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Rates and ratios of fatal and nonfatal drowning attended by ambulance in New South Wales, Australia between 2010 and 2021

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ABSTRACT

Introduction: Drowning is a preventable cause of mortality, with 279 unintentional drowning deaths per year in Australia. Despite larger estimated numbers, less is known about nonfatal drowning compared to fatalities. This study aimed to examine the burden of fatal and nonfatal drowning in the Australian state of New South Wales using pre-hospital case capture. *Methods:* A cross-sectional analysis of individuals attended by an ambulance in NSW for drowning between 2010 and 2021 was conducted. Ambulance data (paper-based and electronic medical records) were linked to emergency department and death registry. Ratios of fatal to nonfatal drowning were constructed overall, by sex, age, and remoteness of incident and residential locations. *Results:* 3,973 ambulance-attended drowning patients were identified (an annual rate of 4.16/100,000 persons). Six percent (6.1%; n = 243) died within 30 days, 82.7% (n = 201) of which died on the day of incident, including at the scene. Mean survival time for those who died between 2 and 30 days was 4.6 days. The overall ratio of fatal to nonfatal incidents was 1:15. Ratios were highest for 10–19 year-olds (1:77), females (1:22), and in metropolitan incident (1:20) and residential (1:23) locations. Across the study drowning declined by 14 incidents and 0.18 fatalities per year. *Discussion:* Temporal trends indicate declining drowning incidents and fatalities. However, this study highlights significant numbers of nonfatal incidents among those traditionally seen as lower risk, such as adolescents and females, necessitating a widened focus on improving water safety among these groups. *Conclusions:* Nonfatal drowning results in significant, yet preventable health system burden in New South Wales. *Practical Applications:* This study highlights the importance of documenting the full burden of drowning, including health system impacts of a preventable cause of injury and death. Such data may be used to encourage further investment in primary prevention efforts.

1. Introduction

Drowning is a cause of preventable mortality, both globally, and in Australia (World Health Organization, 2014; Peden et al., 2021). Globally, drowning is the third leading cause of injury-related mortality with the greatest burden experienced among children and young people under 25 years of age and those living in low- and middle-income countries (World Health Organization, 2021). Accurate estimations of the global burden of fatal drowning are challenging and, in order to add to the evidence base, the World Health Organization (WHO) recommends data collection and the conduct of well-designed studies (World Health Organization, 2017).

In Australia, annual drowning reports indicate an average of 279 people have died due to unintentional drowning in Australia every year

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for the past 10 years (Royal Life Saving Society, 2023). Although fatal drowning rates in Australia are declining due to the combined efforts of drowning prevention organizations, policy makers, researchers and advocates (Peden et al., 2021), reducing fatal drowning is only one part of a comprehensive approach to drowning prevention.

Drowning, which is defined as a process of experiencing respiratory impairment due to submersion or immersion in a liquid, (van Beeck et al., 2005), does not always result in death. Those who experience an incident can survive with or without morbidity (van Beeck et al., 2005). Significantly less is known about the burden of these incidents, recently clarified as "nonfatal drowning," in part due to a lack of standard application of a proposed global definition and classification framework (Beerman et al., 2018). From the limited global literature, nonfatal drowning is estimated to account for a burden that is up to 20 times higher than the fatal drowning burden (Rahman et al., 2017).

In Australia, previous research at the national level has defined nonfatal drowning as a discharge from hospital, following admission for drowning, where the patient survives regardless of ongoing health status (Mahony et al., 2017). National estimates using hospital separation data indicate that for every fatal drowning in Australia, three people receive admitted hospital treatment for drowning and are subsequently released alive (Peden et al., 2018). At the sub-national level, a range of data sources have been used to examine burden and risk factors for nonfatal drowning, including ambulance and linked data spanning ambulance, hospital, and death records (Berecki-Gisolf et al., 2024; Matthews et al., 2017; Wallis et al., 2015). No previous study of nonfatal drowning, including using linked data, has been conducted in the state of New South Wales, Australia's most populous state.

To expand our understanding of the burden of drowning, this study uses linked data (comprising ambulance, emergency department, and death registry) to examine patterns of drowning considered serious enough to be attended by ambulances in New South Wales. It aims to describe their fatal to nonfatal ratios by demographic variables (age, sex, remoteness).

2. Materials and methods

This is a retrospective analysis of linked data on drowning patients (unintentional, intentional, and undetermined intent). The study setting is the Australian state of New South Wales, with a resident population of 8.153 million people (New South Wales Government, 2024). The state has a range of water bodies including 1,460 km of coastline, a range of rivers, lakes, dams and reservoirs used for water storage, transportation, and recreation (New South Wales Government, 2024). In addition, there is a high density of public and home swimming pools, particularly in metropolitan locations and areas with a more temperate climate.

The detailed methodology employed by this study is documented elsewhere (Peden et al., 2021). In brief, the New South Wales Centre for Health Data Linkage (CHeReL) provided a linked administrative dataset with patient identifiers removed, based on the cohort of all individuals attended by a New South Wales ambulance for drowning between 1 January 2010 and 31 December 2021 (Peden et al., 2021). Ambulance data, collected through the paper-based Patient Health Care Record (PHCR) and electronic medical record (eMR), were linked with the New South Wales Emergency Department Data Collection (EDDC), and deaths data through the Registry of Births, Deaths and Marriages (RBDM) (New South Wales Centre for Health Record Linkage, 2024). Population data were retrieved from 2016 Census Quickstats (Australian Bureau of Statistics, 2024). 2016 was chosen as it occurred at approximately the midpoint of the study period.

Drowning cases were identified through a range of drowning-related problem codes in PHCR and eMR, as well as drowning-related International Classification of Diseases (ICD) codes (W65-W74) for fatal drowning cases in RBDM. Detailed codes to identify cases are listed in Appendix 1. Ambulance cases coded as 'scuba accident,' 'diving accident susp neck injury,' and 'E2 diving' were excluded due to unknown involvement of drowning.

During the study period, New South Wales ambulance transitioned from using PHCR to eMR; where records were duplicated across PHCR and eMR, only the eMR record was retained. Where more than one paramedic attended the same patient, only the primary record was retained. Likewise, data for patient transfer between hospitals were also excluded. Multiple independent incidents for the same individuals were treated separately. Fatal drowning was defined as the individual having a death date within 30 days of the ambulance attendance date. If the ambulance recorded the individual as "Deceased on examination" but no death record was linked, the individual was deemed to have died on the ambulance attendance date. All remaining individuals were considered to have experienced a nonfatal drowning incident.

PHCR and eMR both contain a Global Positioning System (GPS) coordinate of the location the ambulance was dispatched to. GPS coordinates were considered valid where they had an accuracy of 111 m or less. The level of remoteness of an incident was then determined by checking whether its location was within the remoteness areas geometry provided by the Australian Statistical Geography Standard (ASGS) 2021 classification (Australian Bureau of Statistics, 2024). Records lacking a valid incident coordinate were classified using the incident postcode (also termed postal code or zip code) if available. ASGS 2021 does not provide a postcode to remoteness area mapping, so the postcode was mapped to a remoteness classification using data provided in the ASGS 2016 classification (Australian Bureau of Statistics, 2018), and then upgraded to the 2021 classification using location correspondences provided in ASGS 2021 (Australian Bureau of Statistics, 2024). The same procedures were also conducted to map the patient's residential postcode to remoteness classification. Some latitude/longitude pairs and postcodes were not able to be mapped to a remoteness classification, in which case the remoteness classification was marked as missing. Remoteness classifications of both incident and residential locations of the patient were grouped into metropolitan (ASGS classification of major city) and non-metropolitan (ASGS classifications of inner regional, outer regional, remote and very remote) (Australian Bureau of Statistics, 2024).

Variables of interest may have had more than one potential source; for example, the patient's sex is recorded by paramedics in the ambulance, in the emergency department (ED), when they are admitted to hospital, and in their death record (if applicable). Demographic variables were validated across sources to confirm concordance, as non-concordance may indicate linkage errors or data entry mistakes. Where an individual had a non-plausible value recorded for age (defined as $>$ 120 years), their age was marked as missing. If the age differed across data sources, the age recorded at the ED was used. Data were cleaned and analyzed using Python 3.12.0 software (Python Software Foundation, 2023) with the Pandas 2.1.4 library (McKinney, 2010).

The rate of incidents per 100,000 individuals per year were calculated using population data from the 2016 census (Australian Bureau of Statistics, 2016); 2016 was selected as it corresponds approximately the mid-point of the study period. Ratios of fatal to nonfatal incidents were calculated by dividing the number of nonfatal incidents by the fatalities overall, 10-year age group and remoteness of incident and residential location. To highlight the significant drowning burden among children 0–4 years, these have been reported separately. Temporal trends were calculated using a least squares linear regression.

Ethics approval for the study was granted by the New South Wales Population & Health Services Research Ethics Committee (approval number: HREC/18/CIPHS/19).

3. Results

A total of 3,973 drowning incidents were found, including 2,061 electronic records and 1,912 digitized paper-based records. This included information for 12 incidents that occurred in locations just outside the border of New South Wales, but where a New South Wales

ambulance responded. In total, 243 individuals (6.1%) died within 30 days of the incident. Of these, 201 (82.7%) died on the day of the incident or were found dead at the scene. Of the 42 patients who survived for 1 or more days but died within 30 days, the mean and median survival times were 4.6 and 2.0 days, respectively. There were 2,316 patients with ED records, of which 86 died; the other 115 people who died did not have an ED record linked.

The average rate of nonfatal incidents was 4.16 incidents per 100,000 persons per year, and the rate of fatal incidents was 0.27 incidents per 100,000 persons per year. The total number of incidents showed a statistically significant ($p = 0.039$) reduction of 14 incidents per year, while the fatal incidents did not show a significant change ($p = 0.79$) during the study period (Fig. 1).

The 0–4 years age group had the highest incidence of both nonfatal and fatal incidents per 100,000 population (Table 1); 14.83 nonfatal and 0.64 fatal incidents per 100,000 persons per year, respectively. Outside of this age group, the ages 15–19 had the highest rate of nonfatal incidents (7.28 incidents/100,000 persons/year) and ages 75 + had the highest rate of fatal incidents (0.62 incidents/100,000 persons/year) (Fig. 2). Ages 10–14 had the lowest rate of fatal incidents (0.04 incidents/100,000 persons/year), while ages 60–64 had the lowest total rate of incidents (1.60 incidents/100,000 persons/year). Males had almost double the rate of nonfatal incidents compared to females (5.25 vs. 2.77 incidents/100,000 persons/year), and over three times the rate of fatal incidents (0.42 vs 0.13 incidents/100,000 persons/year).

The all-age fatal:nonfatal ratio was 1:15.35 (Table 1), however the 10–19 age group had the highest fatal:nonfatal ratio (1:77.11), whereas the 80 + age group had the lowest (1:2.88). Females had a much higher overall fatal:nonfatal ratio (1:22.16) than males (1:12.56) and at all ages (Fig. 3). The higher fatal:nonfatal ratio for females is driven by the absence of fatal incidents in females aged 10–14 and 20–24 years (data not shown).

The fatal:nonfatal ratio for incidents occurring in metropolitan locations was 1:19.60, while it was 1:11.52 in non-metropolitan locations. A similar pattern was seen for residential location, with metropolitan residents having a fatal:nonfatal ratio of 1:22.45, and non-metropolitan residents having a ratio of 1:18.0.

There were more incidents where the victim was male for all ages and locations (Table 2), with an overall female:male ratio of 1:1.9. Under 5 s had the lowest ratio (1:1.31), and the 30–39 age group had the highest (1:3.01). For fatal incidents, the female:male ratio was highest for the 20–29 age group (1:17.0), and lowest for the 0–9 age group (1:1.35) (Fig. 4). The female:male ratio was 1:1.91 for incidents occurring in non-metropolitan areas, and 1:1.79 for incidents occurring in metropolitan areas. The opposite pattern was observed for residential location, with a higher female:male ratio for metropolitan residents (1:1.90) than non-metropolitan residents (1:1.68).

Table 1
Demographics and fatal:nonfatal ratios of drowning patients identified by New South Wales ambulance.

	Fatal incidents n (n/ 100,000 persons/ year)	Nonfatal incidents n (n/ 100,000 persons/ year)	Total incidents n (n/ 100,000 persons/ year)	Fatal: nonfatal ratio (1:n)
Overall	243 (0.27)	3730 (4.16)	3973 (4.43)	15.35
Age group				
0–4	34 (0.61)	827 (14.82)	861 (15.43)	24.32
0–9	40 (0.35)	1034 (9.13)	1074 (9.49)	25.85
10–19	9 (0.08)	694 (6.49)	703 (6.57)	77.11
20–29	18 (0.15)	617 (5.06)	635 (5.2)	34.28
30–39	26 (0.21)	364 (2.92)	390 (3.12)	14.00
40–49	26 (0.22)	314 (2.63)	340 (2.85)	12.08
50–59	30 (0.26)	240 (2.09)	270 (2.36)	8.00
60–69	31 (0.32)	167 (1.73)	198 (2.05)	5.39
70–79	26 (0.42)	96 (1.57)	122 (1.99)	3.69
80+	25 (0.64)	72 (1.86)	97 (2.5)	2.88
Missing	12	132	144	11
Sex				
Male	185 (0.42)	2323 (5.25)	2508 (5.67)	12.56
Female	57 (0.13)	1263 (2.77)	1320 (2.9)	22.16
Missing	1	144	145	145
Incident location				
Metropolitan	116 (0.17)	2274 (3.4)	2390 (3.57)	19.60
Non-Metropolitan	87 (0.38)	1002 (4.39)	1089 (4.77)	11.52
Missing	40	454	494	11.35
Residential location				
Metropolitan	55 (0.08)	1235 (1.85)	1290 (1.93)	22.45
Non-Metropolitan	17 (0.07)	306 (1.34)	323 (1.41)	18.00
Missing	171	2189	2360	12.80

4. Discussion

Despite the significantly higher number of nonfatal drowning

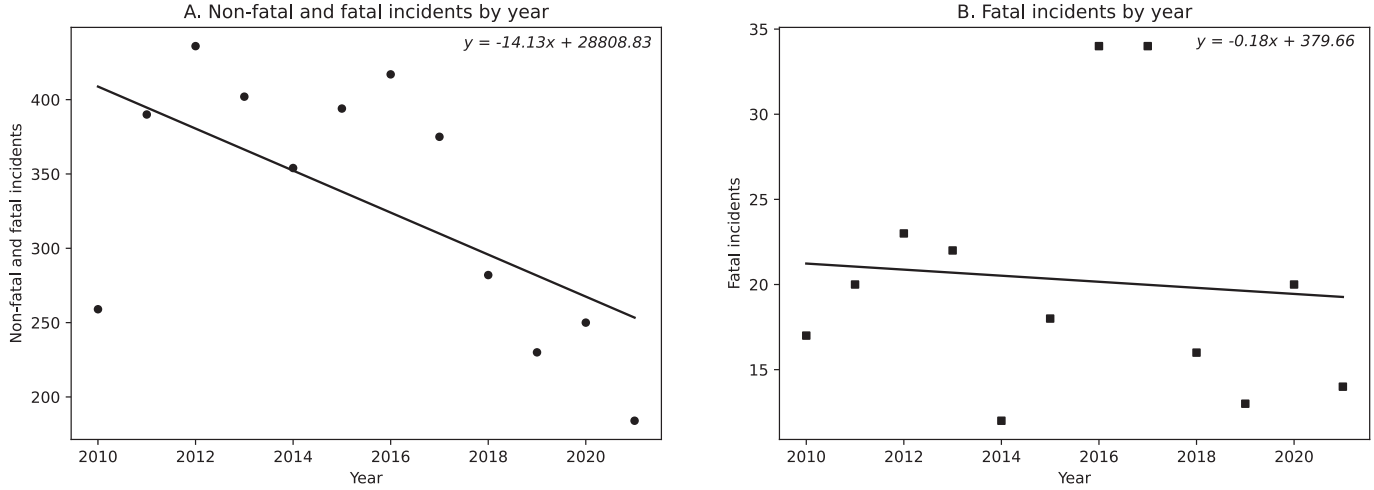

Fig. 1. Trends in the number of nonfatal and fatal drowning incidents attended by ambulance between 2010 and 2021; total incidents (Panel A) and fatal incidents only (Panel B), New South Wales, Australia.

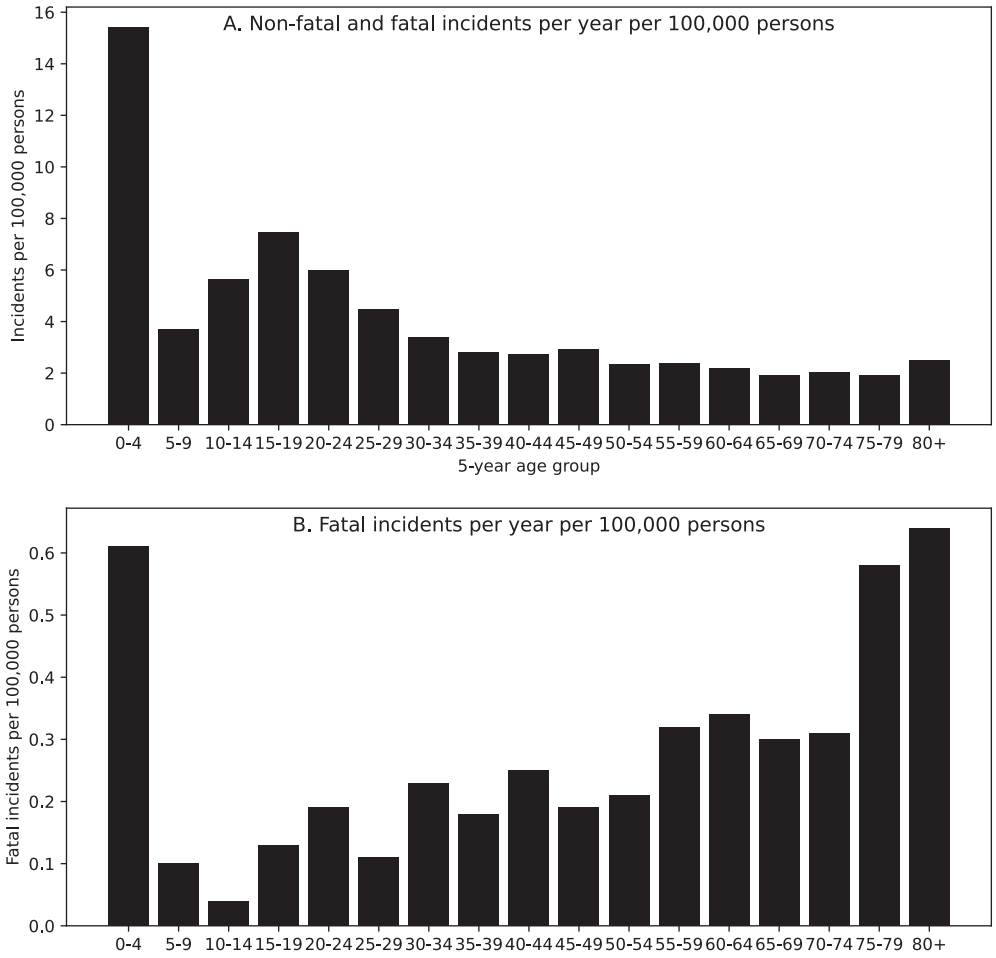

Fig. 2. Rates of total (nonfatal and fatal) (Panel A) and fatal (Panel B) ambulance-attended drowning incidents per 100,000 persons between 2010 and 2021, by 5-year age group, New South Wales, Australia. Note: The sex of individuals involved in fatal incidents is not shown due to low numbers of females in some age groups.

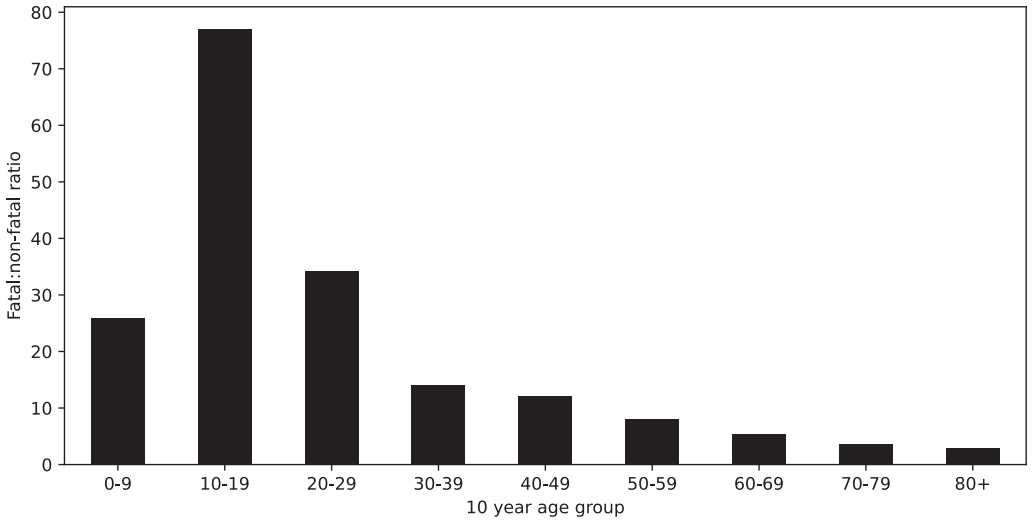

Fig. 3. Fatal:nonfatal ratios of ambulance-attended drowning incidents, by 10-year age group, New South Wales, Australia. Note: Fatal:nonfatal ratios for each sex could not be shown due to low numbers in some age groups.

incidents, relative to fatalities, far less is known about those who survive a drowning incident (Rahman et al., 2021). As such this study aimed to examine trends in fatal and nonfatal drowning to enhance our understanding of the full burden of drowning incidents and contribute to the growing global evidence base (World Health Organization, 2017; Rahman et al., 2021).

Our findings indicate that the burden of nonfatal drowning is much higher than fatalities. The all-age ratio was found to be 15 nonfatal drownings for every fatality. However, this varied according to patient demographics. Despite children under five historically recording the

Table 2
Female:male ratios for all ambulance-attended drowning incidents (nonfatal and fatal), for age 0–4, 10-year age group, incident remoteness and residential remoteness, New South Wales, Australia.

	Females n (n / 100,000 persons / year)	Males n (n / 100,000 persons / year)	Female: male ratio (1:n)
Overall	1320 (2.9)	2508 (5.67)	1.90
Age group			
0–4	355 (13.07)	464 (16.19)	1.31
0–9	439 (7.97)	593 (10.21)	1.35
10–19	278 (5.34)	424 (7.71)	1.53
20–29	195 (3.20)	437 (7.15)	2.24
30–39	97 (1.53)	292 (4.74)	3.01
40–49	93 (1.52)	246 (4.21)	2.65
50–59	79 (1.35)	190 (3.39)	2.41
60–69	59 (1.19)	139 (2.95)	2.36
70–79	33 (1.03)	89 (3.04)	2.70
80+	30 (1.30)	67 (4.27)	2.23
Missing	17	31	1.82
Incident location			
Metropolitan	829 (2.44)	1481 (4.5)	1.79
Non-Metropolitan	356 (3.09)	680 (6.02)	1.91
Missing	135	347	2.57
Residential location			
Metropolitan	441 (1.30)	839 (2.55)	1.90
Non-Metropolitan	120 (1.04)	201 (1.78)	1.68
Missing	759	1468	1.93

highest drowning rates (Peden et al., 2021), the nonfatal burden was highest among adolescents aged 10–19 years (77.11 nonfatal drownings for every fatality) and the absolute rate per 100,0000 persons was second highest for ages 15–19. This finding adds strength to the growing call, both in Australia and internationally, for the need to develop, implement, and evaluate adolescent-specific drowning prevention interventions (Morgan et al., 2022). Investment in drowning prevention for this age group will continue to lag behind that of other age groups without the ability to recommend effective interventions to policy makers and donors (Peden et al., 2023). Co-designing water safety educational interventions alongside adolescents shows promise (Koon et al., 2023).

Similarly to disproportionate fatal drowning rates among children aged 0–4 years, males are traditionally acknowledged as being at significantly greater risk of drowning than females (Lawes et al., 2021; Howland et al., 1996). While our study identified fatalities were more than three times higher among males when compared to females, females recorded almost double the number of nonfatal drownings per fatality compared to males. This implies the existence of a hidden burden of drowning that is not revealed when studies examine only fatalities. The need for focused prevention of drowning among females is increasingly gaining momentum (Richardson & Peden, 2021; Taylor et al., 2020; Roberts et al., 2021) and our findings add to the growing call of ensuring the communication of the risk of drowning is directed to females as well.

Understandably, due to population density and distribution, higher numbers of fatal and nonfatal drownings were identified in metropolitan locations, however, higher overall rates of drowning incidents (nonfatal and fatal combined) occurred in non-metropolitan areas (4.77 vs. 3.57 / incidents / 100,000 population). Similarly, when comparing the remoteness classifications of the patient's incident location, a higher ratio of nonfatal to fatal drowning incidents are reported in non-metropolitan locations. This further strengthens the documented increased risk of a drowning incident in regional and rural areas (Taylor et al., 2020), which is also seen for many other injury mechanisms (Taylor et al., 2022). Studies of exposure based on remoteness are needed to unravel the contributory factors influencing this risk differential.

Pleasingly though, the efforts of those tasked with drowning prevention and water safety in New South Wales appear to be making an impact. Our analysis shows that during the study period, the total number of drowning incidents declined by 14 incidents per year. The significant declining trend in overall drowning appears to being driven by significant reductions in nonfatal drowning incidents. Although it is hard to attribute specific impact to particular programs, New South Wales appears to be benefiting from a range of policies and measures aimed at mitigating drowning risk including lifejacket wear legislation (Willcox-Pidgeon et al., 2019; Peden et al., 2022), beach patrols (Surf Life Saving Australia, 2023), pool fencing legislation (New South Wales Department of Fair Trading. Pool fencing requirements: New South Wales Government, n.d.), learn to swim programs (Macniven et al., 2023) and public education and awareness campaigns among others (Royal, 2021). However, more work is needed to shift stubborn fatal drowning rates. Additionally, further research is required to determine why there has been such a significant downward trend in nonfatal drowning, including where and why these incidents occurred to better understand the reductions identified in this study.

These reductions may be due, in part, to the notable lack of drowning cases overall during periods of lockdown in 2020 and 2021 associated with the COVID-19 period due to reduced exposure and participation (Berecki-Gisolf et al., 2024). However, fatalities were significantly higher in 2020 than preceding or proceeding years, likely attributable to a surge in risky recreational activities such as boating in natural waterway locations (Berecki-Gisolf et al., 2024; Lawes et al., 2021).

Notably, the total number of drowning incidents, and specifically fatalities, were much higher than the annual average during the calendar years of 2016 and 2017. It is not immediately clear what caused this spike, as deaths do not align to the above-average rainfall experienced in New South Wales during these years, although the above-average temperatures may have contributed to increased exposure and thus drowning risk (Bureau of Meteorology. New South Wales in, 2016; Bureau of Meteorology. New South Wales in, 2017). Although drowning is an injury mechanism strongly linked to climate drivers (Sindall et al., 2022), including heatwave and rainfall (Peden et al., 2023), further investigation is needed into the causes of these above average years for fatal drowning. Regardless, we encourage those tasked with preventing drowning to be mindful of changing patterns of exposure and thus risk during times of extreme weather. This should be coupled with tailored supervision of waterways and water safety messaging to the prevailing environmental conditions.

4.1. *Strengths and limitations*

This study is the first to utilize linked data to examine fatal and nonfatal drowning burden in the Australian state of New South Wales. It provides important insights into the quantification of the full burden of drowning, including highlighting the health system burden of preventable drowning incidents. This study also identifies differing risk of nonfatal drowning among different demographic groupings, some traditionally not thought to be at high-risk of drowning due to their lower risk of fatal drowning.

However, this study is not without limitations some of which are due to the use of administrative datasets not designed for research. This study represents a cohort defined from ambulance data. This dataset, and therefore this study, exclude those who came directly to hospital via private car or other means of transport, such as aero-medical retrieval using helicopters. This may underestimate severe drowning cases and those in rural areas, as helicopters were reported to have transported 15.4% of all severe trauma cases in New South Wales, rising to 39.1% cases in rural areas (Garner and van den Berg, 2017). Further, administrative data are unable to account for differences in decisions to call an ambulance. It is possible that the people present may be more likely to

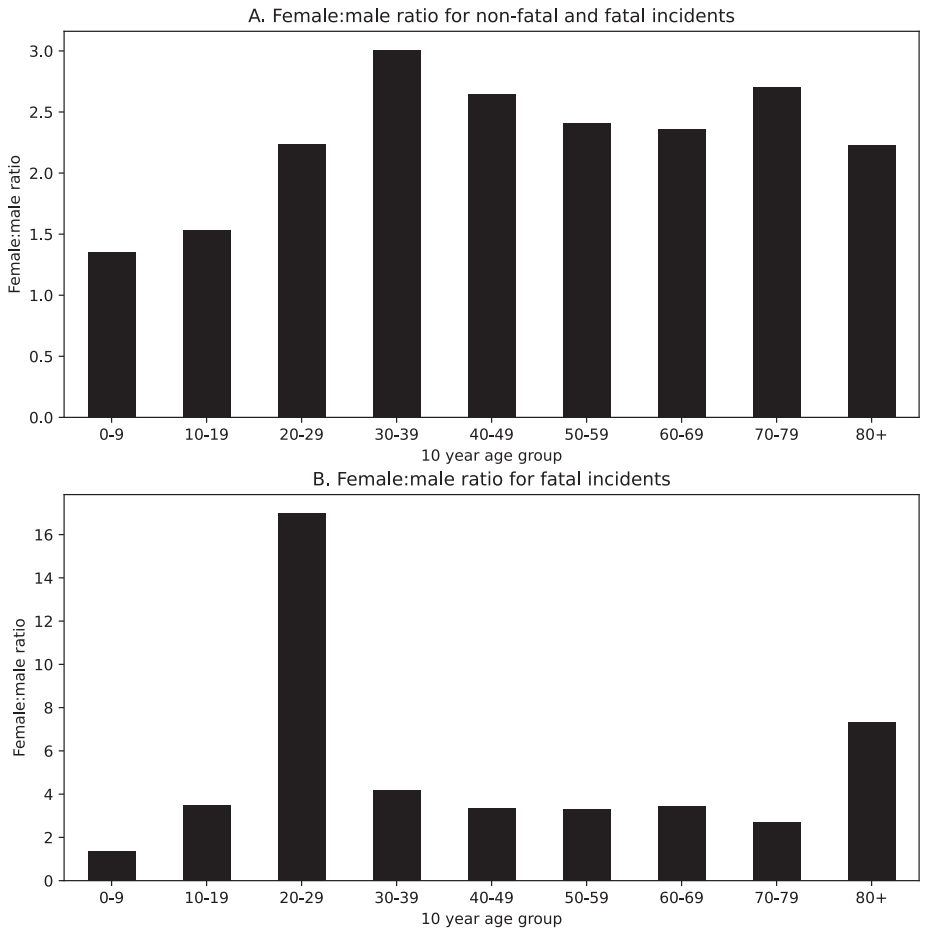

Fig. 4. Female:male ratios for total (fatal and nonfatal; Panel A) and fatal (Panel B) ambulance-attended drowning incidents in New South Wales, Australia between 2010 and 2021, by 10-year age group.

call an ambulance for certain demographic groups (Gardner, 1990).

It should also be noted that according to the draft Clarification and Categorization of Nonfatal Drowning (Beerman et al., 2018), this study misses nonfatal drownings that do not engage ambulance services. It is recommended that future studies incorporate rescue data to further strengthen our understanding of nonfatal drowning. Additionally, as this study comprises a retrospective examination of cases, there is an assumption that each case included in the analysis experienced submersion/immersion and/or respiratory distress as per the definition (van Beeck et al., 2005).

Challenges in linking to hospitalization data mean that unless a patient died, we are unable to determine their treatment pathway. Different methods may have been used for case inclusion to those used to report fatal drowning only, thus resulting in different numbers of fatalities across various reporting mechanisms.

The database lacks information on aquatic location of drowning incident and activity being undertaken prior to drowning, both important variables for understanding causal factors influencing drowning risk. Similarly, data are also lacking on other risk factors for drowning, which are able to be collected on fatal drowning in Australia via the National Coronial Information System (Peden et al., 2023). Drowning rates presented include non-residents in the numerator (drowning patients) but not the denominator (population data), which may artificially inflate the calculated rates. Rates do not consider the issue of exposure, which can dramatically vary drowning risk (Koon et al., 2023). Rates calculated for remoteness of incident location are calculated based on residential population data, and incidents may not have occurred near the person's residence. Finally, we do not have data on the health status of the patients who experienced nonfatal drowning. This is a topic worthy of further investigation given persisting health impacts of nonfatal drowning can be wide ranging, including severe cases that require lifelong medical support.

5. Conclusions

This study adds to the growing body of literature on nonfatal drowning, further illuminating the full burden of drowning on communities, including the associated burden on the health system. Findings support further investment in primary prevention to prevent drowning incidents occurring in the first place, with a particular focus on young children and adolescents. Results also support a widening of preventive approaches that typically target males given the high overall number of drowning incidents among females. Given that the relatively high female nonfatal drowning burden remains hidden if examining drowning fatalities only, this study provides further evidence of the need to collect and analyze quality data on nonfatal drowning. Such analyses ensure those at risk of drowning incidents are acknowledged, highlights the health system burden of drowning, and encourages further investment in this preventable cause of mortality and morbidity.

Author contributions

Authors EM, PS, C-CS, RM and AP were responsible for project conception. Authors PS and AP were responsible for data acquisition. Authors EM and C-CS were responsible for data curation and analysis. Authors EM and AP developed the first draft. All authors contributed to manuscript review and editing and approve the submitted version.

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CRediT authorship contribution statement

Edwina Mead: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Chen-Chun Shu:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Pooria Sarrami:** Writing – review & editing, Project administration, Conceptualization. **Rona Macniven:** Writing – review & editing, Conceptualization. **Michael Dinh:** Writing – review & editing. **Hatem Alkhouri:** Writing – review & editing. **Lovana Daniel:** Writing – review & editing. **Amy E. Peden:** Writing – review & editing, Writing – original draft, Project administration, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Detailed codes used to identify drowning cases across patient health care record (PHCR) and the electronic medical record (eMR) in the ambulance data

Database	variable	Code
PHCR	Protocol 1 - Protocol 8	T21 drowning
	CAD Problem	ARREST UNDERWATER,DOWN/DIVING ACCIDENT OVERRIDE, DROWN/DIVING ALERT SOB,DROWN/DIVING NOT ALERT,DROWN/DIVING ACC ALRT IN WATER,DROWN/DIVING ACC UNKOWN STATUS, DROWN/DIVING ACCIDENT OVERRIDE,DROWN/DIVING OVERRIDE, DROWN/DIVING UNCON OR ARREST,Drowning(Near)/Diving Emergency,NEAR DROWN ALERT OUT OF WATER
eMR	Protocol 1- Protocol 7	T21 drowning
	Case Nature	Drowning / Immersion

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