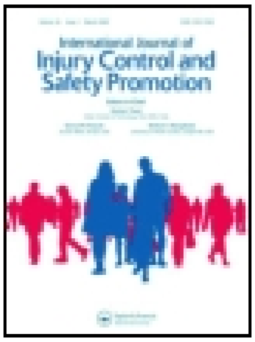

International Journal of Injury Control and Safety Promotion

ISSN: 1745-7300 (Print) 1745-7319 (Online) Journal homepage: http://www.tandfonline.com/loi/nics20

Epidemiology of fatal and non-fatal drowning patients attended by paramedics in Victoria, Australia

Bernadette L. Matthews, Emily Andrew, Robert Andronaco, Shelley Cox & Karen Smith

International Journal of Injury Control and Safety Promotion, 2016
http://dx.doi.org/10.1080/17457300.2016.1175479

Epidemiology of fatal and non-fatal drowning patients attended by paramedics in Victoria, Australia

Bernadette L. Matthews[a]*, Emily Andrew[b,c], Robert Andronaco[a], Shelley Cox[b,c] and Karen Smith[b,c,d]

[a]*Aquatic Risk and Research Department, Life Saving Victoria, Melbourne, Australia;* [b]*Research and Evaluation Department, Ambulance Victoria, Melbourne, Australia;* [c]*Department of Epidemiology and Preventive Medicine, Monash University, Melbourne, Australia;* [d]*Emergency Medicine Department, University of Western Australia, Perth, Australia*

(*Received 14 July 2015; accepted 23 March 2016*)

Drowning is a major cause of injury and death worldwide. This study aims to expand the evidence in fatal and non-fatal drowning. A retrospective study was conducted to investigate fatal and non-fatal drowning incidents attended by ambulance paramedics in Victoria (Australia) from 2007 to 2012. A total of 509 drowning incidents were identified, 339 (66.6%) were non-fatal, with 170 (33.4%) resulting in death. Children aged 0−4 years had the highest crude drowning rate (7.95 per 100,000 persons). Non-fatal incidents were more likely to be witnessed by a bystander when compared with fatal incidents (43.7% vs. 20.0%, $p < 0.001$). Spatial analysis indicated that 35 (43.8%) local government areas (LGAs) were considered at 'excess risk' of a drowning event occurring. This study is the first to apply spatial analysis to determine relative risk ratios for fatal and non-fatal drowning. These findings will enable geographically targeted and age-specific drowning prevention activities.

Keywords: Drowning prevention; unintentional injury; management; health policy

Introduction

Drowning is a major cause of injury and death worldwide. It is estimated that over 370,000 people die each year as a result of drowning, with over 1.3 million disability-adjusted life years lost as a result of premature death or disability, and over 91% of drowning occurring in low- and middle-income countries (Peden & McGee, 2003; WHO, 2014). However these figures underestimate the true burden of drowning because data are not routinely collected in some countries and they do not include drowning due to natural disasters, transportation or non-fatal drowning (WHO, 2014).

Non-fatal drowning can result in severe neurological injury that may result in long-term disabilities requiring extensive rehabilitation and care. Poor outcomes are more common with prolonged submersion (Suominen & Vahatalo, 2012). Estimates of the ratio of fatal to non-fatal drowning incidents vary considerably, with reports from as low as two cases of drowning for each reported death, up to 600 (Kreisfeld & Henley, 2008; Orlowski, 1988; Suominen & Vahatalo, 2012). There have been few epidemiological studies detailing the pattern of non-fatal drowning and the role of contributing factors (Gilchrist, Gotsch, & Ryan, 2004; Kreisfeld & Henley, 2008; Lee, Thompson, & Mao, 2006; Nixon, Pearn, Wilkey, & Corcoran, 1986). Additionally, there have been no studies identified that utilize spatial data analysis to analyse relative risk ratios for fatal and non-fatal drowning events to identify areas of high risk. Limited studies on non-fatal drowning are due in part to under-reporting and issues with the accuracy of hospital coding data (Suominen & Vahatalo, 2012).

The aim of the study is to describe the epidemiology and outcomes of drowning incidents attended by ambulance in Victoria in order to identify patient subgroups most at risk of drowning and who could most benefit from prevention strategies.

Methods

Study design

A retrospective review was conducted on data from fatal and non-fatal drowning cases attended by Ambulance Victoria (AV) paramedics in the pre-hospital environment between 1 January 2007 and 31 December 2012.

Ethics

The study was approved by Monash University Human Research Ethics Committee. The collection of patient outcome data from the Victorian Ambulance Cardiac Arrest Registry (VACAR) is approved by the ethics committees

*Corresponding author. Email: Bernadette.Matthews@lsv.com.au

of participating Victorian hospitals. VACAR is classified as a quality assurance initiative approved by the Victorian Department of Health Human Research Ethics Committee.

Setting

Ambulance Victoria is the sole provider of Emergency Medical Services (EMS) in Victoria, Australia, servicing a population of greater than 5.5 million people. Victoria follows a two-tiered emergency response model, with some paramedics authorized to practice advanced life support (e.g. laryngeal mask insertion), while Mobile Intensive Care Ambulance (MICA) paramedics are authorized to undertake endotracheal intubation, rapid sequence intubation and administer a wider range of drugs. Fire fighters and volunteers also respond to high priority cases in selected areas of Victoria. Triage of emergency phone calls follows the Medical Priority Dispatch System (MPDS) which allocates an event type to all calls and includes an event card specifically for drowning cases. Patients attended by AV are managed according to the Ambulance Victoria Clinical Practice Guidelines (Ambulance Victoria, 2014).

Data sources

Data were sourced from VACIS® and VACAR. VACIS is an in-field electronic data capture system used by paramedics to record pre-hospital data at the point of care (Cox, Martin, Somaia, & Smith, 2013). Paramedics record patient demographics, case history, vital signs, diagnosis, management, time intervals and outcomes. The VACAR collects data for all out-of-hospital cardiac arrests (OHCA) attended by EMS in Victoria (Nehme et al., 2015). It is supplemented with outcome data from Victorian hospitals. In addition, hospital discharge status for major trauma patients (excluding OHCA) was sourced from the Victorian State Trauma Registry (VSTR), which collects information on all major trauma patients across Victoria (Cameron et al., 2004). Cases of drowning resulting in OHCA as a specific group have been described in detail previously (Dyson, Morgans, Bray, Matthews, & Smith., 2013).

Study population

Drowning patients were classified into two groups, namely 'fatal' and 'non-fatal' drowning, according to the accepted definition of 'drowning' (Idris et al., 2003), that is, a process resulting in primary respiratory impairment from submersion/immersion in liquid. True drowning cases were identified via a search of cases with a drowning-related MPDS event code, a paramedic recorded final primary assessment of 'post immersion' or a case nature of 'drowning', 'immersion', 'submersion' or 'diving' (a free text field in VACIS). Fatal drowning incidents included patients identified as deceased within the VACAR or VSTR following a drowning event. All remaining drowning incidents were considered non-fatal. Data for non-accidental drowning were excluded from the analyses.

Statistical analysis

Descriptive statistics are presented across age and incident categories as frequencies and proportions, and as median and inter-quartile range for continuous data. Groups were compared using Pearson's chi-square test, Fischer's exact test and Kruskal–Wallis test as appropriate. All comparisons are presented as p-values. Multivariable logistic regression analysis was performed to determine independent predictors of fatal drowning. The Hosmer and Lemeshow test and area under the receiver operating curve were used to assess the model's goodness of fit. Statistical analyses were performed using IBM® SPSS® Statistics 20.0. Statistical significance was set at $p < 0.05$. Incidence calculations were performed using population figures published by the Australian Bureau of Statistics, 2013 (Australian Bureau of Statistics, 2013).

Spatial analysis

Incidence risk estimates or relative risk ratios for drowning were provided using a constant risk approach (Waller & Gotway, 2004). Latitude and longitude coordinates were used to define geographic position. Relative risk ratios across different geographic units were devised by a count of events per geographic unit, using a Geographic Information System (GIS), ArcGIS for Desktop 10.2.2. The geographic units selected for this study were the Victorian LGA administrative units (Australian Bureau of Statistics, 2011). The State of Victoria has 80 defined LGAs, ranging in size from 8.6 km^2 to 22,082 km^2, and population distribution from 4537 to 1,496,348 (Australian Bureau of Statistics, 2011).

Within the GIS, the point event data-set (verified ambulance responses) were laid across the selected geographic unit layer (LGA) using a common projected coordinate system (Geocentric Datum of Australia [GDA] 1994 VicGrid). The data were joined spatially based on the point event's geographic relationship with the LGA unit. Point events received the attribute information of the individual LGA it was geographically located in ($n = 501$) or closest to ($n = 8$), and then aggregated based on LGA name. Aggregated counts were attributed to the census unit population totals for the study years (Australian Bureau of Statistics, 2013). A relative risk ratio per LGA unit was determined for all applicable attended ambulance drowning events using the following calculation: Relative Risk = (Individual LGA Event Count/Individual LGA Population)

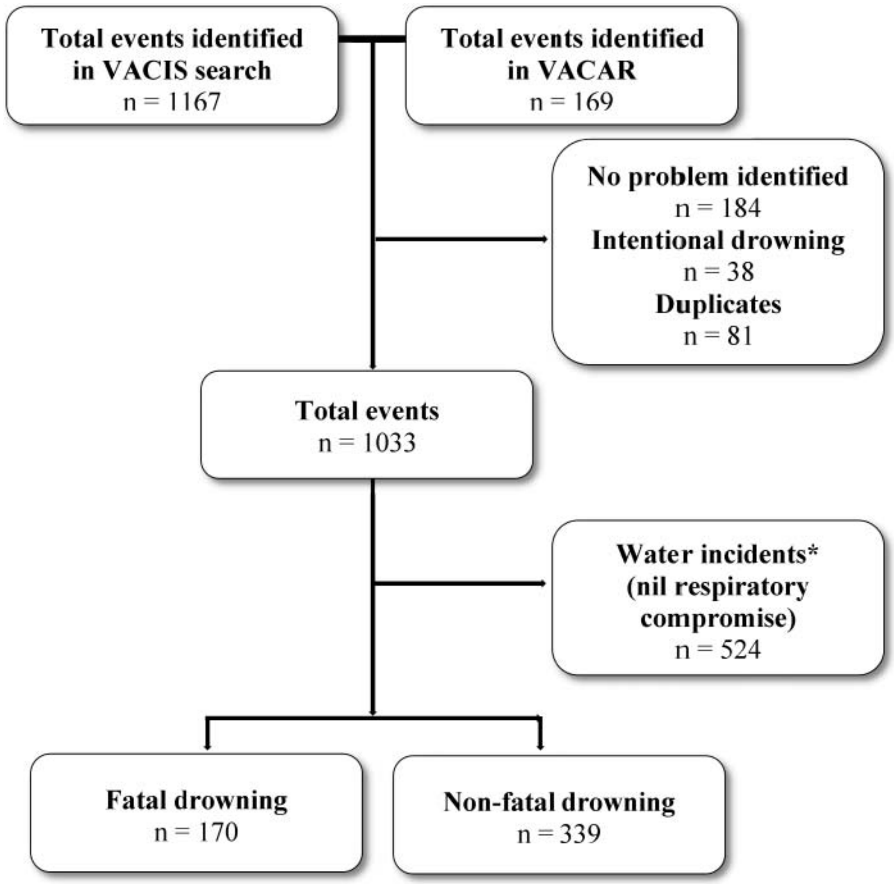

Figure 1. Case selection of drowning incidents attended by Ambulance Victoria between January 2007 and December 2012.
*Water incidents included traumatic, sporting and boating accidents, as well as falls/slips where nil respiratory impairment was recorded.

* (Sum Total Population/Sum All LGA Unit Events). Relative risk ratios greater than 1 were viewed as 'excess risk' (Rothman, Greenland, & Lash, 2008).

Results

There were 509 patients treated by paramedics for unintentional drowning incidents in Victoria from 2007 to 2012 (Figure 1). Of these, 339 (66.6%) events were non-fatal, with 170 (33.4%) resulting in death. The crude incidence of drowning events in Victoria was 1.57 drowning incidents per 100,000 persons. The crude incidence of non-fatal drowning was 1.04 per 100,000 population compared to 0.53 per 100,000 population for fatal drowning (Table 1).

Characteristics of fatal and non-fatal drowning incidents

Children aged 0−4 years had the highest age-specific rates of fatal and non-fatal drowning (7.95 per 100,000). Age-specific drowning rates decreased with increasing age until age 65+ years where an increase was observed (Table 2). Adults aged 65 years and over were more likely to suffer a fatal drowning (26.0%, $p < 0.001$). Males were consistently more likely to be involved in a drowning incident (61.7%) and were over-represented across all age groups.

Most non-fatal drowning incidents occurred in the ocean (27.4%), followed by public or private swimming pools (24.5% and 22.7%, respectively). Fatal drowning incidents most frequently occurred in the ocean (37.9%) followed by inland waterways (27.3%). Patients drowned in salt (38.3%), fresh (30.5%) or chlorinated (28.6%) water.

Incident location varied across age categories. For instance, drowning incidents among children 0−4 years were more likely to occur in private pools (38.0%) or bathtubs (25.8%). Among those 5−19 years of age, drowning occurred most frequently in public pools (40.0%), or in the ocean (27.8%). Open waterways, in particular the ocean, accounted for the highest proportion of drowning in those aged 20−64 years (52.4%) and 65+ years (40.7%).

Table 1. Characteristics non-fatal and fatal drowning incidents in Victoria.

	Total ($n = 509$)	Non-fatal drowning ($n = 339$)	Fatal drowning ($n = 170$)	p-value
Crude incidence/100,000 population	1.57	1.04	0.53	–
Age group, no (%)				
0–4 years	164 (33.7)	145 (43.5)	19 (12.3)	<0.001
5–19 years	93 (19.1)	73 (21.9)	20 (13.0)	0.020
20–64 years	169 (34.7)	94 (28.2)	75 (48.7)	<0.001
65+ years	61 (12.5)	21 (6.3)	40 (26.0)	<0.001
Missing	22 (4.3)	6 (1.8)	16 (9.4)	–
Male gender, no (%)	313 (61.7)	197 (58.1)	116 (69.0)	0.017
Missing	2 (0.4)	0 (0)	2 (1.2)	–
Public place, no (%)	310 (61.3)	203 (60.4)	107 (62.9)	<0.582
Missing	3 (0.6)	3 (0.9)	0 (0)	–
Body of water, no (%)				
Bath/spa/bucket/sink	69 (13.8)	42 (12.4)	27 (16.8)	0.184
Ocean	154 (30.8)	93 (27.4)	61 (37.9)	0.018
Private pool	101 (20.2)	77 (22.7)	24 (14.9)	0.042
Public pool	88 (17.6)	83 (24.5)	5 (3.1)	<0.001
Inland waterways	88 (17.6)	44 (13.0)	44 (27.3)	<0.001
Missing	9 (1.8)	0 (0)	9 (5.3)	–
Season, no (%)				
Summer	262 (51.5)	189 (55.8)	73 (42.9)	0.006
Autumn	87 (17.1)	52 (15.3)	35 (20.6)	0.138
Winter	48 (9.4)	29 (8.6)	19 (11.2)	0.340
Spring	112 (22.0)	69 (20.4)	43 (25.3)	0.204
Witnessed, no (%)	182 (35.8)	148 (43.7)	34 (20.0)	< 0.001
Bystander CPR/EAR, no (%)	141 (34.2)*	104 (30.7)	37 (50.7)*	0.001

Note: All proportions exclude missing data.
*Excludes obviously deceased patients.
CPR, cardiopulmonary resuscitation; EAR, expired air resuscitation.

Many drowning incidents occurred whilst swimming (42.8%), during summer (51.5%). The proportion of drowning incidents associated with sporting/leisure activities increased with increasing age. On the other hand, drowning associated with bathing was highest in children 0–4 years (23.3%) and decreased with increasing age until age 64 years. Over one quarter (26.8%) of patients were found immersed/submersed in water and therefore the activity just prior to drowning was unknown.

While the majority of incidents occurred in a public place (61.3%), only one third (35.8%) were witnessed by a bystander. Non-fatal incidents were more likely to be witnessed than fatal incidents (43.7% vs. 20.0%, $p < 0.001$). Bystander cardiopulmonary resuscitation (CPR) or expired air resuscitation (EAR) was more common for fatal compared to non-fatal drowning incidents (50.7% vs. 30.7%, $p < 0.001$).

Independent predictors of fatal drowning

The results of a multivariable logistic regression analysis showed that the odds of a fatal drowning incident increased with increasing age (odds ratio (OR) 1.038, 95% confidence interval (CI) 1.027–1.049, $p < 0.001$) and male gender (OR 1.886, 95% CI 1.106–3.214, $p = 0.020$), while the odds decreased when an event was witnessed (OR 0.517, 95% CI 0.278–0.964, $p = 0.038$). When compared with patients who were swimming prior to drowning, patients who were boating (OR 4.371, 95% CI 1.154–16.549, $p = 0.030$), bathing (OR 5.337, 95% CI 1.942–14.668, $p = 0.001$) or undertaking sporting activities (OR 3.377, 95% CI 1.560–7.309, $p = 0.002$) had significantly greater odds of the event being fatal, as did patients who were found floating (OR 8.728, 95% CI 4.209–18.099, $p < 0.001$). Season and public location were not significantly associated with outcome.

Spatial analysis

Of the 80 LGAs in Victoria, 42 (52.5%) had 1–5 drowning events attended by ambulance; 22.5% had 6–10 events, 15.1% had 11–35 events and 10.0% had no events. While the majority (62.5%) of LGAs had at least

Table 2. Age-specific characteristics of fatal and non-fatal drowning incidents in Victoria.

	Total ($n = 509$)*	0−4 years ($n = 164$)	5−19 years ($n = 93$)	20−64 years ($n = 169$)	65+ years ($n = 61$)	p-value
Crude incidence/100,000 population	1.57	7.95	1.53	0.85	1.36	–
Out-of-hospital cardiac arrest, no (%)	184 (36.1)	22 (13.4)	21 (22.6)	80 (47.3)	44 (72.1)	<0.001
Confirmed fatal drowning, no (%)	170 (33.4)	19 (11.6)	20 (21.5)	75 (44.4)	40 (65.6)	<0.001
Crude incidence/100,000 population	0.53	0.92	0.33	0.38	0.90	–
Male gender, no (%)	313 (61.7)	99 (60.4)	59 (63.4)	100 (59.5)	39 (63.9)	0.889
Missing	2 (0.4)	0 (0)	0 (0)	1 (0.6)	0 (0)	–
Public place, no (%)	310 (61.3)	43 (26.7)	71 (76.3)	135 (79.9)	40 (65.6)	<0.001
Missing	3 (0.6)	3 (1.8)	0 (0)	0 (0)	0 (0)	–
Witnessed, no (%)	182 (35.8)	50 (30.5)	49 (52.7)	66 (39.1)	11 (18.0)	<0.001
Body of water, no (%)						
Bath/spa/bucket/sink	69 (13.8)	42 (25.8)	5 (5.6)	13 (7.8)	9 (15.3)	<0.001
Ocean	154 (30.8)	7 (4.3)	25 (27.8)	87 (52.4)	24 (40.7)	<0.001
Private pool	101 (20.2)	62 (38.0)	16 (17.8)	15 (9.0)	8 (13.6)	<0.001
Public pool	88 (17.6)	31 (19.0)	36 (40.0)	17 (10.2)	14 (23.7)	<0.001
Inland waterways	88 (17.6)	21 (12.9)	8 (8.9)	34 (20.5)	4 (6.8)	0.015
Missing	9 (1.8)	1 (0.6)	3 (3.2)	3 (1.8)	2 (3.3)	–
Season, no (%)						
Summer	262 (51.5)	86 (52.4)	63 (67.7)	83 (49.1)	23 (37.7)	0.002
Autumn	87 (17.1)	29 (17.7)	5 (5.4)	39 (23.1)	10 (16.4)	0.004
Winter	48 (9.4)	16 (9.8)	8 (8.6)	12 (7.1)	10 (16.4)	0.201
Spring	112 (22.0)	33 (20.1)	17 (18.3)	35 (20.7)	18 (29.5)	0.371
Activity, no (%)						
Swimming	206 (42.8)	60 (36.8)	64 (72.7)	65 (42.2)	13 (23.6)	<0.001
Boating	13 (2.7)	0 (0)	2 (2.3)	8 (5.2)	3 (5.5)	0.006
Bathing	56 (11.6)	38 (23.3)	4 (4.5)	8 (5.2)	6 (10.9)	<0.001
Driving	6 (1.2)	0 (0)	0 (0)	2 (1.3)	2 (3.6)	0.032
Sporting/leisure/Other	71 (14.8)	13 (8.0)	8 (9.1)	33 (21.4)	11 (20.0)	0.002
Found immersed/submersed (unknown activity)	129 (26.8)	52 (31.9)	10 (11.4)	38 (24.7)	20 (36.4)	0.001
Missing	28 (5.5)	1 (0.6)	5 (5.4)	15 (8.9)	6 (9.8)	–
Type of liquid, no (%)						
Salt water	166 (38.3)	13 (9.3)	29 (35.4)	89 (61.4)	24 (50.0)	<0.001
Chlorinated water	124 (28.6)	58 (41.4)	42 (51.2)	18 (12.4)	6 (12.5)	<0.001
Fresh water	132 (30.5)	67 (47.9)	11 (13.4)	34 (23.4)	14 (29.2)	<0.001
Other/mud	11 (2.5)	2 (1.4)	0 (0)	4 (2.8)	4 (8.3)	0.032
Missing	76 (14.9)	24 (14.6)	11 (11.8)	24 (14.2)	13 (21.3)	–

*Includes 22 patients for whom age is missing. Proportions exclude missing data.

one fatal drowning event, over a third (37.5%) of LGAs had no fatal drowning event.

When the risk ratio was applied (accounting for population distribution), 35 (43.8%) Victorian LGAs were considered at 'excess risk' of a drowning event occurring (> 1.00). A number of LGAs along the Victorian coastline were considered at excess risk of a fatal drowning occurring (Figure 2). Other areas showing excess risk of fatal drowning were the central and mid-north regions. The north-eastern and western regions of Victoria had a number of LGAs considered at excess risk for non-fatal drowning.

Discussion

On average, 85 unintentional drowning incidents were attended by paramedics each year, a crude incidence of 1.57 per 100,000 persons in Victoria. The rate of non-fatal drowning was twice that of fatal drowning, which is consistent with an earlier Australian study (Kreisfeld & Henley, 2008). However, our figure is considerably lower than other reports in which non-fatal drowning ranged from two to 600 times higher than fatal drowning (Gilchrist et al., 2004; Lee et al., 2006; Nixon et al., 1986; Orlowski, 1988; Suominen & Vahatalo, 2012). Disparities

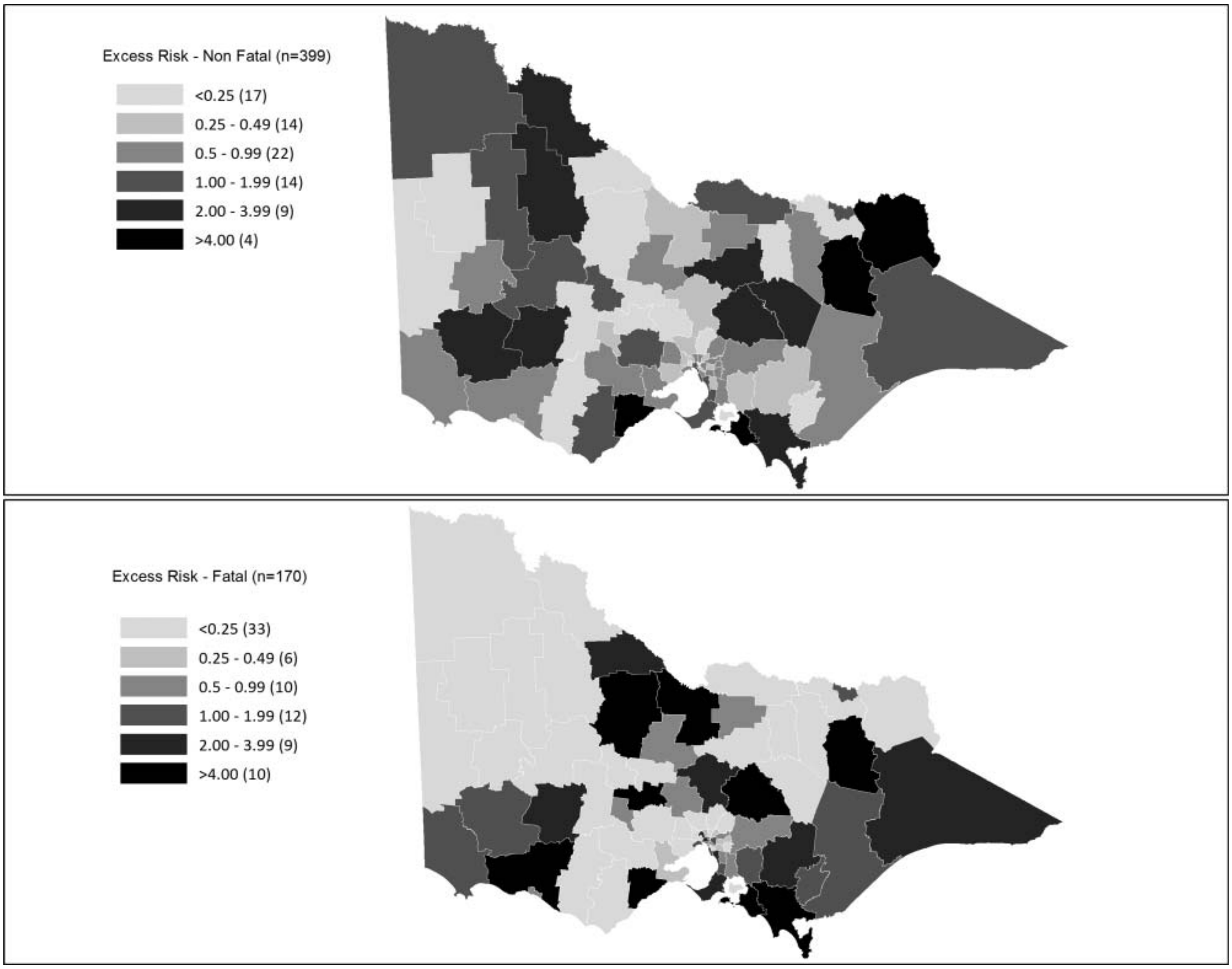

Figure 2. Drowning risk by incident location in local government areas in Victoria ($N = 80$) between January 2007 and December 2012.

between these rates may be the result of other studies examining estimates; data collected prior to the new definition of drowning; studies conducted a number of years ago (drowning rates particularly in high income countries have decreased over the years) or data collected only on specific environment or population subgroups (Gilchrist et al., 2004; Lee et al., 2006; Nixon et al., 1986; Orlowski, 1988; Suominen & Vahatalo, 2012).

A number of similarities exist between our population and those of previous studies. For instance, males were most highly represented across all age groups and incident types, which is consistent with previous fatal drowning research (Quan & Cummings, 2003). Evidence suggests this is due to higher risk-taking activity as well as greater exposure to water through common recreational activities (Howland, Hingson, Mangione, Bell, & Bak, 1996; Morgan, Ozanne-Smith, & Triggs, 2009). Similarly, children aged 0−4 years had the highest age-specific rates of fatal and non-fatal drowning. These incidents typically occurred in private pools or bathtubs and were less likely to be witnessed. These findings are similar to previous studies (Suominen & Vahatalo, 2012) and highlight the importance of supervision of children around water.

Children aged 5−19 years were more likely to experience a non-fatal incident which may in part be due to the location of the incident. The majority of drowning events in this age group occurred in public pools and were likely to be witnessed by a bystander. This reflects the relatively controlled environment of public pools where lifeguard services are in place, increasing the chance of being witnessed and receiving bystander CPR/EAR. In contrast, drowning events in older adults aged 65 and over were more likely to be fatal. This may be due to less events being witnessed despite many occurring in a public location. Over a third of victims were found immersed or submerged in water and were therefore likely to have been alone at the time of the incident. Furthermore, multivariate analysis showed that patients who were male; over 64 years old; and where the event was not witnessed had a greater chance of the event being fatal. Our results highlight the importance of public awareness campaigns in promoting older adult awareness around water and promoting bystander participation in CPR/EAR.

Drowning events were most likely to occur in the ocean and in the summer months. This may be due to higher levels of exposure, as well as the inherent dangers of open waterways, such as rip currents in the ocean, or a lack of knowledge of the conditions (Sherker, Williamson, Hatfielda, Brander, & Hayend, 2010). While more drowning events occurred in the ocean environment, drowning in inland waterways was more likely to be fatal. Many Australian inland waterways are located in regional and remote areas which are isolated from advanced medical services. Favourable outcomes in coastal environments when compared with inland may reflect life-saving services provided in targeted coastal locations which can deliver first aid and fast activation of ambulance services. Risk factors and exposure in ocean environments are well documented (Morgan et al., 2009; Sherker et al., 2010); however, few studies have examined inland waterways (Peden & Queiroga, 2014). Further research is required to compare levels of exposure across all types of aquatic environments and activities.

Ambulance attendance at 43.8% of Victorian LGAs was disproportionate to LGA population distribution. The higher number of LGAs along the Victorian coastline considered at excess risk for fatal drowning and in areas with major inland waterways is not unexpected given the majority of events occurred in open water environments. A recent study demonstrated that people travel large distances to aquatic environments in Victoria (Andronaco, Matthews, Grace, Adams, & Arrowsmith, 2012). It is therefore likely that a number of events occurred in locations other than the patient's LGA of residence, increasing the excess risk of that LGA. In addition, while accounting for population incidence is more accurate than using frequency of events, the relative risk calculation is sensitive to LGA population variance (Waller & Gotway, 2004). Further investigation is required to identify why certain LGAs have a higher than expected level of risk. Additionally, there may be lessons to be learned from LGAs with lower than expected level of risk. Through spatial analyses of socio-demographic, environment and exposure variables, geographically targeted prevention activities could potentially be developed.

Our study has a number of limitations. Retrospective review studies have known limitations. In addition, VACIS was introduced at Ambulance Victoria in 2005/06 with limited use in rural regions for a number of years. Case capture of non-fatal drowning incidents in rural regions may hence be incomplete. Further, only major trauma or OHCA patients received hospital follow-up through VACAR and VSTR. Those patients transported to hospital that did not qualify for entry into VACAR or VSTR were assumed to be non-fatal ($n \approx 270$). Data were collected on patients attended by paramedics in the pre-hospital environment; inclusion of cases was determined by paramedic assessment and MPDS and therefore does not constitute a medical diagnosis. Finally, data does not include those incidents where the patient was not attended by AV (e.g. transported to hospital by means other than ambulance, fatal incidents where the deceased was transported directly to the mortuary).

Conclusion

This epidemiological study has provided detailed evidence of the characteristics of victims of both fatal and non-fatal drowning. Children aged 0−4 years are at greatest risk of both fatal and non-fatal drowning while children of 5−19 years are more likely to experience a non-fatal incident and older adults aged 65 and over are more likely to have a fatal outcome. Subsequently prevention measures should continue to focus on: supervision messages for parents and carers of children; the importance of not recreating alone around water and early bystander CPR/EAR for drowning prevention across all age groups and increasing water safety skills and knowledge for older adults. Potential influencing factors such as exposure and proximity to services require further investigation.

Acknowledgements

Ambulance Victoria, for providing VACIS and VACAR data for this study. The Victorian State Trauma Registry (VSTR) is a Department of Health, State Government of Victoria and Transport Accident Commission funded project.

Disclosure statement

BM and RA work for Life Saving Victoria. EA, SC and KS work for Ambulance Victoria.

References

Ambulance Victoria. (2014). Clinical practice guidelines. Retrieved from http://www.ambulance.vic.gov.au/Paramedics/Qualified-Paramedic-Training/Clinical-Practice-Guidelines.html

Andronaco, R., Matthews, B., Grace, S., Adams, A., & Arrowsmith, C. (2012). Aquatic safety signage recognition and comprehension. *Injury Prevention, 18*(Suppl. 1), A136. doi:10.1136/injuryprev-2012-040590h.15

Australian Bureau of Statistics. (2011). Local Government Area ASGC Ed 2011 Digital Boundaries in ESRI Shapefile Format. Retrieved from http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1259.0.30.001July%202011?OpenDocument

Australian Bureau of Statistics. (2013). Australian Demographic Statistics Table 52. Retrieved from http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3101.0Jun%202013?OpenDocument

Cameron, P., Finch, C., Gabbe, B., Collins, L., Smith, K., & McNeil, J. (2004). Developing Australia's first statewide trauma registry: What are the lessons. *ANZ J Surgery, 74*, 424−428.

Cox, S., Martin, R., Somaia, P., & Smith, K. (2013). The development of a data-matching algorithm to define the 'case patient'. *Australian Health Review, 37*(1), 54−59.

Dyson, K., Morgans, A., Bray, J., Matthews, B., & Smith, K. (2013). Drowning related out-of-hospital cardiac arrests: Characteristics and outcomes. *Resuscitation, 84*(8), 1114−1118.

Gilchrist, J., Gotsch, K., & Ryan, G. (2004). Nonfatal and fatal drownings in recreational water settings − United States, 2001−2002. *Morbidity and Mortality Weekly Report, 53*(21), 447−450.

Howland, J., Hingson, R., Mangione, T.W., Bell, N., & Bak, S. (1996). Why are most drowning victims men? Sex differences in aquatic skills and behaviour. *The American Journal of Public Health, 86*(1), 93−96.

Idris, A.H., Berg, R.A., Bierens, J., Bossaert, L., Branche, C.M., Gabrielli, A., … Modell, J.H. (2003). Recommended guidelines for uniform reporting of data from drowning: The "Utstein style". *Circulation, 108*(20), 2565−2574.

Kreisfeld, R., & Henley, G. (2008). *Deaths and hospitalisations due to drowning, Australia 1999−00 to 2003−04*. Injury Research and Statistics Series, Number 39. Adelaide: Australian Institute of Health and Welfare (AIHW).)

Lee, L.K., Thompson, K.M., & Mao, C. (2006). Demographic factors and their association with outcomes in pediatric submersion injury. *Academic Emergency Medicine, 13*(3), 308−313.

Morgan, D., Ozanne-Smith, J., & Triggs, T. (2009). Self-reported water and drowning risk exposure at surf beaches. *Australian and New Zealand Journal of Public Health, 33* (2), 180−188. doi:10.1111/j.1753-6405.2009.00367.x

Nehme, Z., Bernard, S., Cameron, P., Bray, J.E., Meredith, I.T., Lijovic, M., & Smith, K. (2015). Using a cardiac arrest registry to measure the quality of emergency medical service care: Decade of findings from the victorian ambulance cardiac arrest registry. *Circ Cardiovasc Qual Outcomes, 8*(1), 56−66. doi:10.1161/circoutcomes.114.001185

Nixon, J., Pearn, J., Wilkey, I., & Corcoran, A. (1986). Fifteen years of child drowning: A 1967−1982 analysis of all fatal cases from the Brisbane Drowning Study and an 11 year study of consecutive near-drowning cases. *Accident Analysis and Prevention, 18*(3), 199−203.

Orlowski, J.P. (1988). Drowning, near-drowning, and ice-water drowning. *JAMA, 260*(3), 390−391. doi:10.1001/jama.1988.03410030106040

Peden, A., & Queiroga, A.C. (2014). *Drowning deaths in Australian rivers, creeks and streams: A 10 year analysis*. Sydney: Royal Life Saving Society − Australia.

Peden, M.M., & McGee, K. (2003). The epidemiology of drowning worldwide. *Injury Control and Safety Promotion, 10*(4), 195−199. doi:10.1076/icsp.10.4.195.16772

Quan, L., & Cummings, P. (2003). Characteristics of drowning by different age groups. *Injury Prevention, 9*(2), 6.

Rothman, K.J., Greenland, S., & Lash, T.L. (2008). *Modern epidemiology* (3rd ed.). Philadelphia: Wolters Kluwer Health/ Lippincott Williams & Wilkins.

Sherker, S., Williamson, A., Hatfielda, J., Brander, R., & Hayend, A. (2010). Beachgoers' beliefs and behaviours in relation to beach flags and rip currents. *Accident Analysis and Prevention, 42*, 20.

Suominen, P.K., & Vahatalo, R. (2012). Neurologic long term outcome after drowning in children. *Scandinavian Journal of Trauma Resuscitation and Emergency Medicine, 20*, 55. doi:10.1186/1757-7241-20-55

Waller, L.A., & Gotway, C.A. (2004). *Applied Spatial Statistics for Public Health Data*. Hoboken, NJ: John Wiley & Sons.

WHO. (2014). *Global report on drowning: Preventing a leading killer*. Barcelona: World Health Organization.