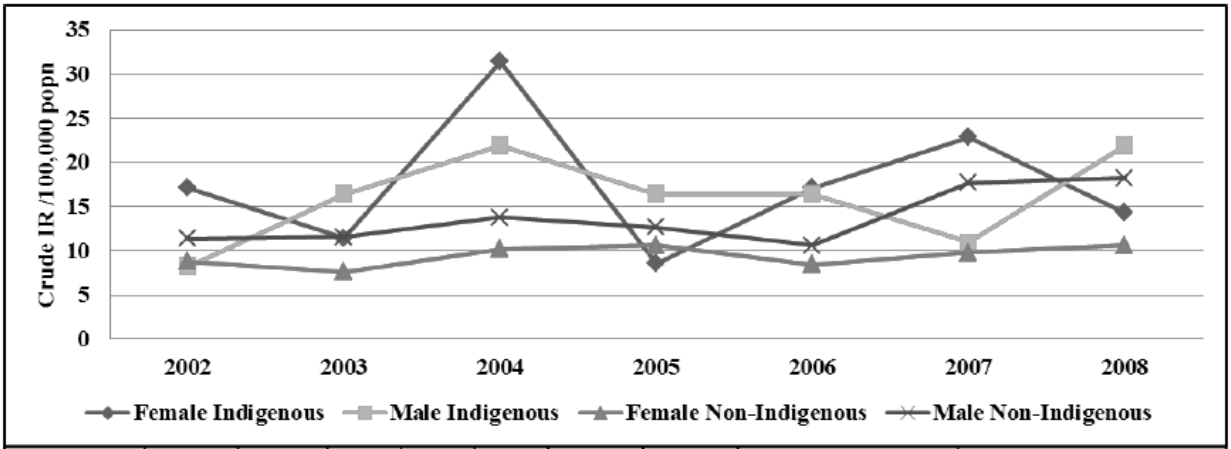


	Indigenous IR (n=84)	Non-Indigenous IR (n=852)	RR† 95% CI
0-19yrs (n=936)	Total IR 2002-2008	Total IR 2002-2008	
All Drowning	16.77	11.63***	1.44 (1.15-1.80)
Fatal	1.80	1.45	1.24 (0.629-2.45)
Non-Fatal	14.98	10.18***	1.47 (1.16-1.87)
Admitted	11.78	7.82	1.51 (1.15-1.97)
Not Admitted	3.19	2.36***	1.35 (0.81-2.26)

Figure 7-2 - Crude incidence rates for Indigenous and Non-Indigenous 0-19yrs by severity and gender, Queensland 2002-2008

Although Indigenous drowning rates were higher overall than Non-Indigenous rates, drowning incidence increased over the study period for both groups at a similar magnitude 44% (12.58 in 2002 to 18.17 in 2008) in Indigenous children (not significant) and 43% (from 10.13 to 14.52) among Non-Indigenous children (this was significant X^2= 11.68; p<.001). There were no significant changes over time in any Indigenous drowning rates, most probably due to small numbers and the unusual peak that occurred in 2004. Significant increases were observed in non-fatal and non-admitted rates for Non-Indigenous males, rates.

Highest rates were observed in Indigenous females rather than males, **(Figure 7-3)** however, these rates did not increase over time as did Indigenous males, (though not significantly) and for both male and female Non-Indigenous children. Rates were higher in Indigenous females than males for four of the seven years. Among Indigenous males drowning incidences increased by a factor of 2.3 over the



	2002	2003	2004	2005	2006	2007	2008	Total IR and Trends 2002-2008 (change %)	RR (95% CI)
Indigenous									
Female	17.13	11.42	31.41	8.57	17.13	22.84	14.28	17.54↓(20%)	0.91 (0.60-1.40)†
Male	8.21	16.43	21.91	16.43	16.43	10.95	21.91	16.04↑(160%)	
Non-Indigenous									
Female	8.83	7.65	10.20	10.59	8.43	9.81	10.59	9.44↑(20%)	1.45 (1.27-1.67)†
Male	11.36	11.55	13.79	12.67	10.62	17.70	18.26	13.71↑***(61%)	

†RR risk of any drowning event (Indigenous male drowning rate / Indigenous female drowning rate) ***p<0.001

Figure 7-3 - Crude incidence rates all drowning among Queensland residents by calendar year, Indigenous status and gender 2002-2008

period. Total drowning rates were higher in female Indigenous children than male Indigenous children, but the opposite was true for Non-Indigenous children. Indigenous females had a risk 1.86 times that of Non-Indigenous females (RR=1.86 95% CI 1.35-2.55) whereas Indigenous males was 1.17 times Non-Indigenous males (RR=1.17 95%CI=0.85-1.61).

7.5.3 INCIDENCE BY AGE GROUP AND GENDER

Data on trends over time by age group and gender are not shown due to small numbers, however, summary data are described below. Rates were higher for Indigenous children in all age groups except 15-19yr old males, **(Table 7-4)** where there was no drowning event recorded during the study period, resulting in a 31% less risk of drowning than their Non-Indigenous counterparts (RR=0.69 95%CI=.218-2.19). Indigenous females aged 0-4yrs incurred the highest rates in any year. For Indigenous females 5-9yrs and Indigenous boys aged 10-14yrs, there were no recorded drowning events in five of the seven years of the study period. For 10-14yr old Indigenous females there were no recorded fatal or non-fatal drowning events in three of the seven years of the study period.

Increases over time were observed in the Indigenous population for total drowning in 0-4yrs (50% increase). Increases were also seen in Indigenous males 0-4yrs (150%) and 10-14yrs, as well as Indigenous females 5-19yrs. However, no significant changes over time occurred in rates in any Indigenous age group or gender over the study period.

Table 7-4: Incidence rates for total drowning by age group, and gender, Queensland 2002-2008

	Indigenous			Non-Indigenous			RR† (95%CI)		
All Drowning Events	Male	Female	Total	Male	Female	Total	Males	Females	Total
0-4yrs	47.73	50.14	48.92	42.97*	29.60	36.48	1.16 (0.81-1.66)	1.70 (1.18-2.43)	1.34 (1.04-1.73)
5-9yrs	8.99	4.63	6.84	5.85**	3.42**	4.66***	1.54 (0.66-3.56)	1.35 (0.41-4.44)	1.47 (0.74-2.92)
10-14yrs	4.45	6.35	5.37	2.77	2.92	2.84	1.59 (0.48-5.23)	2.18 (0.76-6.22)	1.89 (0.86-4.16)
15-19yrs	0.00	5.82	2.83	5.00	3.16	4.10	-	1.84 (0.56-6.05)	0.69 (0.22-2.19)

†Relative Risk (RR) risk of total Indigenous drowning relative to total Non-Indigenous drowning by age group
*p<0.05; **p<0.01; ***p<0.001 used to denote significance for change over the seven year period

7.6 DISCUSSION

The effectiveness of data linkage across the continuum of care has demonstrated that a most accurate assessment of drowning incidence is possible. These data reveal a drowning rate of 16.8/100,000 per annum for Indigenous children 0-19yrs, which is 1.44 times higher than the incidence rate for Non-Indigenous children. Overall incidence was higher among Indigenous children and adolescents than Non-Indigenous children for every calendar year and age group (0-4yrs; 5-9yrs; 10-14yrs) except those aged 15-19yrs. Indigenous children have been identified as at risk,(18) and in this study a national drowning mortality rate of 1.8 compares favourably against a national figure of 2.8 among Indigenous children 0-17yrs in 2003-2007.(5) Furthermore the fatality risk ratio for Queensland is an improvement on the national figure (1.2 vs 1.7 respectively). (5) However, this study shows that considering death data alone is not necessarily a clear view of the drowning burden on the Indigenous community or the health system. There is room for improvement, particularly where hospitalisation rates for injury (which includes drowning) in Indigenous children showed no significant change from 2004-05 to 2009-10.(19)

A drowning survival ratio for Queensland Indigenous children was 9:1. That is, for every fatality nine others are rescued and survive. On average one Queensland Indigenous child or adolescent was involved in a drowning episode each month. Indigenous children 0-19yrs represent 6% of the Queensland population, and this study found they represent 6.7% of drowning events. However, if 246 events with unidentified status were not included this figure would indicate over-representation at 8.3%.(15)

Indigenous children have a significantly higher risk (44%) of drowning than Non-Indigenous children. Drowning rates increased over the seven year period by 43% in Indigenous children. No significant changes in rates were observed during the study period for Indigenous children overall, or for gender and age subgroups. This is of concern because it demonstrates that there was no reduction in drowning in the Indigenous population aged 0-19yrs over the study period, and highlights the need for targeted culturally appropriate drowning prevention programs.

Drowning has the heaviest toll on the young(1, 20-22), and Indigenous toddlers have been previously identified as the most at-risk group.(21-23) The rates identified in this study for fatal and non-fatal drowning at 48.92 and 36.48 for Indigenous and Non-Indigenous toddlers respectively concur with those findings. Indigenous toddlers had a risk 1.34 times that of Non-Indigenous, although Indigenous toddlers had (non-significant) increased drowning over time. Compared to these findings however, national data for non-fatal hospitalisations for Indigenous children 0-4yrs were more than double that of their Non-Indigenous counterparts (34/100,000 vs 14/100,000).(3) These results are also in contrast to three previous studies from the Northern Territory where fatal Non-Indigenous toddler drowning was at higher rates than Indigenous.(24-26) Comparisons are problematic however, with rates calculated for fatal, admissions or fatal and non-fatal combined. An evaluation of any drowning prevention interventions which may be introduced as a result of these data would support and further inform drowning prevention in this age group.

There is no apparent rationale other than random variability for the 2004 high point in Indigenous drowning, where Indigenous female non-fatal drowning effectively doubled the average numbers and was contributed to by higher than average Indigenous male drowning and toddlers. Prevention interventions and weather were ruled out. It also should be noted that there were no fatalities among

the 19 female events. Whereas being male is a risk factor in most injury or drowning scenarios(1), Indigenous females 0-19yrs drowned at higher rates than their male counterparts. This finding has not been found elsewhere; however this apparent incongruity was more likely due to no drowning being recorded for males 15-19yrs over the seven years of the study. Female drowning differed by age group, the 15-19yr age group incurred higher rates than their male counterparts, and this gender anomaly was consistent with national data for females 5-14yrs where rates were higher as well. (3) Drowning rates in Indigenous adolescents were half (45%) that of Non-Indigenous 15-19yrs, and this is certainly a factor worthy of further investigation both in terms of culture and behaviour to identify protective factors. Injury prevention approaches should focus on the activities of females for swimming ability and supervision around pools and bath time. Similarly, investigation of potential protective factors for adolescent males would inform prevention strategies.

Very little prevention work has been undertaken around adolescent drowning previously. West Australian Indigenous children 0-14yrs fatally drowned at twice the rate of Non-Indigenous in the early 1990's(22), and in the Northern Territory Indigenous fatal rates varied from 9% higher (5.4/100,000 1983-1998) to Non-Indigenous rates being 34% higher (9.2/100,000 in 1998).(24, 25) Adolescent behaviour may play a role in fewer drowning incidents in this age bracket. Indigenous numbers in the adolescent age groups are relatively low and may be linked to cultural practices. Roaming further from home and with less supervision are life skills which require to be learned earlier in some cultures than others, and for those who live in less urbanised areas, this freedom comes more easily. Similarly, protective factors may be associated with groups of adolescents looking out for each other.

The older adolescent age group will require culturally appropriate interventions to be devised which are specific to regions as well as aquatic locations. Incorporating links to land and community will assist success such interventions.(27) The method of delivery is particularly important for these populations and will require appropriate consultative input.(28, 29)

The top three ranked locations although the same in each of the populations were statistically different with Indigenous drowning less frequent in pools and more frequent in baths. These findings are consistent with earlier research from the 1970's(30-32) and also the unique drowning pattern found in the Northern Territory where lower pool drowning rates were found in Indigenous children 0-4yrs than in Non-Indigenous children the same age(25, 26). The authors attributed this over-representation of Non-Indigenous children to lifestyle affluence and access to pools. Interestingly, findings in this study agree with pool drowning being connected to more advantaged residences(12), but that Indigenous children also have access (54%) to such pools as well, and consequently share the drowning risk. Better supervisor and life guard vigilance at public pools could potentially reduce the 27% of drowning events at those locations for Indigenous children. All other Indigenous drowning locations were in areas at the most disadvantaged end of the scale pointing to a need for prevention education for this demographic.

Our geographic data indicate that Regional areas and Remote or Very Remote locations have proportionately more (84%) Indigenous drowning events than do Major Cities. Education interventions must reflect appropriate and current demographics and target a broad cross-section of the population to be effective. It may be that new media should be explored as a method of water safety programs to small populations across vast distances.

There were differences in drowning locations by age group. Parents and carers of infants less than one year old should be reminded never to leave baby alone in water or in the care of another sibling. Of concern is the high number of drowning incidents in pools in both Indigenous and Non-Indigenous populations, especially those aged less than five years. National data on injury hospitalisation are similar indicating the majority of 0-4's non-fatal drowning is related to pools or bathtubs.(3) Queensland has the highest pool ownership in Australia at one pool per six households.(33, 34) Data on presence or adequacy of pool fencing was not available for this population, however pool fencing has been proven successful in preventing unintended access to pools of young children and coupled with adequate enforcement, such as Queensland has implemented in 2010 is necessary to make this strategy effective.(35, 36) (37, 38) Other life saving measures such as first responder attempts at CPR were collected from police and paramedic reports and while proportions are equal amongst the two populations, a 30% uptake indicates room for improvement in learning or attempting CPR. This may be of greater importance to the Indigenous population where the majority of incidents occurred in regional and remote areas and where help may take longer to arrive.

***Strengths and Limitations*:**

The detail in the data from this study provides the first evidence of fatal and non-fatal drowning incidence among Indigenous and Non-Indigenous children in Queensland.

This is the first study in which state-wide data across the continuum of care (pre-hospital to fatality) have been linked to estimate the magnitude and nature of drowning events among Indigenous Australian children, over a significant period of time, and the authors believe it is the most comprehensive and accurate data on Indigenous drowning in Australia to date. The inclusion of data from sources such as pre-hospital (QAS) and QISU (dedicated injury surveillance data)

represent a significant improvement over previous studies (especially in relation to details of non-fatal drowning events (for example, drowning location and time of day).

It is acknowledged that Indigenous status has not been well documented in health records(4, 6), however, accuracy of Indigenous identification from public hospital records in Queensland was 87% in 2011-12. For Australia-wide data in 2007-2008 this estimate was 89%(39, 40). The authors therefore acknowledge that data on Indigenous status may be under-reported by 11-13%, and that this along with 19% of cases which were excluded due to unknown status may create a bias in the data. However, there is no way of knowing what proportion of children who were excluded from these analyses due to unknown Indigenous status were Indigenous. It is also possible that some of the drowning events involving Indigenous children during the study period were misclassified into the non-Indigenous group, due to reluctance to report true Indigenous status by carers, or due to errors by medical staff. In addition, identification of Indigenous status is not routinely or consistently collected in all data sets. This information is not collected in QAS data so drowning events which had prehospital attendance only were not included in this study. For all these reasons, it is likely that these results are an underestimate of Indigenous involvement in drowning events.

It appears that the absence of drowning events in the Indigenous 15-19yr males is accurate, as there is no apparent anomaly in the data collection for the same age-group in the Non-Indigenous population. The authors can only assume that if there were drowning events that they were not serious enough to have sought medical attention.

7.7 CONCLUSIONS

Fatal and non-fatal drowning incidence among Indigenous and Non-Indigenous children in Queensland is presented for the first time, where the Indigenous population rate was 1.44 times higher. Among the Indigenous population, for every fatality, nine children survived. The over-representation of young Indigenous children and females over the study period will need to be addressed in a culturally appropriate manner at many levels to reduce drowning rates. Equally the apparent over-representation of Indigenous adolescent females should be weighed against the absence of drowning among Indigenous male adolescents in the same age groups in consecutive years of the study. Investigation around behaviour and culture may highlight gender-related protective factors. The quality of data from this study identifies risk factors and gives good insight for interventions to target specific socio-demographics, age and gender groups. Regional areas and Remote and Very Remote communities within Queensland and pool and bathtub safety for the young are particular prerequisites.

Abbreviations

A&TSI Aboriginal and Torres Strait Islander

ABS Australian Bureau of Statistics

ARIA Accessibility Remoteness Index of Australia

CPR Cardiopulmonary Resuscitation

IR Incidence Rates

IRSAD Index of Relative Socioeconomic Advantage and Disadvantage

np not publishable

NSW New South Wales

WA Western Australia

Qld Queensland

Tas Tasmania

NT Northern Territory

SA South Australia

SEIFA Socio-economic Index for Areas

Authors' contributions

BW conceived the study, study design, acquisition of the data, carried out analyses and wrote the first draft of the manuscript. KW assisted with the collation of data, and analyses, synthesis of analyses and assisted with the draft of the manuscript. RF assisted with the acquisition of data, participated in the drafting of manuscript and synthesis of analyses. RMK participated in the study design and helped draft the manuscript. All authors read and approved the final manuscript.

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Data availability

All the data are from the Queensland drowning study titled "7-year Review of drowning in children and adolescents 0-19yrs, Queensland, 2002-2008", and were obtained from third party data custodians with strict ethical guidelines protecting privacy covered under Legislation. Ethics committees, data custodians and Approval from Director General under the Public Health Act all have specific conditions and requirements relating to access to these data which we cannot breach. Due to the ethical restrictions, the data cannot be sent to a public repository. However, aggregate and non-identifiable data are provided in the tables, and requests for the original data can be sent to the data custodians. The contact details for each data custodian can be provided by contacting any of the following authors:

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CH 8: DISCUSSION & CONCLUSIONS

CHAPTER 8. SUMMARY OF KEY FINDINGS AND IMPLICATIONS FOR FUTURE POLICY, PRACTICE AND RESEARCH

8.1 OVERVIEW

This is the first study to link data from multiple portals across the continuum of care for fatal and non-fatal drowning. This study has shown a complete picture of the full extent of drowning in the Queensland child and adolescent population for the first time, and has articulated the drowning process which can end in death or survival. A substantial finding was to confirm that those who survived a drowning event were 10 times more than those who died. That equates to 168 children every year who experience a "near miss" drowning event and demonstrates the overwhelming potential for additional drowning injury, as well as a burden on the health system. Furthermore, the non-fatal drowning rate over the study period more than doubled leaving no room for complacency, and further stimulates the need for prevention stratagems.

One of the many strengths of this study is the additional detail on non-fatal drowning location, and contributing factors facilitated by data linkage. This includes detailed information related to drowning on the demographic characteristics (socio-economics, geographical location, Indigenous status), environmental characteristics (time, day, season,

location, owner/operator, proximity to water) and clinical characteristics (severity, CPR, Glasgow Coma Scale, and health service usage), most of which have not been presented previously. Further synthesis and the value of this information is demonstrated by landmark GIS mapping, and the application of a framework to assist the analysis of narrative text (Chapter 4). Furthermore, recommendations for future research (some of it invested in this dataset) and prevention initiatives have been formulated, and suggestions are made as to where these initiatives might best be realised – whether at individual, community, institutional or policy level.

This study is a population-based study which means that it has a high degree of applicability beyond Queensland. The main findings can be extended to other populations within Australia or other similar high income countries (HICs), although risk factors such as indigenous status, location and social or socio-economic factors are contextual.

In this final chapter, further discussion is provided on the benefits and feasibility of routine data linkage to track drowning and the barriers that would have to be overcome to achieve this. The important value of the data extracted, particularly with regard to the drowning survivors, and the implications of these results for non-fatal drowning prevention and future initiatives are far-reaching. Such administrative difficulties have been overcome in Western Australia with a 30-year proof that privacy can be protected. It is apparent that drowning inflicts a heavy burden on the health system with critical services most often used. Reduced drowning has potential savings for the health system which could be redirected to prevention. It is anticipated that the results of this study will change the way that drowning is viewed, and

that practitioners can make tactical changes to prevention practices through the recommendations and research initiatives suggested.

All objectives of this study were linked to a specific chapter, and a summary of how each of them was successfully addressed and the significant findings is presented here.

In **Chapter 1**, an overview of the burden of drowning from global and Australian perspectives presents evidence that drowning is a considerable burden worldwide imposed disproportionately on the very young. While an international drowning agreement in the last decade defines drowning as a process that can end in death or survival(1, 2) there are no data routinely collected on non-fatal drowning or the associated morbidity in Queensland (or Australia) to assess the magnitude. Three studies(3-5) in Australia have conducted cost analyses of drowning and although figures vary, and are now also more than a decade old, there is no doubt that this injury is a substantial impost on the health system. It is possible that the data presented in this thesis could support a cost analysis in the future.

The theoretical framework that underpins this thesis is the public health approach to injury prevention, by 1)

Chapter 1 concludes with a rationale for this thesis. In Queensland, drowning data are not held in one easily accessible place; comparable data are rarely published; there has been no recent estimate of the cost of drowning; there is no real-time collection of drowning death data; non-fatal drowning events have not been recorded in any consistent or complete fashion; location of drowning events are only recorded for drowning deaths; and interventions have been hampered by lack of detail in coded data. There is a lack of population-based studies of sufficient quality including relevant information on the true magnitude of fatal and non-fatal drowning, and more specifically, on the circumstances leading to the event. In this thesis, data were collated and linked from the various agencies

who participated in the care of the drowned victim aged between 0-19yrs, from retrieval to rehabilitation or death. This approach captured as many non-fatal cases as possible, and effectively mapped the patient journey to reveal chain-of-event data. An accurate incidence rate of fatal and non-fatal drowning incidents is a much needed surveillance tool for appraisal of new or changing needs in the population.

The overarching aim of this thesis was to link data from multiple portals regarding fatal and non-fatal drowning in children and adolescents 0-19yrs in Queensland. To achieve this aim a series of underlying objectives were to:

Objectives:

- Provide a list of drowning prevention interventions for children and young people (0-19yrs) including associated risk factors for drowning (Chapter 2)
- Locate, collate and link data, accessed from multiple databases on fatal and non-fatal episodes of drowning in children aged 0-19yrs in Queensland for the years 2002-2008 (Chapter 3)
- Describe the demographic, clinical and environmental characteristics of fatal and non-fatal drowning (Chapter 4)
- Estimate the incidence of fatal and non-fatal drowning events in Queensland involving children aged 0-19yrs (Chapter 5)
- Identify locations of drowning events in Queensland and quantify the magnitude of drowning at particular sites, to examine how drowning location varies in relation to other characteristics such as age, gender or socio-economic status (Chapter 6)
- Determine whether the incidence of drowning events, characteristics of children sustaining these events, or injury characteristics differed with respect to Indigenous status (Chapter 7)

- Provide a set of recommendations including future research and approaches to prevention of drowning deaths in children aged 0-19 years in Queensland (Chapter 8)

In this current chapter, the key findings of this thesis (Chapters 2-7) are summarised. Detailed discussions are contained in each of the chapters where they are considered in the context of the current literature, and strengths and limitations of the research. The following is a synthesis of these discussions which distil conclusions for this thesis. The research findings and recommendations are summarised in a table at the end of each section with a relevant action level for the recommended initiative to be developed. The various levels where initiatives could be developed begin with a focus on the individual and family, then on to community norms, institutional practices and laws.(6) This systems approach for drowning prevention work is aimed to assist practitioners design and implement comprehensive intervention with the objective of translating this research into practice and moving drowning prevention forward.

8.2 SUMMARY OF KEY FINDINGS AND IMPLICATIONS FOR FUTURE POLICY, PRACTICE AND RESEARCH

8.2.1 LITERATURE REVIEW: POSITIVE INTERVENTIONS

Despite a large body of literature on drowning spanning many decades, this is the first systematic review of drowning interventions for children aged 0-19yrs. The evidence presented in the systematic literature review (**Chapter 2 "Literature Review"**) shows that within the extensive literature on drowning interventions, relatively few studies employ rigorous methods to assess the impact of interventions designed to reduce drowning, and so the quality of the available evidence is not high. What is clear is that child drowning is a significant issue, especially for children aged less than 5yrs, and that there is very little information about drowning prevention among adolescents aged 15-19yrs. The three strategies with the strongest evidence utilised education for water safety strategies; swimming lessons and water safety classes; and pool fencing. The systematic review showed methodological limitations in the evaluation of the intervention strategies. This should not be interpreted to mean that the intervention strategies are not effective – rather, conclusions about the effectiveness of the interventions are limited by the methods used for evaluation. Importantly, no one strategy is independently effective in preventing all drowning.

The strongest evidence was from pool fencing for young children aged less than 4yrs, but only when fences are 4-sided, well maintained with a self-closing gate, and compliance is enforced (organisational change at government level). The effect of legislation on injury rates can only be measured by up to date and reliable surveillance, which includes pool numbers and the presence and status of fencing. Data collected should include the sequence

of events leading to drowning, pool density, exposure, and fencing configuration in place. Most importantly when children are in the pool space, supervision and aquatic skills are required. Organisational change (at government level) is necessary to improve safety behaviour beyond the mere passing of safety laws.

Swimming lessons and water safety are possible effective strategies, particularly for young children aged 2–4 years, but no children less than 2yrs were included in any of the reviewed studies. There is no evidence about whether this is a sustained or enduring skill, nor whether it is transferable to various aquatic settings. Children in older age groups who can swim still drown, so whilst swimming ability can improve, this is an adjunct preventative intervention - not a solution on its own. Further research should focus on studies of observed behaviour and skills rather than self-report, and/or knowledge-based measures, particularly around swimming skills and wearing life jackets. Successful education interventions for drowning prevention should cover one particular water safety aspect at one time (e.g., CPR) and deliver tailored information appropriate to the target age groups (e.g., school classroom) with safety devices provided (e.g., face masks).

Three significant gaps in current research have been highlighted. Firstly, a lack of consistency in measured outcomes and drowning terminology is a shortcoming that requires international input. The glossary provided in Chapter 2 encompasses terminology which arose during the course of the thesis that is potentially confusing. Secondly, clarification is required regarding measurable criteria such as what a formal swimming lesson entails, participation, retention of skills, and a definition of what "being able to swim" requires. Thirdly, water familiarisation in children less than 2yrs is controversial, younger children can

acquiring water safety skills however, the average time taken to achieve these skills from the start of the formal lessons, takes longer with the decreasing age of the child.(7)

Recommendations	Where to target action for prevention activity(6)
FUTURE RESEARCH	
Methodologically sound studies on evaluation of drowning interventions, using comparable control groups and objective and reliable measures including morbidity and mortality data, sufficient sample size, sufficient time period, consistent definitions and include an accurate measure of exposure.	Coalitions, networks and collaboration for funding particularly between LMIC and HIC
Of the highest priority should be intervention studies that focus on the following:	
Clarification of measurable criteria such as what a formal swimming lesson entails, participation, retention of skills, and a definition of what "being able to swim" entails.	Coalitions, networks and collaboration for funding particularly between LMIC and HIC
Development of modules of education interventions that cover specific topics (e.g., CPR) to be delivered to specific groups, with appropriate free devices	Community norms: by promoting community education and strengthening individual knowledge and skills
Develop a marketing behaviour-change strategy for drowning prevention for adolescents 15-19yrs	As above
Better quality studies to demonstrate the efficacy of pool fencing and supervision to reduce non-fatal drowning	As above
The benefits of water familiarisation classes for children <2yrs	As above
Observed behaviour studies on acquired swimming skills, PDF wearing	As above
PREVENTION INITIATIVES	
National uniform pool fencing laws based on evidence based building codes and standards applied retrospectively to all pools no matter when constructed	Policy and legislation Organisational change in practice
Active enforcement of uniform pool fencing laws with inspection regimes that ensure maintenance of fencing and dynamic gates, particularly on sale or rental of properties	Policy and legislation Promote community education Strengthening individual knowledge and skills
Four-sided isolation fencing that limits access from the house	Policy and legislation Educating providers Fostering coalitions and networks
Registry of pools and status of fencing compliance to monitor the density of installation of pools, and the exposure of children <4yrs	Policy and legislation
Promote supervision and CPR skills as mandatory for all pool owners.	Policy and legislation Promote community education Strengthening individual

	knowledge and skills
Swimming lessons and water safety lessons for children >2yrs. Certified classes that use consistent and measurable outcomes.	Promote community education Strengthening individual knowledge and skills
Relevant references for each of these initiatives and research options are contained in Wallis et al. **(8)** *QFCC (Queensland Family and Child Commission (formerly Commission for Children and Young People and Child Guardian)	

8.2.2 DATA LINKAGE

Chapter 3 "Methods: Data Linkage" outlined the methodology and the study design in this thesis to access and acquire the data for both fatal and non-fatal drowning from multiple datasets and custodians. This study design was used to provide the highest quality data possible to inform development and implementation of countermeasures such as those discussed in the literature review.

Drowning is defined as a process that can result in death or survival.(1, 2) This is the first study to highlight that process where data have been linked across the continuum of care to map the 'patient journey' from rescue to recovery, or death. Data provide antecedent information, the physiological effects, and aetiology of fatal and non-fatal drowning. The barriers and benefits of the process for acquiring and linking the data are highlighted for replication of this process.

The benefits and barriers of acquiring and linking data

These data were manually linked because electronic resources to do so were not available. It was also considered that the numbers of cases of drowning would be manageable. At the time

of data collection no data linkage unit was in place in Queensland, however this process is somewhat more accessible today.

The integrity of the data retrieved is believed to be of the highest quality because all possible sources of drowning data were accessed. This resulted in a much greater number of eligible cases than initially expected which was an indication of the duplication of record keeping within the health system and highlights the need to be able to identify unique cases for accurate research outcomes. This applies to any research or audit-based interrogation of health data in Queensland, where episodes of care in emergency, ward admissions or ICU are counted as separate encounters(9) effectively obscuring any accurate assessment of numbers of people, in pursuit of service delivery.

Due to the relatively unusual or uncommon nature of drowning, date and time of injury were easily matched, although identified data were invaluable in assisting this process. Not every case appeared in each database, emphasising the need to access more than one database for research, or alternatively the need for the linking process to be done routinely within Queensland Health.

The drawback to data linkage was the time taken to gain access to the data which for this project was 18 months in all, and a further 6 months to acquire all of the data independently from the seven relevant agencies (and 12 separate databases). This barrier could be eliminated if core data were routinely linked (e.g., within the statistics unit of Queensland Health). Reducing or eliminating the individual consultation process with each of the relevant

agencies and the Public Health Application process would expedite the process and allow faster access to important injury prevention data.

Health data have historically been collected to track the delivery of health services rather than the monitoring of health problems. These data are an untapped resource to harness what the Productivity Commission refers to as 'evidentiary power' however, the enthusiasm for such linkage is not matched by many custodians.(10) Western Australia has benefited from linked health data for more than 30 years without any breaches of privacy, indicating that confidentiality can be protected.(10, 11) The importance of routine linkage of core data sets has been recognised by the National Collaborative Research Infrastructure Strategy, which provided a mechanism (and approximately $30 million in funds) to states and territories in Australia to develop capacity and infrastructure for data linkage activities between 2009-2012.(12) . Despite this national agenda, and despite a commitment in 2008 by each of the relevant stakeholders in Queensland to routinely link core data specifically for the purposes of injury surveillance and prevention (as a consequence of extensive consultation in the Trauma Data Scoping Project), this has not yet been achieved(13).

The benefits of linked data

There were two main benefits from using the linked data in relation to demonstrating the burden of fatal and non-fatal drowning. Firstly, the linked data allowed more precise capture of the number of patients on each database. Secondly, the flow of the patients through the system and the resources utilised at each level of care (Table 3-2), particularly for non-fatal drowning cases, was clearly articulated for the first time. The patient capture pyramid

highlights the duplication of record keeping and how data would be skewed if episodes of care or linkage were not possible. Patient flow illustrates that the severity level of drowning is a major burden on hospital admissions. Significant resources are utilised for the rescue and recovery of the non-fatal drowning patient (Table 3-3) with most patients utilising at least three levels of care during their medical treatment. Reducing the numbers of non-fatal episodes from entering the health system would be a significant cost saving.(3-5) Furthermore, better integration of clinical service and community prevention would result in better health outcomes and cost savings.(14, 15) There is a clear need for the previously unexplored non-fatal drowning burden to be monitored as deaths are clearly only a small part of the drowning problem.

The inherent value of this linked data is evidenced by the previously unexplored magnitude of non-fatal drowning. Using linked data to correctly ascertain the number of non-fatal drowning events in Queensland during the study period demonstrated that the burden of non-fatal drowning proved larger than expected, and the impact on health services is much greater than previously thought. Had data only been sought from the conventional data sources relating to hospital admissions and fatalities, the total number of cases would have been 825. That is, an additional 474 drowning incidents were captured by linking data across the continuum of care. The importance of not relying solely on one data source was also highlighted in this study. For example, extracting data only from EDIS to obtain information about cases presenting to an Emergency Department in Queensland would have yielded 335 cases – this is approximately only a quarter (26.3%) of all drowning cases that presented to an emergency department in Queensland during the study period.

The other main advantage in using linked data across the continuum of care was the enhanced quality of data. More sophisticated statistical analyses regarding the circumstances of and leading up to the drowning event were made possible by the improved level of detail available. Of particular benefit was the additional information from the pre-hospital and emergency data sources on drowning. Evidence-based and reliable information on time of drowning, non-fatal drowning location, some demographics, and treatment were presented for the first time in this thesis.(16) This information was extracted from narrative text, and is crucial to accurately inform effective injury prevention stratagems, to reduce drowning among children in Queensland.

Recommendations	Where to target action for prevention activity (6)
PREVENTION INITIATIVES	
Core data from QAS, EDIS, QHAPDC and QFCC* be routinely linked so that a transparent assessment of treatment for people is captured rather than service delivery	Policy Organisational practice Collaboration, coalitions, networks
Data from EDIS, SATR and QHAPDC be linked at a minimum	Policy Organisational practice Collaboration, coalitions, networks
Relevant references for each of these initiatives and research options are contained in Chapter 3.	

8.2.3 CHARACTERISTICS OF DROWNING

Analyses conducted to determine the "who, what, when, where and why" of drowning were presented in **Chapter 4 "Characteristics of Drowning"**. These data relate to all fatal and non-fatal drowning events for which medical attention was sought in Queensland during 2002-2008, for children aged 0-19yrs and portray many strengths of this study.

Descriptive analyses on the demographic, environmental and clinical characteristics of children involved in a drowning event were presented in the context of minimal interpretation in this chapter, because all data were explored in further detail (incidence rates, trends over time, relative risks, etc.), in Chapters 5-7.

During the seven years of the study period, there were 1299 (120 fatal and 1179 non-fatal) cases of drowning in children 0-19yrs in Queensland, which is approximately 17 fatalities and 168 non-fatal drowning episodes every year. The male to female ratio was 1.5:1, and children aged 0-4yrs were the age group most frequently involved. Three percent of drowning events involved children visiting from overseas, and 6% from interstate. Over half of all drowning episodes were in children living in areas categorised as higher relative advantage.

Environmental characteristics

Twice the number of fatal events occurred in families who resided in more disadvantaged areas indicating that CPR and water safety efforts be prioritised for these families. Events occurred more frequently in Major Cities (50%). More than three quarters (77%) of drowning

occurred in the warmer months between October-March, and most occurred on weekends (42%).

Time of incident for non-fatal events is routinely recorded through QISU, and as mentioned previously this covers only 25% of Queensland, therefore the time of drowning was primarily extracted from QAS data. Drowning represents a unique set of data, where the criticality of the case means that paramedic and triage arrival times are a reasonable proxy for time of injury. The most vulnerable period for drowning has been identified in this thesis as being between 12:00 noon and 18:00 and the majority of these events were between 3pm-6pm. Typically these are times where the chaos of school pick up and the presence of other children can easily distract supervisors' attention away from the younger members of the family. Adolescents' most vulnerable time is not surprisingly during the night. These susceptible periods require building into prevention initiatives. Response times are recorded on call out and arrival and provide the most accurate recording of time of drowning ever presented for fatal and non-fatal drowning

Non-fatal immersions revealed three locations requiring attention for prevention interventions for tourists or non-residents. These were pools, coastal water and in inland static water bodies. Commercially run pools such as those in hotels and resorts were a common risk factor suggesting that these venues need to specifically inform tourists of the safety features available and required around swimming pools where it may be assumed that there is life guard support. These are worthwhile targets for future prevention efforts.

The Geographic Information System (GIS) mapping presented in Chapter 4 is groundbreaking as it has never before been undertaken for drowning in Australia. This kind of mapping portrays the distribution of numbers of drowning events and locations across Queensland. It has highlighted the popular holiday destinations (Cairns, Mackay and Gold Coast) as targets for prevention efforts. No doubt there is much more that could be done with these kinds of analyses, and it is intended that mapping the distribution of Severity and Remoteness are two such examples for future work. It is also evident that this is a particularly useful tool for other injury mechanisms that lend themselves to spatial analysis.

Clinical outcomes

The Glasgow Coma Scale (GCS) is used to assess the consciousness of a patient, and a score equal to or less than eight means that a patient is comatose and is routinely intubated. In these data, two thirds (67%) of children with GCS<=5 died as a consequence of the drowning event. This leaves one third who survived the drowning event. This has implications for further research to determine the length of survival, and quality of life of survivors. It was beyond the scope of this research to examine long term outcomes of drowning events, however further research is obligatory in this area. There is no research as to the length of survival after the drowning event, the cost to families (both emotional and actual) and the relevant health services, or if these children have drowning recorded as an underlying cause of death. The data examined in this thesis suggests this is not the case.

CPR was recorded in QAS, NCIS police reports, and CCYPCG data and was reported as being attempted in 30% of cases. Narrative text indicates that there is further information to

come from the data in future research, regarding the regaining of spontaneous respiration, and inexperienced attempts at CPR. A 30% uptake indicates there is much room for improvement in learning CPR. This should be a mandatory requirement for at least one member of the household where a pool is present to be trained and maintain currency.

For the first time data were presented in this thesis regarding health service use as a consequence of drowning. This provided a clear articulation of the burden on health services due to fatal and non-fatal drowning. This could be explored even further and elaborated on in future research. There were some 2,522 separate levels of care provided to the 1299 drowning victims over the study period, the majority (97.3%) of them being for non-fatal incidents. This represents a significant impost of the health system. These kinds of data are rarely available to researchers, and this presents a potential source for future economic analyses. The extra ordinary difference that these data present is the opportunity and the figures to enable the costing of fatalities and the criticality of care that is involved in those first 30 minutes from rescue and transition through emergency care, and hospitalisation. There are still many costs not accounted for in these data. Inter-facility transfers from regional or remote centres are not included, nor are the unaccounted costs of fatality services such as intensive care, family trauma (loss of work and counselling, social work) rehabilitation. Police and coroner reports, toxicology and autopsy all have an associated cost as well.

Narrative text

Drowning is a complex injury mechanism and often has multiple causes. Narrative text was utilised in this study to extract additional information about the circumstances surround the drowning event to add value to coded data. Narrative text was examined and associated contributing factors were extracted and presented in **Table 4-4**, using the Host, Agent,

Environment framework originally proposed by Haddon and adapted for this study. This framework will be an invaluable tool to facilitate further analyses of this dataset, as it also follows into the three dimensional matrix which introduces pre-event, event, and post-event phases as an aid for choosing a means for intervention. The third dimension is the application of weighted value criteria, which assesses the cost (or value) of conducting the intervention compared with the potential effectiveness of the intervention(17) and has the potential for further research. In this thesis, only one example of the type of information that can be extracted from the data using this framework was presented (this was location of drowning event). It is anticipated that this framework can be used to explore drowning (and other injury mechanism) data in much further detail. For instance, this framework could be used to obtain information on clinical outcome measures, and CPR. An upcoming study on supervision is planned, and this framework will be vital in extracting the supervision information.

Recommendations	Where to target action for prevention activity (6)
FUTURE RESEARCH	
Complete and comprehensive data extraction of the risk factors and additional drowning attributes extracted from the narrative text of linked data to inform injury prevention strategies, using the suggested framework presented in chapter 4	Coalitions, networks and collaboration for funding
Future research using GIS mapping to explore the distribution of Severity and Remoteness (using these data), but also for other injury mechanisms	Coalitions, networks and collaboration for funding
Review of clinical outcomes for survivors GCS <5-8 to determine quality of life and length of survival after drowning. Costs associated with drowning death or disability.	Coalitions, networks and collaboration for funding (Partnering NCIS, RLSSA)
PREVENTION INITIATIVES	
CPR and water safety initiatives prioritised for families residing in disadvantaged areas and also Major Cities	Policy Organisational practice Collaboration, coalitions, networks

In households with a swimming pool, at least one member of the family be trained in CPR and maintain currency. This presents the opportunity to add other water safety information.	Policy (Airline safety) Organisational practice Collaboration, coalitions, networks (Surf Life Saving) Promote community education Strengthening individual knowledge and skills
Tourist education on water safety available and required at resort pools (whether lifeguards are available), coastal water, and the dangers of underestimating water current strength.	Policy (Airline safety) Organisational practice Collaboration, coalitions, networks (Surf Life Saving)
Drowning prevention to focus on popular holiday destinations (Cairns, Mackay and Gold Coast) as targets for prevention efforts.	Policy (Airline safety) Organisational practice Collaboration, coalitions, networks (Surf Life Saving) Promote community education Strengthening individual knowledge and skills
Most vulnerable time for drowning could be added to other education programs: All ages: most at-risk times (midday-6pm) 15-19yrs: most at risk times are through the night	Promote community education Strengthening individual knowledge and skills
Relevant references for each of these initiatives and research options are contained in Wallis et al "Where children and adolescents drown in Queensland", submitted to BMJ Open in June 2015;**(8)** and Chapters 4-7.	

8.2.4 INCIDENCE RATES & SEVERITY OF DROWNING

Using linked data across the continuum of care facilitated capture of all drowning events that occurred in Queensland children and adolescents and shows a realistic picture of the full extent of drowning over the seven year study period. This allowed calculation of population-level drowning incidence rates, as well as incidence rates for drowning events of differing severity (fatal, non-fatal admitted, non-fatal non-admitted). This is the first study of its kind to report population level incidence rates for Queensland children which facilitates comparison of drowning across borders and boundaries. Data shows that rates for Queensland are more than double those of the USA.(18)

For every child or adolescent drowning fatality in Queensland, ten others were rescued and survived. Two out of three of those survivors were admitted to hospital. After finding the larger than expected total numbers of drowning events in Queensland, these higher severity figures were a second flag for better surveillance and monitoring of non-fatal drowning.

The trends over time for drowning events resulting in admission and fatality reduced (but not significantly) over the period of the study. However, non-fatal drowning events that did not result in admission to hospital more than doubled (135%). Research where only fatality and hospital admission data were accessed would miss this important point. Both pre-hospital and emergency attendances, which make up the bulk of presentations and resource-use, would be effectively hidden. Any reduction in the 55% increase in overall drowning rates (primarily due to non-fatal presentations) would provide better health outcomes and lower health costs. Some may argue that drowning events resulting in death or hospitalisation represent the most

serious of events, and should be the focus of prevention efforts and resources. The overwhelming numbers of non-fatal events and the increase in these numbers over the study period cannot be ignored as each and every one has the potential to be fatal or disabling. It is therefore important to carefully examine the 'near misses' to glean as much information as possible to hopefully deliver the distinction between a fatal and a non-fatal event in either the circumstances leading up to the event, or the responses post-event.

This state-wide data collection has revealed previously unknown incidence and survival ratios. Analyses presented in Chapter 5 quantified the magnitude of drowning by age, gender and severity help to understand survival and patient care.(19) Increased trends in drowning survival rates may be viewed as both positive and challenging for drowning prevention and the health system. Males are over-represented, and although infants and toddlers did not have increased fatality rates, they had the greatest drowning burden demonstrating the need for continued drowning prevention efforts.

Recommendations	Where to target action for prevention activity (6)
FUTURE RESEARCH	
Examination of the protective factors surrounding those who survive drowning events for insights as to why children and adolescents 10-14yrs have the lowest rates of drowning and hospital admissions; and why males are over-represented in all age groups except 10-14yrs.	Coalitions, networks and collaboration for funding. Work with providers (swim schools, RLSSA)
Whether there any association between resuscitation response, medical management, or continuing morbidity with increased survival rates.	Coalitions, networks and collaboration for funding
Utilising these data for cost analysis for services utilised to treat drowning in Queensland. These data could provide information regarding treatment required for fatalities as well as non-fatal drowning. Costings could also tally emergency services, QAS, emergency department, admission to hospital, ICU and social work.	Coalitions, networks and collaboration for funding

PREVENTION INITIATIVES	
Campaign marketed to carers of 0-4yr olds (particularly those aged 1-3yrs) highlighting the benefits of passive barriers to water access, and the differences between active direct and indirect of supervision	Individual knowledge and skills Community Education Coalitions and networks
Relevant references for each of these initiatives and research options are contained in Wallis et al **(8)**	

8.2.5 WHERE CHILDREN AND ADOLESCENTS DROWN

This thesis most importantly presents data identifying the locations of non-fatal drowning as well as fatal drowning (Chapter 6). The resulting enhanced quality data and larger sample size quantifies drowning incidence rates for specific locations by geographic region, age group and by severity for the first time. Descriptive analyses utilised narrative text (rather than codes provided in routinely collected data) to reveal valuable antecedent information and risk factors associated with specific particular locations and drowning events.

Drowning location is routinely collected in drowning deaths; however for non-fatal drowning episodes, broad categories are the only indicative data and this applies only to cases resulting in hospital admission. In Queensland, additional data on drowning location is captured by QISU (Queensland Injury Surveillance Unit), however QISU data capture is not state-wide (it covers approximately 25% of cases presenting for treatment to Emergency Departments). Drowning prevention has been substantially hindered by current ICD-10(20) coding of drowning events which only nominates three specific locations: baths, pools and natural water. All other locations are grouped under "specified or "unspecified" which can attract large percentages of coding,(21) thus rendering data wasted for prevention efforts. An international standard to classify water bodies would make comparisons of locations and contributing factors between countries analogous. In this thesis, as previously described, narrative text from sources such as pre-hospital and Emergency Department were scrutinised to obtain data on location of drowning event. Hence, this thesis presents five categories for water bodies (pool, bath, inland water, coastal water, and other man-made water hazards) which are further stratified as: static or dynamic; and public or private. Pools in particular

were categorised by operational access (public restricted and unrestricted) to reveal that privately owned pools require intervention to reduce drowning.

Drowning locations ranked in order of highest overall incidence were pools, inland water, coastal water, baths and other man-made water hazards. In terms of the most lethal locations (calculated by fatal events/non-fatal events) the rank order reversed: other man-made water hazards first, followed by inland static water and then dynamic water; coastal water; baths and pools equal last. This probably has to do with the closer proximity of the rescuer at the last three locations, however the high numbers associated with each of these locations warrants prevention input.

Toddlers 0-4yrs remain the group with the largest burden regardless of location; however they were most at risk around pools and static water bodies such as dams and buckets. The highest fatality ratio was for this age group. Children 5-14yrs incurred the lowest incidence rates regardless of drowning location. Adolescents 15-19yrs were more frequently involved in a drowning incident on the coast shoreline, followed by inland dynamic water bodies. Recommendations for prevention initiatives are tabulated below.

Swimming pools incurred the highest incidence rates for overall drowning events and analyses identified privately owned pools, affluent neighbourhoods and major cities as the targets with most gains for prevention. Although pool fatality rates have dropped since first being identified as drowning hazards in the 1970's(22)the increases in non-fatal drowning at

this location leaves no room for complacency. The density of pool installation is the highest in Queensland, and the Pool Registry will provide excellent data in the future.(23)

Most mortality and morbidity will be reduced by improving water safety through engaged supervision around pools and bath time, and a heightened awareness of buckets and man-made water hazards around the farm home for young children. These data provide a different approach to inform prevention strategies. A breakdown of pool operators, static and dynamic water bodies, coastal waters, and geographic and socio-economic information provides new perspectives for drowning locations to inform prevention strategies.

Recommendations	Where to target action for prevention activity(6)
FUTURE RESEARCH	
Development of an international standard for categorising water body type and integration of the standard into ICD coding.	Policy Institutional practices
PREVENTION INITIATIVES	
Campaigns with safety initiatives which can be cleverly marketed to specific age groups or the users of particular locations. Modules developed in this way have utility for being rolled out nationally. Particular priority areas are: <1yrs bathtubs and direct and constant supervision 1-4yrs swimming pools, baths, dams, buckets and rural water hazards. Appropriate barriers, supervision and emptying buckets 5-9yrs: Inland water and coastal water. Life jackets wearing (PFDs) in boats 10-19yrs: Inland water (dynamic) and coastal water (shoreline) – particularly around behaviour and under estimating current strength, or over-estimating ability.	Policy Institutional practices Explore new digital media Educating pool owners particularly privately owned pools
All age groups: Males; Pool owners; Inland water (dynamic and static water and the risk of over-estimating ability, and underestimating current strength); Coastal shoreline and risks of swimming alone or at night.	Coalitions and networks Individual knowledge and skills Community Education

Pools: privately owned; commercially operated; affluent neighbourhoods in major cities	Coalitions and networks Individual knowledge and skills Community Education
Highlighting the lesser known but most lethal locations which are the reverse order of the most frequent locations: other man-made water hazards first, followed by inland static water and then dynamic water; coastal water; baths and pools equal last. Highlighting the closer proximity of the rescuer at the last three locations.	Coalitions and networks Individual knowledge and skills Community Education
Inclusion of location coding or data in QAS and ED data beyond ICD coding. Ensuring that narrative text is available in preference to drop down categories that allow "other specified".	Policy and legislation Educating providers Fostering coalitions and networks
Relevant references for each of these initiatives and research options are contained in Wallis et al manuscript submitted and under review with BMJ Open in June 2015.	

8.2.6 DROWNING IN ABORIGINAL & TORRES STRAIT ISLANDER CHILDREN

This thesis presents previously unpublished data on incidence rates and characteristics of Indigenous fatal and non-fatal drowning **(Chapter 7 "Drowning in Aboriginal & Torres Strait Islander Children")**. The drowning survival ratio for Indigenous children was 9:1. It is known that Indigenous status is often difficult to identify within data, however this study achieved definitive analyses due to access to fatal and non-fatal cases of drowning. There were differences by Indigenous status for locations and geographic regions and severity; and within Indigenous status by gender and age.

Drowning sites were similar in both Indigenous and Non-Indigenous populations, with the top three ranked as pools, bath and natural water, however the proportions varied. Drowning for Indigenous children occurred less frequently in pools, and more frequently in baths highlighting prevention efforts for parents of children <1yr.

Geographic location of drowning event was different for Indigenous and non-Indigenous populations. More drowning events and greater severity of drowning occurred for Indigenous children in Regional and Remote areas. The opposite was true for Non-Indigenous children where more events and greater severity occurred in Major Cities and regional areas. This has implications for targeting regional and remote Indigenous communities with specific drowning prevention messages. A further significant finding was that for Indigenous children, pool drowning was the only drowning site where households were in the highest 50% of the Index of Relative Socioeconomic Advantage and Disadvantage.(24) This finding indicates that Indigenous children have access (54%) to such pools as well, and consequently share the drowning risk. Better supervisor and life guard vigilance at public pools could potentially reduce the 27% of drowning events at those locations for Indigenous children. All

other Indigenous drowning locations were in areas at the most disadvantaged end of the scale pointing to a need for prevention education for this demographic.

Although higher Indigenous drowning rates prevailed, no significant changes over time are concerning and indicate room for improvement and a need for targeted culturally appropriate prevention programs. Equally concerning, is the apparent over-representation of Indigenous adolescent females which should be weighed against the absence of drowning among Indigenous male adolescents in the same age group in consecutive years of the study. Females, swim ability, supervision and the young are areas which need to be incorporated into Indigenous-specific interventions for drowning prevention. Further investigation around behaviour and culture may highlight protective factors. Culturally specific prevention strategies which take into account social and demographic indicators identified in this study should be delivered to carers and peers of vulnerable age groups who frequent specific locations.

First responders attempted CPR at the same proportion in both Indigenous and Non-Indigenous populations. A 30% uptake however, indicates room for improvement in learning or attempting CPR, particularly for those in regional and remote areas where help may take longer to arrive.

For the first time, the quality of data from this study identifies risk factors and gives insight for interventions to target specific socio-demographics, age and gender groups. Regional areas and Remote and Very Remote communities within Queensland and pool and bathtub safety for the young are particular prerequisites.

Recommendations	Where to target action for prevention activity(6)
FUTURE RESEARCH	
Investigation of Indigenous drowning protective factors: social, demographic, and particularly gender in 15-19yrs where females are apparently over-represented; Swim ability in females.	Coalitions and networks to seek Indigenous researchers and appropriate funding
PREVENTION INITIATIVES	
Parents of Indigenous children <1yr at bath time – never leave baby alone in the bath (constant visual direct supervision) or in the care of a sibling	Individual knowledge and skills Community Education
Develop new ways of targeting small populations of Indigenous people over vast distances for drowning prevention information. Especially pool safety	Individual knowledge and skills Community Education
CPR training for all residents of Indigenous communities. Combined with water safety information on sites other than pools.	Coalitions and networks Individual knowledge and skills Community Education
Public pool education: "life guards are not baby sitters" and responsible direct supervision	As above
Development of modules of Indigenous culturally specific education interventions. Modules that cover water safety topics in appropriate language and application (e.g., CPR, supervision) for delivery to particular groups, with any free devices to encourage practice given freely	As above
Relevant references for each of these initiatives and research options are contained in Wallis et al currently under review with the Journal BMC Public Health, submitted in March, 2015.	

8.3 CONCLUSIONS: MOVING UPSTREAM IS THE WAY FORWARD

Every three minutes somewhere across the world, a child drowns. If this drowning epidemic were a disease, finding a vaccine would be a priority to save 175,000 child deaths every year – and that's just the deaths. We have no worldwide figures on how many children suffer a disability from surviving drowning.

This is the first study to effectively link data from multiple portals across the continuum of care for fatal and non-fatal drowning. The purpose of this thesis was to link data from all relevant sources to capture as accurately as possible all cases of death and survival from drowning incidents in Queensland. This was to accurately determine the burden of drowning in Queensland, and also to explore the characteristics of the drowning event, and circumstances leading up to the event, using the enhanced data, to inform prevention stratagems. All objectives of this study have been met and a number of key areas of research and drowning prevention initiatives have been suggested.

The comprehensive level of detail able to be extracted for drowning aetiology and prevention analysis is substantial. Discussion provided in this thesis supports the benefits and feasibility of routine data linkage to track drowning. It is a gloomy prospect that the priority for the 40 recommendations and prevention initiatives suggested in this thesis will be prioritised by funding availability rather than principled need to prevent death and disability in our young. Currently, administrative data are collected for service delivery audits rather than injury prevention. Shifting the focus of administrative data to community prevention efforts will

take political will from within state government in the first instance. The potential benefits from better health outcomes are immeasurable and the recouped impost on the health system could easily be redirected to prevention efforts across many injury mechanisms.

The important value of the data extracted, particularly with regard to the confirmation of a drowning survival ratio; the realisations of potential for further drowning injury; the impost on the health system; and the implications of the findings for evidence-based non-fatal drowning prevention are ground-breaking. GIS mapping provides a new perspective that has not been previously explored and demonstrates significant potential for prevention energies. Counting the dead is clearly not a good measure of drowning prevention achievements. The improved detail revealed in contributing factors from narrative text is invaluable to inform preventative stratagems. The numerous recommendations and initiatives suggested here to reduce drowning are framed in a way to assist practitioners translate this research to design and implement comprehensive interventions. The ultimate goal is to translate this research into practice and move drowning prevention upstream.

"Counting the dead is an unsatisfactory method of gauging safety"(25)

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APPENDICES:

APPENDIX 1:

Figure shows the increase (35%) of pools in 5 years from 2005-2009 utilising Google Maps. Swimming pools registered on the Queensland pool register numbered approximately 311,000 in 2012 giving a ratio of one pool for every 14 people in Queensland. This is arguably, the highest pool per capital ratio in Australia.

34 in 2005

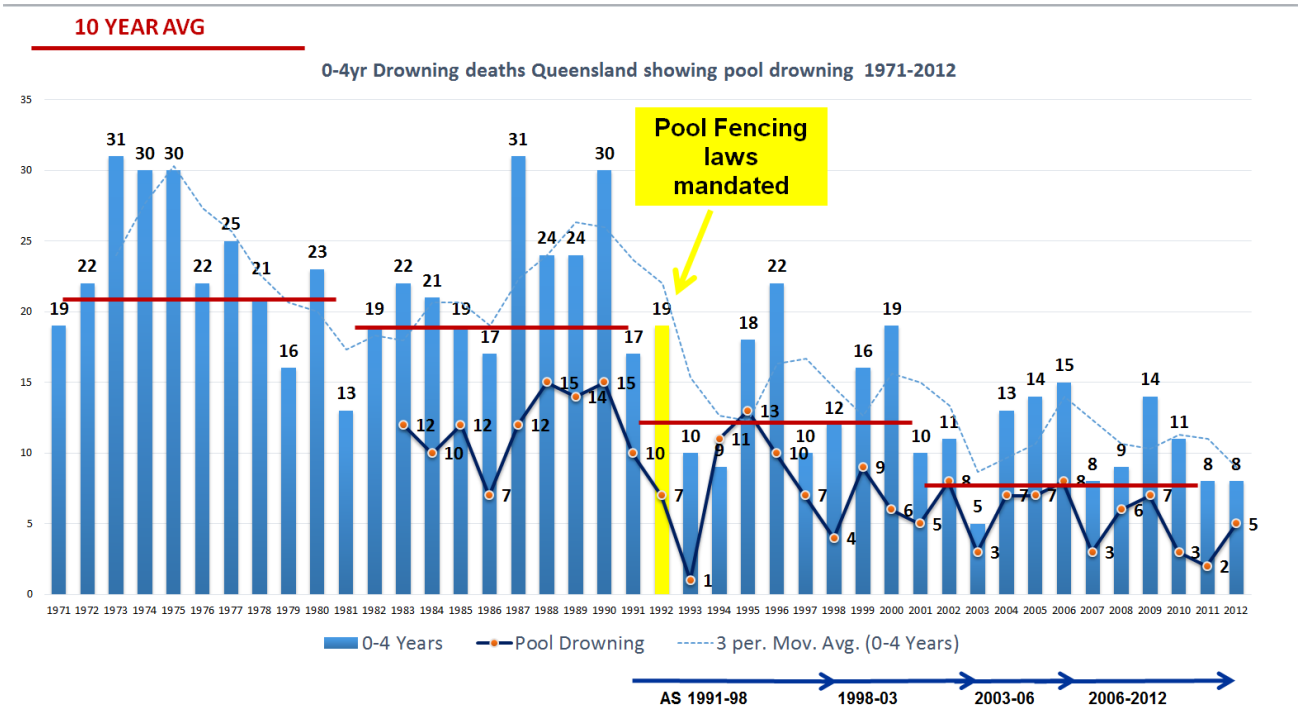
+35% 5yrs

46 in 2009

- QLD SWIMMING POOLS approx. 311,000
- 1 Pool:14 people
- 1 Pool:5 houses
- 2700 NEW POOLS PER YEAR

Source: Pools DLGP Register 2012; New pools SPASA 2005

Figure which shows lowering pool drowning deaths in 0-4yrs in line with divisive debate and strengthening pool fencing standards over 40 years in Queensland.



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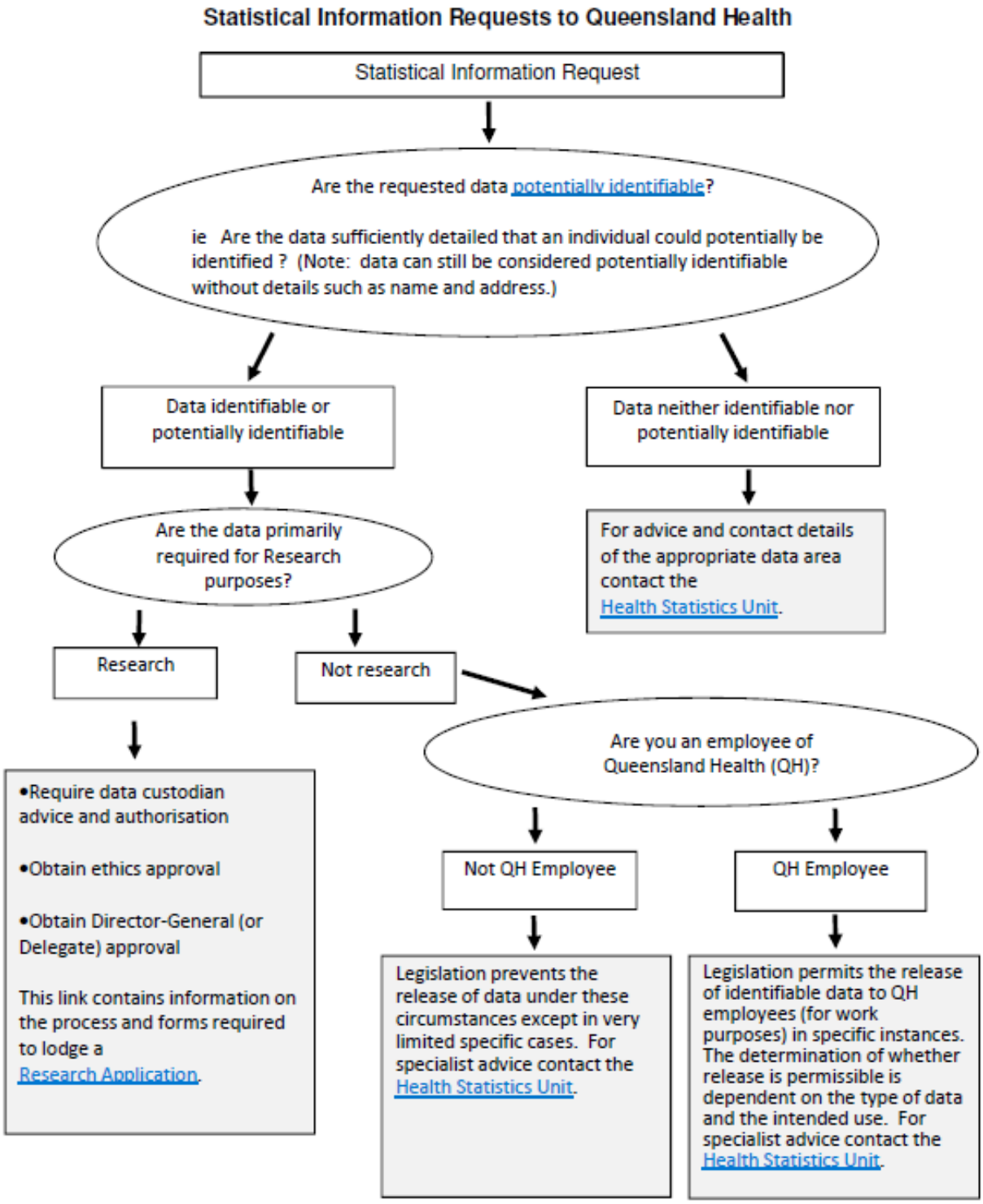
The former CCYPCG transitioned to Queensland Family and Child Commission in July 2014.

APPENDIX 2: DATA REQUEST PROCESS



Statistical research request from Health Statistics Unit, 2015.

APPENDIX 3: DATA LINKAGE

	QHAPDC-QH	SATR-QH	EDIS-QH	QISU-MHS_QH	MHS -(MCH & MAH)	QAS-(eARF & AIMS)	NCIS INC RLSSA	CCYPCG
DEMOGRAPHICS								
	SURNAME	**Surname**	Present Name Surname		**PATIENT SURNAME**	T_FAMILY_NAME	Name	Surname
		Given Names	Present Name First		**PATIENT FIRST NAME**	T_GIVEN_NAME		First Names
						T_MIDDLE_INITIAL		
	ADDRESS	**Address**	Present Street Address Line 1			T_STREET_NAME		
	SUBURB	**Suburb**	Present Suburb		**SUBURB**	T_SUBURB_NAME	ResidenceLocation	
	POSTCODE	**Pcode**	Present Postcode	POST_CODE	**POSTCODE**	T_POST_CODE	Post Code (UR)	Postcode of place of occurrence
	UR	**UR**	MRN - Medical Record Number	UR_NUMBER	**PATIENT UR**			
	DOB	**DOB**	Present Date Of Birth	DOB	**DOB**	D_BIRTH		Date of birth
	AGE AT ADM	**Age**	Present Age in Years	AGEYR		N_ACTUAL_AGE_YEARS	Age	Age
				AGEMTH			Age Unit	
				SEX-code				
	SEX	**Sex**	Present Gender	SEX_DEF	**GENDER**	T_GENDER	Sex	Sex
	INDIG STATUS CDE	**Indig Status_code**	Indigenous Status Code	INDIGENOUS_CODE				
	INDIG STATUS	**Indig Status_desc**	Indigenous Status Desc.	INDIGENOUS_DEFINTION	**ETHNICITY**		Indigenous Origin	ATSI Status
	STHSEA_ISL							
	COB CODE		Country Of Birth Code	COUNTRY_CODE				
	COB	**COB**	Country Of Birth Desc.	COUNTRY_DEFINTION	**COUNTRY OF BIRTH**		Country (birth)	
	MEDCR ELIG		Country of Residence Desc.					
			Insurance Status Desc.					
	SLA							
	SLA NAME							
	SLA VERSION							
	ARIA	Post code of location	Post code of location	Post code of location	Post code of location	Post code of location	Post code of location	Post code of location
	ARIA Desc	Post code of location	Post code of location	Post code of location	Post code of location	Post code of location	Post code of location	ARIA of usual residence
	SEIFA Decile	Post code ur as above	Post code ur as above	Post code ur as above	Post code ur as above	Post code ur as above	Post code ur as above	SEIFA of usual residence
	SEIFA Declie 06	Post code ur as above	Post code ur as above	Post code ur as above	Post code ur as above	Post code ur as above	Post code ur as above	
				LANGUAGE_CODE				
	LANGUAGE			LANGUAGE_DEFINITION	**LANGUAGE**			
TREATMENT								
	FACILITY ID(AD)		Facility Code	HOSPITAL_CODE				
	FACILITY NAME(AD)		Campus Desc.	HOSPITAL_DEFINITION				
	DISCHG_STATUS	**Visit Type_code**						
	DISCHG_STATUS_DESC	**Visit Type_desc**	Type of Visit Desc	MODE_OF_SEPERATION_DEFINITION (copy)	**VISIT TYPE**			
	FnyrAdm			year	**DATE SEEN**	D_CASE(date) D_RECEIVED(time date)	YeardeathDoIncident	Date of incident
	TFR_TO_FCLTY_ID	**Facility Code**				T_TO_PROPERTY_NAME		
	Tfr to name	**Facility**	Transfer Destn. Hospital Desc.(EDtoAD)		(MCH)	T_TO_STREET_NO		
	ARRVL_CDE	**Ref Source_code**	Referred by Hospital Desc.			T_TO_STREET_NAME		
	ARRVL_DESC	**Ref Source_desc**	Referred by Desc.		**REFERRED BY**	T_TO_STREET_TYPE		
	ADM SRCE	**Arrival Method_code**	Mode of Arrival Code		**TRANSPORTATION**	T_TO_SUBURB_NAME		
	ADM SRCE DESC	**Arrival Method_desc**	Mode of Arrival Desc.			T_TO_POST_CODE		
	ADM DATE	**Arrival Date**	Arrival Date Time	ATTEND_DATE	**ARRIVAL DATE**	D_OFF_STRETCHER		
	ADM TIME	**Arrival Time**	Admitted At (ADfrmED inc SSU)	ATTEND_TIME	**ARRIVAL TIME**	D_AT_DEST		
				INJURY_DATE	**TIME SEEN**	D_COMPLETED		
	TFR_FROM_FCLTY_ID							
	Tfr from name							
	QAS_PIN			INJURY_TIME				

	QHAPDC-QH	SATR-QH	EDIS-QH	QISU-MHS_QH	MHS -(MCH & MAH)	QAS-(eARF & AIMS)	NCIS INC RLSSA	CCYPCG
LOCATION								
	MAIN EXT CSE				**TRIAGE DESCRIPTION**			
	EXT_CSE_DESC		Presenting Problem	INJURY_DESCRIPTION	**TRIAGE ASSESSMENT**	COMMENTS C_FINAL_ASSESSMENT	Notes	
	ACTIVITY			ACTIVITY_CODE			Activity Code	Activity
	ACTIVITY DESC			ACTIVITY_DEFINITION_LEVEL2			Activity Code 2	
							Activity Other	
				MAJOR_INJURY_FACTOR_CODE				
				MAJOR_INJURY_FACTOR_DEFINITION			Location Code 1	Place of Occurrence Descriptor
				NATURE_OF_INJURY_CODE				Type of location
				NATURE_OF_INJURY_DEFINITION			Time Location Post Code(death)	Postcode of place of death
				MECH_INJURY_CODE			Object Type 1	Type of drowning incident
	PLOCC			MECHANISM_OF_INJURY_DEFINITION			Object Type 2	Type of Pool
	PLOCC DESC			PO_PLACE_CODE			Object Description	Type of Non-Pool Water Hazard
				PO_PLACE_DEFINITION_LEVEL1			Object Other	Swimming ability
				PART_OF_PLACE_DEFINITION_LEVEL2			Location Code 2	
				TYPE_OF_PLACE_CODE			Location Other	
				TYPE_OF_PLACE_DEFINITION_LEVEL1				
				TYPE_OF_PLACE_DEFINITION_LEVEL2				
				ICD_CODE				
				ICD_DEFINITION				
						T_LOCATION_TYPE		
						T_PROPERTY_NAME		
						T_STREET_NO		
						T_STREET_NAME		
						T_STREET_TYPE		
						T_SUBURB_NAME		Pool fencing
						T_POST_CODE		Pool fencing - Type of fence
						T_TO_LOCATION_TYPE		Fencing or other barriers to non-pool water hazard
						T_TO_PROPERTY_NAME		
						T_TO_STREET_NO		
						T_TO_STREET_NAME		
						T_TO_STREET_TYPE		
						T_TO_SUBURB_NAME		
						T_TO_POST_CODE		

	QHAPDC-QH	SATR-QH	EDIS-QH	QISU-MHS_QH	MHS -(MCH & MAH)	QAS-(eARF & AIMS)	NCIS INC RLSSA	CCYPCG
SEVERITY								
	EPIS_ID	Triage (priority)	Triage Priority	TRIAGE_CODE	TRIAGE CAT	C_DISPATCH_CRITICALITY		Date of Death
	EPIS_TYPE		Triaged At	TRIAGE_DEFINITION		C_TRAN_CRITICALITY		Time between last seen and noticed missing
			Departure Destination Code	MODE_OF_SEPERATION_CODE		t_code_h(primary)		Time between last seen alive and discovered
	DISCH DATE	Discharge Date	Departure Destination Desc.	MODE_OF_SEPERATION_DEFINITION	DATE READY FOR DEPARTURE	N_PULSE_RATE		
		Discharge Time			TIME READY FOR DEPARTURE	N_BLOOD_PRESSURE_SYSTOLIC		
					DISCHARGE DATE	T_BLOOD_PRESSURE_DIASTOLIC		
					DISCHARGE TIME	N_RESPIRATORY_RATE		
	DISCHG STATUS	Departure Status_code	Departure Status Code		DEPARTURE DESITNATION	N_GCS		
	DISCHG STATUS DESC	Departure Status_desc	Departure Status Desc.			N_PAIN_SCORE		
	PATIENT DAYS		Ward Unit Code			F_RESUS_ATTEMPTED		Resuscitation attempted
	ADM WARD		Departure Referred To Code			F_BYSTANDER_CPR		
	ADM UNIT		Departure Referred To Desc.			F_ADRENALINE		
	PD		Died At			F_ATROPINE		
	PD DESC					F_OXYGEN		
	PP BLOCK					Pulse Reg		
	PP BLOCK DESC					Resp Effort		
	PP					o2Sat		
	PP DESC			INTENT_CODE		ETC02	Intent Notification	Cause of Death (as per death registration)
	DRG VERSION			INTENT_DEFINITION		ECG	Intent Completion	Updated Cause of Death - BDM
	DRG					Eye Opening		Updated Cause of Death - Coronial Findings
	DRG DESC					Verbal	Medical Cause 1a	ICD-10 Underlying Cause of Death (3-character code)
	ADM STND UNIT CODE					Motor	Medical Cause 1b	ICD-10 Underlying Cause of Death (Descriptor)
	Adm Stnd Unit Desc					Trauma	Medical Cause 1c	ICD-10 Multiple Cause code 1a)
						Defib	Medical Cause 1d	ICD-10 Multiple Cause code 1a) - (Descriptor)
						Temperature	Medical Cause 2	ICD-10 Multiple Cause code 1b)
							Medical Cause 3	ICD-10 Multiple Cause code 1b) - (Descriptor)
							Primary Mechanism	ICD-10 Multiple Cause code 1c)
							Secondary Mechanism	ICD-10 Multiple Cause code 1c) - (Descriptor)
							Tertiary Mechanism	ICD-10 Multiple Cause code 1d)
							Mechanism Other	ICD-10 Multiple Cause code 1d) - (Descriptor)
								ICD-10 Multiple Cause code 2
								ICD-10 Multiple Cause code 2 - (Descriptor)
DAT	QAS PIN			QISU_ID		Source earf		Registration No
ADJ	ICD VERSION			REMOTE		N_EARF	ID	
	SNAP EPIS NUM		Injury Related Presentation (Y/N)	EMPLOYMENT_CODE	ICD CODE	T_CASE_NO	NCIS No.	
	SNAP TYPE		Paediatric Code Limit	EXTERNAL_CODE	RELIGION	D_DISPATCH	Status	
	MULTICAREPLAN FLAG		Diagnosis ICD Code	EXTERNAL_DEFINITION	PATIENTS USUAL GP	D_EN_ROUTE	Rank	
	STATE		Diagnosis Desc.	BODY_REGEIONS_CODE	DIAGNOSIS DESCRIPTION	D_AT_SCENE	Event	
			Referred by Hospital Code	BODY_REGEIONS_DEFINITION		D_AT_PAT	Procedure Type	
			Referred by Code	ACTIVITY_DEFINITION_LEVEL1		C_CASE_NATURE	Procedure #	
			Transfer Reason Free Text(to)				Marital Status	
			Transfer Destn. Hospital Code(to)				Years in Australia	
							Employment Status	
							Occupation Text	
							Occupation Code	
							Inquest Held	
							Recommendation / Warning	
							Case Type Notification	
							Case Type Completion	
							State	
							Time Location State	
							Local No.	
							Time Location Country (death)	
							Product Related	
							URPcode	

APPENDIX 4: PUBLICATIONS AND CONFERENCE PRESENTATIONS

ORAL PRESENTATIONS

2015

B Wallis. PhD Final Review: Drowning in Queensland children and adolescents 0-19yrs: Identifying incidence, risk factors and interventions. 30 minute presentation, L/7 LCCH Education Centre, South Brisbane 31st March 2015.

As above 30 minute presentation to 'In House' Paediatric Trauma Education, L/7 LCCH Education Centre, May 28th 2015.

As above 45 minute presentation to Trauma Education Network. Televised state-wide from L/7 LCCH Online Health Teleconference, July 22 2015.

2014

B Wallis, R Franklin, K Watt, J Nixon, & R. Kimble. The Burden of Childhood Drowning: What about those who survive? Invited Speaker, National Drowning Prevention Summit 2014. 5&6th August, 2014 Parkroyal Darling Harbour, Sydney Australia.

As above: QCMRI Student Seminar Series, QCMRI Conference Room L/4 Foundation Bldg, RCH, 26 August 2014

As above: presented In-House Paediatric Trauma Education, L/5 Auditorium RCH, 26 August 2014.

B Wallis – The Burden of Childhood Drowning: What about those who survive? Sept 2014 – QCMRI Student Expo, UQCCR Education Auditorium RBWH, Herston

2013

B Wallis, K Watt, R Franklin, R Kimble. Fatal & Non-Fatal Drowning Incidence in children and young people in Queensland 2002-2008. 11 Nov 2013 – AIPN Conference, Esplanade Hotel, Fremantle 2013

B Wallis – Identifying incidence, risk factors and interventions associated with drowning in children and young people 0-19yrs in Queensland 2002-2008. PhD Mid Candidature Review 30 July 2013 - State-wide Paediatric Trauma Education session (Videoconference) RCH Education Centre, L/5 RCH Foundation Building, Herston.

B Wallis, K Watt, R Franklin J Nixon and R Kimble. Fatal and Non-Fatal drowning incidence in Indigenous children and young adolescents in Queensland (Australia) 2002-2008. 26 July 2013 – Australian Injury Prevention Network (AIPN) Aboriginal and Torres Strait Islander Injury Prevention Symposium, The George Institute, Sydney.

B Wallis – Fatal and Non-Fatal drowning incidence in Indigenous children and young adolescents in Queensland, 2002-2008. 15 Aug 2013 – QCMRI Student Expo, RCH Auditorium L/5 Woolworths Building, Royal Children's Hospital

2012

B. Wallis, K Watt, R Franklin, J Nixon, R Kimble. PhD confirmation: Identifying Incidence, risk factors and interventions associated with drowning in children and young people (aged 0-19 years) in Queensland. Confirmation of Candidature, QCMRI Seminar Room, July 31 2012

B. Wallis, K Watt, R Franklin, J Nixon, R Kimble. Identifying Incidence, risk factors and interventions associated with drowning in children and young people (aged 0-19 years) in Queensland. Paediatric Trauma Education Session, RCH Education Centre, July 31 2012

B. Wallis, K Watt, R Franklin, J Nixon, R Kimble. Identifying incidence, risk factors and interventions associated with drowning in children and young people (aged 0-19 years) in Queensland. QCMRI Student Expo, RCH Education Centre, August 30, 2012

2011

B Wallis, R Franklin, K Watt, J Nixon, R Kimble. "Using linked data to review drowning in children and young people in Queensland 2002-2008: Trials and Tribulations" 10th National Conference on Injury Prevention and Safety Promotion, Brisbane Convention Centre, Brisbane November 2011

2010

B Wallis, J Nixon, R Kimble, K Watt, R Franklin, 6-Year Review of Drowning in Children and Young People 0-19 yrs in Queensland 2002-2008 – preliminary death data and progress. QIPC Securing Safety in Queensland: Challenges and responses to Injury Prevention, 1 March 2010, 53 Albert Street, Brisbane.

B Wallis, J Nixon, R Kimble, K Watt, R Franklin, Preliminary mortality results for a 6-year review of drowning in children and young people 0-19yrs in Queensland 2002-2008. Australian Water Safety Council Conference, May 13-14 2010 Sydney.

B Wallis, J Nixon, R Kimble, R Franklin, K Watt. Linking Data - morbidity and mortality case capture for drowning in children and young people 0-19 years 2002-2008, QIPC - Evidence to Action Symposium 18-19 Nov 2010, Townsville

POSTER PRESENTATIONS

2015

B Wallis, R Franklin, K Watt, R Kimble. Looking upstream to prevent drowning: a paper on supervision. Australian Injury Prevention Conference, November 2015, Sydney.

2012

B Wallis, K Watt, R Franklin, J Nixon, R Kimble. Out of sight but not out of mind: Rural drowning in Queensland Australia. Safety 2012 World Conference, 1-4 October, Wellington, New Zealand.

2011

Wallis, B. Et al Non-fatal drowning in children and young people 0-19yrs in Australia - World Conference on Drowning Prevention Vietnam 10-13 May 2011

Wallis, B. Drowning in Queensland – at risk age groups and locations, 4th Healthy Cities: Making Cities Liveable Conference - Noosa - 27-29 July 2011

2010

B Wallis, J Nixon, R Kimble, K Watt, R Franklin, Non-fatal drowning in children and young people in Queensland (Australia) 2002-2008. Safety 2010 World Conference, September 21-24 2010, London.

B Wallis, J Nixon, R Kimble, K Watt, R Franklin, Non-fatal drowning in children and young people in Queensland (Australia) 2002-2008. 19th Annual RBWH Trauma Symposium 11-15th October 2010

K Watt, R Franklin, E Fearnley, B Wallis, Estimating mortality and morbidity associated with fatal and nonfatal unintentional drowning. Safety 2010 World conference, September 21-24 2010, London.

B Wallis, J Nixon, R Kimble, K Watt, R Franklin, Non-fatal drowning in children and young people in Queensland (Australia) 2002-2008. World Conference on Drowning Prevention Vietnam 10-13 May 2011

Herston Medical Library display 1-30 Nov 2010 – Water Hazards Display: statistics on drowning, prevention tips on open water, beaches, pools, home hazards, flood water, safety skills, and pool and spa skimmer boxes and filters.

QIPC – Evidence to Action Symposium 18-19 Nov 2010, Townsville - Fatal and non-fatal data linking work in progress titled “Linking Data – morbidity and mortality case capture for Drowning in Children and Young People 0-19 Yrs 2002-2008”

Presentation for World Safety Conference 2010, London.

NON-FATAL DROWNING IN CHILDREN AND YOUNG PEOPLE 0-19 YRS IN AUSTRALIA

Belinda A. Wallis, Kerrianne Watt, Richard Franklin, Jim Nixon & Roy M. Kimble

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INTRODUCTION

This study aims to determine the morbidity and mortality of drowning in young people (0-19 yrs) in Queensland, Australia, from 2002-2008. Drowning is the leading cause of death for Queensland toddlers aged 1-4 years, and drowning death rates in Queensland have increased from 1.2/100,000 in 2004-05 to 1.8/100,000 in 2006-2007.[1] About half of all child drowning deaths occur in public or private pools, with bathtub and rural locations such as dams significant other locations.[2]

Young children aged under five are vulnerable to drowning. Substantial literature on fatal drowning events exists, however, the incidence, mechanisms and consequences of nonfatal drowning episodes remain largely unexplored. Drowning episodes among adolescents have not previously been studied in detail in Queensland.

METHODS

Retrospective data on nonfatal drowning events among children 0-19yrs (2002-2008) were obtained and linked from multiple sources (pre-hospital; emergency department; admitted patients). These data were supplemented by surveillance data (Queensland Injury Surveillance Unit) where possible.[3]

PRELIMINARY RESULTS

	Deaths	Non Fatal
Number	116	732
Mean	17/yr	106/yr
M:F	2:1	1.4:1
Rate /100,000*	Mean 1.5	Mean 9.5
At risk Age Group 0-4 yrs	62%	72%

TABLE 1: Summary of drowning episodes 0-19 yrs for 2002-2008 Queensland
*Mean age specific rate/100,000 population 2002-2008.

- Ratio of six non fatal hospital admissions for every fatality (1:6) (See Fig 1)
- 10% (70/732) admissions transported to a second hospital for advanced treatment
- 5 patients were re-admitted to hospital on a separate occasion for additional treatment

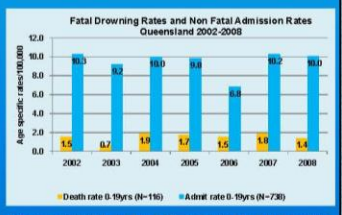

FIG 1: Age Specific Fatal Drowning Rates and Non Fatal Admission Rates by year for children aged 0-19years, Queensland 2002-2008

- 15% (112/732) children were admitted for 2 or more days (Range 2-82 Median 12.5)
- 5% (40/732) survivors were intubated and required ventilation
- 44% arrived by either road or air ambulance
- 9% (68/732) country of birth other than Australia - 29 tourists
- Japanese visitors (37%) most frequently treated as inpatients

RESULTS (CONT)

- Age specific rates for hospital admissions for various age groups (See Fig 2)
- 0-4 yr age group range 35/100,000 to 19.7/100,000

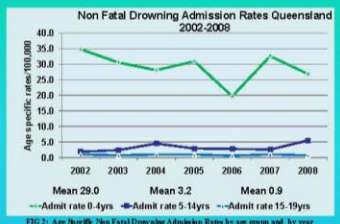

FIG 2: Age Specific Non Fatal Drowning Admission Rates by age group and by year 0-19 yrs Queensland 2002-2008

At-Risk Age Groups & Drowning Locations

	Deaths	Non Fatal
Under 1	Baby Baths 60%	Bathtubs 54%
1 - 4 yrs	Pools 56%	Pools / Spa 70%
5 - 9 yrs	Seashore 38%	Pools/Spa 76%
10 -14 yrs	Causeways 29%	Pools 40%
15 -19 yrs	Rivers / Waterholes 40%	Beach/ Watersports 37%

FIG 3: Age groups and the highest risk drowning locations by % of group drowned

DISCUSSION AND CONCLUSION

There are approximately six admissions to hospital for every drowning death. Locations, gender and age groups differ for fatal and non fatal. Linked data have improved case capture, particularly in fatalities where a lag in registration on the national system may yet notify more deaths in the 18-19 year olds. Identifying common ground between different data collection systems and inconsistent coding has enabled interpretation which would otherwise be lost to injury prevention patterns and treatment.

It is postulated that availability of linked data will provide detail to allow the development of appropriate prevention strategies, and provide clinicians with an opportunity to explore non fatal outcomes, and how children respond to particular treatments. Degree of severity and drowning related sequelae will be further investigated.


Photo Chris Hyde

REFERENCES

1. CCYPCG Snapshot 2008. Commission for Children and Young People and Child Guardian, Brisbane, 2008.
2. CCYPCG Annual Report: Deaths of Children and Young People, Queensland 2007-08. Commission for Children and Young People and Child Guardian Queensland, Brisbane, 2009.
3. Queensland Injury Surveillance data are collected from approximately 25% of Hospitals across Queensland.

This project is funded by the Queensland Injury Prevention Council.


Photo: Qld Ambulance Service

Presentation for World Safety Conference 2012, Wellington New Zealand

OUT OF SIGHT BUT NOT OUT OF MIND: RURAL DROWNING IN QUEENSLAND AUSTRALIA

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Centre For Children's Burns & Trauma Research | The University Of Queensland AUSTRALIA | Queensland Children's Medical Research Institute

INTRODUCTION

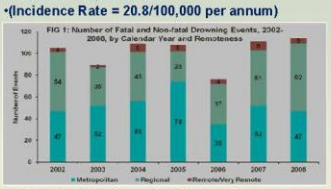
Drowning in children and adolescents (0-19 yrs) is a significant cause of preventable death in Queensland. Recent fatal drowning data suggests that one quarter of all deaths 0-17yrs occurred on farms.[1] Fatalities are well investigated however, the incidence, mechanisms and consequences of non-fatal drowning are unexplored, especially in relation to rural and remote regions and adolescents. The aim of this study was to determine the morbidity and mortality of drowning in young people living in rural and remote regions in Queensland, and to identify risk factors.

METHODS

Retrospective data on fatal and non-fatal drowning events among 0-19 year olds (2002-2008) were linked from multiple sources (pre-hospital; emergency department; admitted patients, and fatality data).[2] Location of usual residence (by postcode) was categorised using Accessibility and Remoteness Index of Australia (ARIA) to define rural and remote (metropolitan; regional; remote/very remote).[3]

RESULTS

- In total, there were 1299 drowning events during 2002-2008 in Queensland.
- (Incidence Rate = 20.8/100,000 per annum)

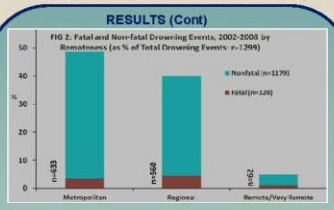


- 60% fatal (n=72) and 47% (n=550) non-fatal drowning events occurred outside a major city.
- 21% (n=13) of events in remote/very remote areas of Queensland were fatal compared with 10.5% (n=59) in regional areas, and 7% (n=44) in major cities (p<.05).
- The majority of non-fatal drowning in remote and very remote areas occurred in females.

Table 1	Deaths	Non-Fatal
Number 2002-2008	120	1179
Metropolitan*	44	589
Regional	59	501
Remote/Very remote	13	49
Mean no/year	17.1 / yr	168.4 / yr
Metropolitan	6.3 / yr	84.1 / yr
Regional	8.4/yr	71.6 / yr
Remote/Very remote	1.8/yr	7.0 / yr
M:F ratio	1.9 : 1	1.4 : 1
Metropolitan	2.7 : 1	1.5 : 1
Regional	1.6 : 1	1.3 : 1
Remote/Very remote	1.6 : 1	1 : 1.5

*Note: Missing ARIA data for 4 fatal and 40 non-fatal cases.

RESULTS (Cont)



- The majority of fatal and nonfatal drowning events occurred in 0-4yrs (70%)
- More fatalities occurred in 5-9yr olds in regional (20%) and remote/very remote (15%) than in metropolitan (2%) (p<.05)
- Among 0-19yr olds, locations for fatal and non-fatal drowning for those who lived outside a major city were: pools (58%), bath (14%), beach/ocean (12%) river/creek 7%; tanks/buckets (5%); dam (4%). See table below for age-specific data.

Fig 3: Top Drowning Locations for Rural/Remote Residents by Age Group

	Deaths (n=72)	Non-Fatal (n=550)
Under 1	Baths 60% (n=3) (metropolitan: Baths 67%)	Baths 73% (n=167) (metropolitan: Baths 72%)
1 - 4 yrs	Pools 47% (n=18) (metropolitan: Pool 79%)	Pools 80% (n=194) (metropolitan: Pool 88%)
5 - 9 yrs	Dam /Lake 29% (n=4) (metropolitan: Pool 100%)	Pools 76% (n=25) (metropolitan: Pool 83%)
10 -14 yrs	River/Creek 80% (n=4) (metropolitan: Beach/Ocean 67%)	Beach /Ocean 33% (n=18) (metropolitan: Pool 58%)
15 -19 yrs	River/Creek 30% (n=3) (metropolitan: River Creek/Beach 33%)	Beach /Ocean 68% (n=29) (metropolitan: Beach/Ocean 62%)

DISCUSSION AND CONCLUSION

Drowning in rural and remote areas is a significant issue. Using linked data, we have provided the most accurate estimate possible of drowning mortality and morbidity in Queensland over seven years.

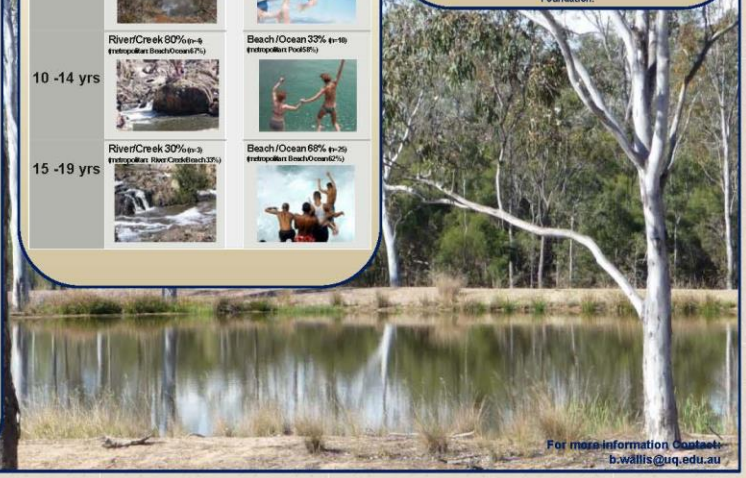
Approximately 1/3 of 0-19yr olds in Queensland live outside metropolitan cities[4], but this group represents half of all drowning events, and outcomes are more frequently fatal.

Drowning prevention strategies in rural areas should focus on children 0-4yrs in relation to pools and baths. Strategies should also take into account higher fatality rates among 5-9yr olds in these regions relative to metropolitan areas. For 15-19yr olds, drowning locations differ between metropolitan and rural areas. Tailored drowning prevention strategies are required for those living in rural areas and should focus on age-specific differences.

REFERENCES

1. CCYPCG. Trends and issues paper No 10 Child deaths – Rural Drowning Aug 2012. Commission for Children and Young People and Child Guardian (CCYPCG), Brisbane, 2012.
2. Data sources: Pre-hospital & Emergency: QAS; EDIS, SATR, QISU, Admitted patients: QHAPDC; Fatality: NCIS, CCYPCG, RLSSA.
3. Accessibility/ Remoteness Index of Australia. Office of Economic and Statistical Research. http://www.oesr.qld.gov.au/about-statistics/statistical-standards/national/aria.php
4. Australian Bureau of Statistics 2011. Population by Age and Sex, Regions of Australia (2005, 2011). Cat 3235.0.

This project is funded by the Queensland Injury Prevention Council and we acknowledge support from the Queensland Children's Health Foundation.



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