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Quantifying fatal and non-fatal drowning among children under five in Aotearoa, New Zealand

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Abstract:	Objective: To quantify unintentional drowning trends and risk factors for children under five in Aotearoa, New Zealand. Methods: A total population analyses of fatal and non-fatal (hospitalisations and Accident Compensation Corporation [ACC] claims) unintentional drowning of children 0-4 years of age between 2005-2019 was conducted using DrownBase™ data. Analyses comprises calculation of linear temporal trends, crude drowning rates and relative risk (95% confidence interval) and ratios of fatal to non-fatal drowning. Results: 557 incidents (16.0% fatal) were recorded. Fatalities declined (y=-0.0769x + 2.5678; R2=0.01509), while hospitalisations increased (y=0.1418x+9.1093; R2=0.0979). Males were overrepresented in fatal and non-fatal statistics. One year-olds recorded the highest fatal (4.39) and non-fatal (2.14) rates. Home pools were the leading fatal drowning location, while domestic environments attracted the highest hospitalisation rate. For every 1 fatal drowning there were 6.85 hospitalisations and 74.67 ACC claims. Conclusions: Drowning among young children represents a preventable cause of injury-related harm. While fatalities are declining, non-fatal drowning is increasing. Implications for Public Health: Strategies to prevent drowning among young children are well understood, particularly restricting access to water and active adult supervision. Further investment in effective prevention strategies for young children will deliver significant social, economic and health system savings.

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Conclusions: Drowning among young children represents a preventable cause of injury-related harm. While fatalities are declining, non-fatal drowning is increasing.

Implications for Public Health: Strategies to prevent drowning among young children are well understood, particularly restricting access to water and active adult supervision. Further investment in effective prevention strategies for young children will deliver significant social, economic and health system savings.

Introduction

Drowning disproportionately impacts children and young people, with half of the global burden of fatal drowning occurring among people under 25 years of age (1). However, drowning is not only fatal, with outcomes including morbidity or no morbidity (defined as non-fatal drowning) (2). Available data indicates significantly more people are impacted by non-fatal drowning (3-7).

Global drowning statistics highlight the greatest fatal drowning burden among children aged 0-4 years (8). Similarly, children under five are overrepresented in cases of hospitalisation due to non-fatal drowning (6). Domestic water hazards such as bathtubs for children under one (9-11) and home swimming pools and dams for children between the ages of one and four years pose the greatest risk (12-14).

Aotearoa, New Zealand records an annual average of 79 unintentional drowning fatalities and a further 135 hospitalisations (15). Studies point to historically high rates of drowning (16, 17), and a recent comparison study identified higher fatal drowning rates in New Zealand than in Australia or Canada (18). High drowning rates result in significant social and economic costs. The Aotearoa, New Zealand Ministry of Transport has developed an estimate using the willingness to pay and statistical value of a life approach, which is generally considered to be the benchmark for the cost to society of a death in New Zealand (19). The latest estimate of the cost of a fatality, such as drowning, using the value of a statistical life approach, is $4.7 million New Zealand dollars (NZD) per fatality (20).

Such impacts are not restricted to fatal drowning alone. Non-fatal drowning can result in detrimental health and personal outcomes from conditions resulting from long-term water-related injuries. Additionally, individuals, families, the community, and the health sector experience considerable financial and social costs. Long-term conditions which result from water-related injuries consume a vast number of resources in New Zealand including direct healthcare costs. In addition, individuals incur direct costs (i.e., healthcare, medication and income support), indirect costs (i.e., lost productivity) and intangible costs (i.e., the physical and emotional effects on the individual and their family) from conditions resulting from long-term water-related injury or disability (21). The New Zealand Accident Compensation Corporation (ACC) estimates the cost of non-fatal drowning-related injuries to be $16,208 NZD for a minor injury and $405,202 NZD for serious injuries (22).

Child drowning is a significant issue in New Zealand (23), with drowning the leading cause of injury-related death among children under five (24). Drowning fatalities and hospitalisations are highest among the 0-4 years age group, representing significant social and economic impact, as well as health system burden (24).

Given the disproportionate impact of drowning on young children under five years of age and the importance of exploring the full burden of drowning (i.e., both fatal and non-fatal), this study aims to explore causal factors and temporal trends in drowning among children aged 0-4 years in New Zealand between 2005 and 2019 to inform drowning prevention efforts.

Methods

This study reports a total population analysis of all fatal unintentional drowning and drowning-related hospitalisations in New Zealand among children under five between 2005 and 2019.

Fatal drowning data acquisition

Fatal drowning data acquisition in New Zealand has been reported in depth previously (18, 25). However, in brief, data on all drowning deaths (preventable [unintentional] and non-preventable) which have occurred in New Zealand are included in DrownBase™, the database of Water Safety New Zealand (WSNZ) (26). Unintentional or preventable cases include both recreational and non-recreational drowning deaths. Drowning fatalities are classified as 'non-preventable' if the death arises due to road or air vehicle incidents, homicide, suicide, or are of unknown origin (i.e. where it is unknown how the person came to be in the water). For the purposes of this study, we have explored preventable (unintentional) cases of fatal drowning only.

Data used to populate DrownBase™ comprises of data initially collected from the New Zealand Police via *Drown reports and media reports. This is supplemented by data from Coroners reports and Ministry of Health information. Data included in this study are correct as at 12-02-2021.

Non-fatal drowning-related hospitalisation data acquisition

Data on unintentional non-fatal drowning requiring hospitalisation were also sourced from DrownBase™. A case of non-fatal drowning was defined as admission to hospital resulting in a hospital stay of any duration. Data on hospitalisations were provided by the Ministry of Health New Zealand Health Information System and include all hospitals in NZ. Only those incidents that have been identified to be a drowning-related event were sent to WSNZ and subsequently recorded in DrownBase™. All drowning fatalities which occur in hospital are removed before data is provided for inclusion in DrownBase ™. Data is correct as at 12-02-2021.

Accident Compensation Corporation (ACC) data acquisition

Data on drowning-related claims for medical care were sourced from ACC. ACC is the New Zealand crown entity responsible for administering the country's no-fault accidental injury compensation scheme. The information WSNZ receives is largely reliant on the information claimants provide when the ACC45 (ACC claim form) is completed. This research includes all claims defined as drowning based on free text where the word DROWN appeared or claims coded with contact=drowning or where the claim's readcode was 'Drown' or 'Submersion'. Data from ACC is available for 2012-2017 only. ACC data included in this study is correct as at 15-02-2021.

Data coding and statistical analysis

Individual case level data for both fatal drowning and drowning-related hospitalisations were received in Microsoft Excel format and transferred into SPSS V25 (27) for analyses. Ethnicity was coded to one of the four largest ethnicities in Aotearoa, New Zealand being NZ European, Māori, Pasifika and Asian. A fifth category 'other' comprises all other ethnicities in New Zealand. Drowning location was coded to beaches, domestic, home pools, inland still waters, public pools, rivers and tidal waters. Domestic locations include large containers used for immersing the body (i.e., bathtub), containers with handles for carrying liquids, other environments in the home or garden area surrounding the home (i.e., toilets, troughs, dog bowls, personal thermal pools) (28). Inland still waters natural or artificial bodies of water surrounded by land which may be small (i.e., fishponds, duckponds) or large (i.e., lakes, quarries). Inland still waters also comprise drains, channels and pipes and rural drainage systems such as water races and effluent pits (28).

Due to limitations regarding reporting activity coding associated with drowning fatalities, activity coding for non-fatal drowning-related hospitalisations and ACC drowning-related claims, were

recoded to match the fatality codes of immersion incident and water sports/recreation (Table S1). An immersion incident occurs where the person who drowned had no intention of participating in recreational activity in or on the water such as a fall and water sport/recreation incidents are those which require intentional exposure to water such as swimming. Hospitalisation cases coded as 'not classified' (n=15) and ACC cases coded as 'other' (n=47) were excluded from the ratio calculations.

[INSERT LINK TO SUPPLEMENTARY TABLE 1 HERE]

Temporal trends in fatal and non-fatal drowning related hospitalisations for 2005-2019 were calculating using the linear trend function in Microsoft Excel. Crude drowning rates per 100,000 resident population were calculated by sex, single year of age and ethnicity using population data from Stats NZ (29). Resident population data by ethnicity and age group is only available in New Zealand Census years (2006, 2013 and 2018) (30). To calculate drowning rates by ethnicity, a 15-year average of drowning deaths and non-fatal drowning related hospitalisations were used as the numerator, with a three-year average of the resident population used as the denominator. Rates were used to calculate relative risk with a 95% confidence interval using females, 0-11 month-olds, Asian ethnicity, beaches and water sport/recreation as the reference groups. As ACC data was only available for the 2012-2017 period only, ratios of non-fatal drowning-related hospitalisations and ACC drowning-related claims to fatal drownings were calculated for the 2012-2017 period only. As ACC drowning-related claims data are not available by location of drowning incident, ratios of fatal to non-fatal drowning related hospitalisations by location were calculated separately for the entire study period (2005-2019).

Ethics and consent to participate

Water Safety New Zealand has agreements with Coronial Services New Zealand, the National Coronial Information System (Australia) (NZ008) and the New Zealand Ministry of Health (2007–0825) to access data in order to maintain DrownBase. The protocols of DrownBase access adhere to the principles of the New Zealand Privacy Act 2020. A data access agreement is in place between WSNZ and the Accident Compensation Corporation (ACC) to access anonymised ACC data as requested for research. Consent to participate was not gained as data is de-identified, reflects people who are deceased and reported in an aggregated manner. As such consent to participate was not required by ethics committees who provided approval for this research.

Results

Across the full study period (2005-2019) there were 557 drowning incidents, of which 16.0% fatal drownings (n= 89) and 84.0% (n=468) non-fatal drownings requiring hospitalisation. Across the study period, the average fatal drowning rate was 1.95 per 100,000 children while the non-fatal drowning hospitalisation rate was 10.25 per 100,000 children. When exploring temporal trends, the rate of fatal child drowning decreased across the study period ($y=-0.0769x + 2.5678$; $R^2=0.01509$), while the rate of drowning-related hospitalisations increased ($y=0.1418x+9.1093$; $R^2=0.0979$). (Figure 1)

[INSERT FIGURE ONE AROUND HERE]

Males accounted for 62.9% of drowning deaths and 61.8% of non-fatal drowning-related hospitalisations respectively. Compared to females, males were 1.6 times more likely (RR=1.61; CI:1.05-2.48) to fatally drown than females, and 1.5 times (RR=1.54; CI: 1.27-1.85) more likely than females to be admitted to hospital due to a non-fatal drowning. (Table 1)

[INSERT TABLE ONE AROUND HERE]

The highest drowning rates were seen among one year-olds (4.39/100,000 children) with children of this age 4.5 times more likely to drown than four year-olds (RR=4.46; CI: 2.16-9.19). One year-olds also recorded the highest rate of non-fatal drowning-related hospitalisation (15.90 per 100,000 children), a rate that was 2.14 times higher (RR=2.14; CI: 1.60-2.85) than the hospitalisation rate among four year-olds (Table 1). When exploring linear trends in fatal and non-fatal drowning by single year of age, all ages recorded reductions in fatal drowning, aside from 4 year-olds ($y=0.0346x + 0.7005$; $R^2=0.0133$). For non-fatal drowning-related hospitalisations all ages recorded increases aside from 3 ($y=-0.01429x + 10.407$; $R^2=0.0234$) and 4 ($y=-0.4071x + 10.806$; $R^2=0.0133$) year-olds. (Table S2).

Children of 'other' ethnicity recorded the highest fatal drowning rate (8.77 per 100,000 children) followed by Māori children (2.49 per 100,000 population). Conversely, the highest non-fatal drowning-related hospitalisation rates were seen among Māori children (14.68 per 100,000 children), a rate that is almost four times (RR=3.88; CI: 0.75-20.25) the hospitalisation rate of Asian children. (Table 1)

The highest fatal drowning rate was recorded for home pools (0.68 per 100,000 children), followed by inland still waters (0.48) and domestic locations (0.39). Compared to beaches, children 0-4 years in New Zealand were 15 times (RR=15.5; CI: 3.71-64.77) times more likely to drown in a home pool, 11 times (RR=11.00; CI: 2.59-46.78) more likely to drown in inland still waters and nine times (RR=9.00; CI: 2.09-38.79) more likely to drown in domestic environments. (Table 1)

For non-fatal drowning-related hospitalisations, the highest rates were seen for domestic locations (3.24 per 100,000 children), followed by public pools (2.69) and home pools (2.39). When compared to beaches, drowning-related hospitalisations were four times as likely (RR=4.35; CI: 3.00-6.32) for domestic locations and 3.6 times (RR=3.62; CI: 2.47-5.29) more likely for public pools. Fatalities were 21 times (RR=21.25; CI: 7.80-57.93) more likely as a result of an immersion incident when compared to a water sports/recreation incident. However, this trend was reversed for non-fatal drowning with a hospitalisation rate of 6.11 for water sports/recreation, compared to a rate of 3.81 for immersion incidents.

Between 2012 and 2017, for every fatal drowning in New Zealand of a child 0-4 years of age, there are 6.85 non-fatal drowning-related hospitalisations and 74.67 ACC drowning-related claims. The fatal to non-fatal drowning-related hospitalisation ratio is higher among males 1:7.25) than females (1:6.27), however there were more ACC claims for each fatal drowning among females (1:78.64) when compared to males (1:71.94). (Table 2)

[INSERT TABLE TWO AROUND HERE]

The highest non-fatal drowning-related hospitalisation to fatal drowning ratio is seen among the 0-11 months age group (a ratio of 1:15.00), whereas for ACC drowning-related claims, the highest ratio is seen among the 4 years age group (1:326.50). For every 1 fatal drowning of Māori children there were 13 non-fatal drowning-related hospitalisations (1:13.33), the highest of all ethnicities explored in this study. For ACC drowning-related claims, the highest number were seen among Asian children, with 112 claims for each drowning fatality. (Table 2)

The highest ratio of non-fatal drowning related hospitalisations to fatal drowning incidents among children under five occurred at public pools, with 30.75 hospitalisations for every one fatal drowning. The lowest ratio occurred at inland still waters, with 1.27 hospitalisations for every fatal drowning. (Table S3)

Discussion

Drowning is a significant yet preventable threat to public health. Children under five are particularly susceptible to drowning due to many age- and developmental-related factors (31). To inform drowning prevention efforts, this study aimed to explore fatal and non-fatal drowning among children aged 0-4 years in New Zealand between 2005 and 2019. This study identified drowning accounts for a significant personal, social and economic impact, with every fatal drowning resulting in 7 non-fatal drowning hospitalisations and 75 ACC claims. Males are overrepresented in both fatal and non-fatal drowning incidents, with one year-olds at highest risk.

As with older age groups, Māori children are overrepresented in both fatal and non-fatal drowning statistics (15, 26). In the current study, Māori children experience high rates of fatal drowning (2.49/100,000 children) and non-fatal drowning related hospitalisations (14.68/100,000 children). As part of WSNZ's strategic focus on Māori, WSNZ has a funding arrangement with ACC for the delivery of drowning prevention initiatives using a kaupapa Māori approach and the Wai Puna approach (32) developed by Dr Chanel Phillips underpins Wai ora Aotearoa the water safety sector strategy 2025 outlook (33). Work is currently underway on a Māori strategy and specific outcomes for Māori, which will include strategies specific to reducing drowning risk in under-fives.

Home pools were the leading location for both fatal drowning (a rate of 0.68 per 100,000 children) and the third leading location for non-fatal drowning-related hospitalisations (2.39 per 100,000 children). In New Zealand, the Building (Pools) Amendment Act 2016 states that all residential pools (including portable pools) that are filled or partly filled with water must have physical barriers that restrict access by unsupervised children (34). This requirement applies to pols that can be filled with water to a depth of 400 millimetres (mm) or more. The act also provides for the mandatory inspections of swimming pools every three years by territorial authorities, and gives territorial authorities additional enforcement tools, including notices to fix (34).

Despite legislation in place, there is pushback by select groups of residential pool owners (35). Some councils issued waivers to pool owners if they had a pool cover, however the Ministry of Business Innovation and Employment has clarified that this is not an acceptable barrier and as such many pool owners now need to bring their pools up to safety fencing standards. This is a particular issue in the Marlborough region of New Zealand with locals setting up a group to push back against the Ministry's determination (35). This is despite that fact that pool covers have been shown to not be an effective barrier with at least five drownings among children under five years of age in pools and spas which were meant to have safety covers fitted (in the last 20 years) and several hospitalisations stemming from incidents in pools with removed covers (26). Consumer awareness campaigns are clearly required though ensuring coverage among all pool owners will be challenging with the current number of residential pools unknown but thought to be well in excess of the current official estimate of 40,000 residential pools (36).

Supervision lapses are commonly implicated in cases of child drowning (37) and current initiatives such as Recreation Aotearoa's Poolsafe campaign aim to remind parents and caregivers of the importance of constant supervision at pools and that accidents can happen in seconds (38). This is important, as although public pools have a low fatality rate (0.09 per 100,000 children) due in part to lifeguard supervision, they have the second highest non-fatal drowning-related hospitalisation rate (2.69 per 100,000 children), indicating significant health system burden.

Several other interventions aimed at reducing drowning risk among young children are currently in place in New Zealand. These include a bathmat campaign to reduce bathtub drowning deaths (39),

social marketing campaign 'Eight ways to keep babies and toddlers safe' (40) and swimming pool legislation (34). Such interventions have no doubt impacted on the reduction in fatal drowning seen across the study period. However, as this study has identified, non-fatal drowning-related hospitalisations are increasing, indicating the need for a broader range of interventions or expansion of existing interventions (41).

Implications for public health

Drowning is preventable, yet all-age drowning fatalities and non-fatal drowning-related hospitalisations have resulted in an economic burden totalling $4.79 billion NZD in the 10 years to 2017 (42). This economic burden disproportionately impacts young children, where the greatest health losses are attributed (43). However, financial figures alone do not illustrate the real cost in pain and suffering, and disruption to families and work. The lifetime economic and social consequences of non-fatal drowning are also significant (44). Drowning related injuries are estimated to have the highest average lifetime cost of any injury type (21) and have a significant impact on families including psychosocial consequences for victims, parents, siblings, and caregivers. As such significant, and ongoing, investment in expansion of prevention interventions is warranted, including culturally appropriate strategies for Māori and other culturally diverse populations, as well as innovative approaches to promoting appropriate parental supervision. The sector is well-placed for such approaches, given the newly released Wai ora Aotearoa, the New Zealand Water Safety Sector Strategy 2025 (33), includes a strategic focus on preventing drowning among children under five.

Strengths and limitations

This is a total population analyses which explores both fatal and non-fatal drowning, including the lesser known area of drowning-related compensation claims, thus addressing a research gap in published knowledge on the full burden of drowning (6). The collation of data from three official sources (coronial, hospitalisation and ACC) strengthens data validity however does present some limitations. ACC data may include some cases of drowning represented in hospitalisation data, if these children were treated and released with ongoing medical costs. ACC data does not include location information thereby limiting the ability to calculate ratios of fatal to hospital to ACC claims by location of drowning incident. Crude drowning rates do not take into account exposure to aquatic location. Gathering exposure data is recommended as an area of future research to more accurately identify those at highest risk.

Conclusion

Drowning is a preventable cause of fatal and non-fatal injury and health system burden. While investment in prevention efforts is contributing to a reduction in fatal drowning among this age group, non-fatal drowning is increasing, representing a significant personal, social and health system burden. Investment in prevention efforts must be focused on culturally and linguistically diverse groups (children and parents/caregivers) and identify strategies to achieve reductions in non-fatal drowning, as have been seen in fatal incidents. Investment in effective prevention for this age group will deliver significant social, economic and health system savings and WSNZ is well-placed to monitor impacts across the full burden of drowning.

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Figure captions

Figure 1: Rate and linear trends of fatal unintentional drowning and non-fatal drowning-related hospitalisations in children aged 0-4 years, New Zealand, 2005-2019

Table 1: Crude drowning rates for fatal and non-fatal drowning-related hospitalisation by sex, age in years and ethnicity, 0-4 year-olds, New Zealand 2005-2019

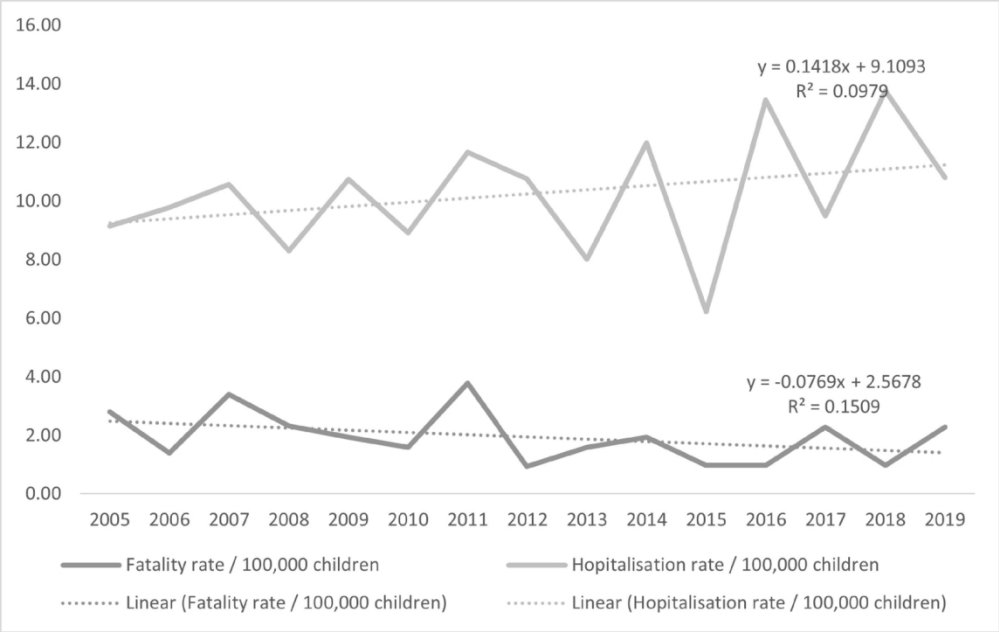
	Fatal drowning		Non-fatal drowning	
	Fatal drowning rate / 100,000	Relative Risk (95% Confidence Interval)	Hospitalisation drowning rate / 100,000 pop	Relative Risk (95% Confidence Interval)
Total	1.95	-	10.25	-
Sex				
Male	12.34	1.61 (1.05-2.48)	2.39	1.53 (1.27-1.85)
Female	8.05	1	1.48	1
Age in years				
0-11 months	1.21	1.23 (0.51-2.96)	8.22	1.11 (0.80-1.54)
1 year	4.39	4.46 (2.16-9.19)	15.90	2.14 (1.60-2.85)
2 years	1.64	1.67 (0.73-3.81)	10.40	1.40 (1.02-1.91)
3 years	1.53	1.56 (0.67-3.60)	9.30	1.25 (0.91-1.72)
4 years	0.98	1	7.43	1
Ethnicity				
Asian	0.31	1	3.78	1
NZ European	1.30	4.14 (0.02-1015.88)	6.91	1.83 (0.36-9.36)
Māori	2.49	7.92 (0.03-2037.78)	14.68	3.88 (0.75-20.25)
Pasifika	1.09	3.47 (0.01-1537.51)	6.86	1.81 (0.26-12.46)
Other	8.77	27.89 (0.06-12348.59)	6.27	1.64 (0.04-69.90)
Location of drowning incident				
Beaches	0.04	1	0.74	1
Domestic	0.39	9.00 (2.09-38.79)	3.24	4.35 (3.00-6.32)
Home Pools	0.68	15.50 (3.71-64.77)	2.39	3.21 (2.18-4.71)
Inland Still Waters	0.48	11.00 (2.59-46.78)	0.61	0.82 (0.50-1.36)
Public Pools	0.09	2.00 (0.37-10.92)	2.69	3.62 (2.47-5.29)
Rivers	0.22	5.00 (1.10-22.82)	0.55	0.74 (0.44-1.23)
Tidal waters	0.04	1.00 (0.14-7.10)	-	-
Activity prior to drowning				
Immersion incident	1.86	21.25 (7.80-57.93)	3.81	0.62 (0.52-0.75)
Water sports/recreation	0.09	1	6.11	1

Note: There were two cases of unknown ethnicity which are excluded from the fatal drowning rate calculations. There was one non-fatal drowning-related hospitalisation with an unknown location, which has been excluded from the rate calculations.

Table 2: Ratios of fatal drowning to non-fatal drowning related-hospitalisations and ACC drowning-related claims overall and by sex, single year of age, ethnicity and drowning location, Aotearoa, New Zealand, 2012-2017

	Fatal drowning (N=27)	Non-fatal drowning	
		Drowning-related hospitalisation (N=185)	Accident Compensation Corporation (ACC) drowning-related claims (N=2,016)
Total	1	6.85	74.67
Sex			
Male	1	7.25	71.94
Female	1	6.27	78.64
Single year of age			
0-11 months	1	15.00	63.00
1 year	1	3.41	18.00
2 years	1	13.67	148.33
3 years	1	12.33	162.00
4 years	1	9.50	326.50
Ethnicity			
Asian	1	10.00	112.00
NZ European	1	6.00	91.54
Māori	1	13.33	78.67
Pasifika	1	8.00	70.50
Other/Unknown	1	0.20	20.20
Activity prior to drowning			
Immersion incident	1	2.35	8.31
Water sports/recreation	1	117.0	1753.0

Note: there were 3 cases of drowning-related hospitalisation with unknown activity; these have been excluded from the calculation of ratios.



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