Preventive Medicine 179 (2024) 107832

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Association between air temperature and unintentional drowning risk in the United Kingdom 2012–2019: A nationwide case-crossover study

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ARTICLE INFO

Keywords:
Water
Safety
Accident
Death
Temperature

ABSTRACT

Objective: Drowning is a leading cause of death. The World Health Organization (WHO) and United Nations (UN) emphasise the need for population-level data-driven approaches to examine risk factors to improve water safety policies. Weather conditions, have the potential to influence drowning risk behaviours as people are more likely to spend time around water and/or undertake risky activities in aquatic spaces as a behavioural thermoregulatory response (e.g., seeking coolth).

Methods: A case-crossover approach assessed associations between changes in daily maximum air temperature (data from the nearest weather station to each drowning event) and unintentional drowning risk using anonymous data from the validated UK Water Incident Database 2012–2019 (1945 unintentional deaths, 82% male). Control days were selected using a unidirectional time-stratified approach, whereby seven and 14 days before the hazard day were used as the controls.

Results: Mean maximum air temperature on case and control days was 15.36 °C and 14.80 °C, respectively. A 1 °C increase in air temperature was associated with a 7.2% increase in unintentional drowning risk. This relationship existed for males only. Drowning risk was elevated on days where air temperature reached 15–19.9 °C (Odds Ratio; OR: 1.75), 20–24.9 °C (OR: 1.87), and ≥ 25 °C (OR: 4.67), compared with days <10 °C. The greatest elevations in risk appeared to be amongst males and when alcohol intoxication was suspected. Precipitation showed no significant association with unintentional drowning risk.

Conclusions: Identifying such relationships highlights the value of considering weather conditions when evaluating environmental risk factors for drowning, and may inform water safety policy and allocating resources to prevention and rescue.

1. Introduction

Drowning has been estimated to claim >370,000 human lives annually around the world (UN, 2021; WHO, 2014), whilst data from 2017 suggest that >295,000 unintentional deaths were attributable to drowning in that year (Franklin et al., 2020). In the UK, >600 people fatally drown each year (Hills et al., 2021). Notably, the true global figure may be up to four or five times higher due to poor reporting practices in some countries, and difficulties associated with classifying deaths that occur during transport or periods of flooding (Bierens et al., 2016; Lu et al., 2010). Drowning and non-fatal water-based incidents affect families, friends, and communities; placing a substantial economic and social burden on communities (NWSF, 2016). Data from developed countries indicate that >£106 million is spent each year responding to drowning and water-based incidents in Australia, equating to >£200,000 per event (RLSSA, 2017). Similarly, in addition to the onward costs of medical care, morbidities and co-morbidities associated with fatal and non-fatal drownings, >£139 million is spent annually on running the rescue response to drowning and water-based incidents in the UK (RNLI, 2022). Despite substantial effort and investment in prevention initiatives, there were 5051 recorded water-related fatalities in the UK between 2012 and 2019 (Hills et al., 2021). Similarly to other developed

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https://doi.org/10.1016/j.ypmed.2023.107832
Received 5 September 2023; Received in revised form 18 December 2023; Accepted 20 December 2023
Available online 23 December 2023

countries (Peden et al., 2019), ~74% of victims were male (Hills et al., 2021), whilst suspected accidents and suicides accounted for ~44% and ~ 35% of these events, respectively (Hills et al., 2021).

Despite the scale of the problem, drowning has traditionally been neglected as a public health concern (Meddings et al., 2021; WHO, 2014). However, drowning has recently received increased attention via worldwide initiatives such as the 2021 United Nations (UN) global resolution on drowning prevention (UN, 2021) and the World Health Organization (WHO) establishing an annual World Drowning Prevention Day each 25th July. Moreover, with specific reference to climate change and the extreme air temperatures observed in 2022, the importance of drowning prevention action has been discussed in the UK parliament (Hansard, 2022). Population level research plays a vital role in informing evidence-based water safety measures, especially given the multifaced nature of drowning as a problem (Peden et al., 2019; Peden et al., 2022; Stoop, 2006). Indeed, individual, behavioural, and environmental factors may each influence drowning risk (Peden et al., 2019; Peden et al., 2022; Stoop, 2006). For example, males may engage in more risky behaviours round water (e.g., swimming at night, not wearing lifejackets, consuming alcohol etc.) and contribute a substantially higher proportion of drowning fatalities compared with females. (Gulliver and Begg, 2005; Hamilton et al., 2018; Hills et al., 2021; Howland et al., 1996; Leavy et al., 2022). The WHO outlined an implementation guide for drowning prevention, which emphasised the importance of research that focuses on improving understanding of drowning data and analysing risk factors associated with different drowning circumstances (WHO, 2017). The UN resolution also highlighted the value of nuanced population level drowning research, outlining the need for innovative data driven approaches to inform multisectoral solutions to reduce loss of life in water (Meddings et al., 2021; UN, 2021).

There exists a perception amongst the public and policy makers in the UK that warmer days lead to higher unintentional drowning rates as people's behavioural temperature regulation response is to relieve thermal discomfort by spending time in or near water (i.e., an innate mammalian thermal response to high temperatures) (Stillman, 2019), as well as people being more likely to consume alcohol in aquatic spaces and thereby increasing risk behaviours (Hansard, 2022; Johnston et al., 2023). As cold shock and/or swim failure are potentially causative of accidental drowning (Barwood et al., 2018; Bowes et al., 2016; Keatinge et al., 1969), it is notable that despite air temperature increasing at this time of year, UK open water temperatures are usually lowest during the spring (Holliday et al., 2008). The potential role of weather conditions as a drowning risk factor has been investigated in specific regions of Canada, with research showing elevated drowning risk on days when air temperature exceeded 30 °C compared with days where temperature remained <30 °C (Chauvin et al., 2020; Fralick et al., 2013). Moreover, in Fiji, the volume of rainfall was positively associated with monthly drowning rates (Murray and Carter, 2017), whilst sea level pressure over the Mediterranean basin was correlated with unintentional drowning rates in Spain (Real et al., 2021). The relationship between weather and drowning risk is likely specific to any given country and may increase in relevance as global temperatures rise (Sindall et al., 2022). For example, warmer drier conditions in some countries may prompt people to spend time around water, whereas the primary weather-related risks in other countries may come directly from rainfall and flooding (Murray and Carter, 2017).

In the UK, all known fatal drowning events are recorded in the Water Incident Database (WAID). WAID contains one entry per fatality, with 22 substantive fields that are populated with information about the victim, circumstances of the fatality, and specific location coordinates (Hills et al., 2021). Our previous work has established that WAID meets WHO data quality requirements and thus is a suitable basis on which to progress to the next stage of the WHO drowning prevention implementation guide; establishing risk factors (Hills et al., 2021; WHO, 2017). The aim of this study was to examine the association between acute weather conditions, specifically daily air temperature and precipitation, and the risk of unintentional (i.e., recorded in WAID as 'accident suspected') fatal drowning in the UK. Secondary aims include assessing whether this relationship differs by sex and intoxication status. Such information may help local and national water safety organisations to refine current water safety practices by helping to forecast drowning events and deliver proactive prevention advice. This work represents the UK progressing through the WHO drowning prevention implementation guide (WHO, 2017).

2. Methods

2.1. Study design and setting

This study conducted a retrospective case-crossover analysis of UK fatal drownings from 2012 to 2019, inclusive, to examine the association between maximum daily air temperature and the risk of unintentional drowning. This case only approach is similar to a case-control study but uses each individual drowning event as its own control (Lombardi, 2010; Maclure, 1991; Valent et al., 2010), whereby exposure at the time of a case/event is compared with exposure at one or more control periods. Therefore, all stable individual covariates such as age, sex, and socioeconomic status are automatically adjusted for in the models. This approach is well suited to analysing binary and final outcomes such as drowning, where exposure happens close to the fatal event (Chauvin et al., 2020; Mittleman and Mostofsky, 2014).

2.2. Participants and data sources

Ethical approval was granted by the Bournemouth University Science, Technology and Health Research Ethics Panel (ID: 41676). Individual participant consent was not necessary or possible as only data relating to people who have died were obtained and all data were anonymous throughout. Anonymised individual-level data for all fatal drownings that occurred in the UK from 2012 to 2019, inclusive, that were the result of suspected accidents (i.e., unintentional deaths, irrespective of whether water entry was voluntary or otherwise) were extracted from WAID. Victims could be any age or sex. Records without a known date of water entry (e.g., cases where only the date of body recovery is known) were removed, leaving a total of 1945 unintentional drowning deaths to be analysed in this study.

Data reflecting the specific location, maximum air temperature, and amount of precipitation recorded for 402 UK weather stations each day from 2012 to 2019, inclusive, were obtained directly from the Met Office. For each drowning event, the nearest active weather station was identified based on latitude and longitude coordinates. Weather data for the date of fatality, as well as for the dates representing exactly seven and 14 days prior to the event, were extracted and linked to the event using the *scipy* and *pandas* libraries in Python (Version 3.10.5, Amsterdam, Netherlands).

2.3. Data analyses

Control days were selected on an individual case level using a unidirectional time-stratified approach, whereby seven and 14 days before the hazard day were used as the controls (Chauvin et al., 2020; Fralick et al., 2013; Wu et al., 2021). Each drowning case therefore had two controls. This accounts for potential influences that may be attributable to variables such the day of the week (e.g., patterns associated with potential increased exposure to aquatic spaces at the weekend for recreation or during the week for some forms of employment) and time of the year. The weather on case days was compared with that on control days to examine the association between acute weather conditions and unintentional drowning risk (Chauvin et al., 2020; Janes et al., 2005).

Conditional logistic regression was used to estimate coefficients and odds ratios (OR) for associations between maximum daily air temperature and the risk of unintentional drowning. Fatal drowning in this dataset represents a binary outcome (i.e., *drowned*; case days, or *not drowned*; control days). Precipitation was also included in the models as a predictor to control for any moderating influence that this weather feature may have. To avoid losing information by dichotomising data (Ranganathan et al., 2017), maximum air temperature (°C) and amount of precipitation (mm) were entered initially as continuous variables. However, to aid interpretation further models were run with air temperature modelled as categorical, whereby drowning risk on days with maximum air temperatures of 10–14.9 °C, 15–19.9 °C, 20–24.9 °C, and ≥ 25 °C were compared with days where air temperature failed to reach 10 °C. Analyses were conducted for the whole sample and then stratified by sex to see whether associations differed between males and females. Models were also run stratified by intoxication status to see whether associations differed for cases where alcohol intoxication was suspected (i.e., either alcohol alone or in combination with drugs) compared with cases where no intoxication was suspected. Suspected intoxication status represents an existing field in WAID, and data were coded as "yes" or "no" depending on whether the victim was suspected to have been intoxicated with alcohol at the time of death. Several models were run to adjust for further variables including location characteristics, day of the week, age range, activity being performed. However, the inclusion of these variables did not substantially alter the temperature coefficients or ORs. Statistical analyses were conducted using the *survival* package in RStudio (Version 4.2.1, Boston, USA). Unless otherwise stated, data are presented as mean ± standard deviation, whilst ORs are presented with 95% confidence intervals (CIs).

3. Results

3.1. Descriptive statistics

Table 1 shows the characteristics of the unintentional fatal drowning events that were included in this study. Most cases were male (82%), whilst the highest and second highest proportion of deaths were amongst 36- to 60-year-olds and 19- to 35-year-olds, respectively. Although males represented a relatively higher proportion of fatalities in the current unintentional drowning dataset (i.e., 82% vs 74%), these breakdowns broadly reflect the patterns that were evident across all drowning outcomes (i.e., intentional and unintentional) combined (Hills et al., 2021). Table 2 provides descriptive statistics for weather conditions on case and control days.

3.2. Association between weather and unintentional fatal drowning risk

Table 3 shows the coefficients from the conditional logistic regression models. There was a significant positive association between daily maximum air temperature and the risk of unintentional drowning. A 1 °C increase in maximum air temperature was associated with a 7.2% (CI: 5.2–9.2%) increase in unintentional drowning risk. When stratified by sex, this relationship existed for males, but not for females. For males, a 1 °C increase in maximum air temperature was associated with a 7.6% (CI: 5.4–9.9%) increase in the risk of unintentional drowning on a given day. For cases where no alcohol intoxication was suspected, a 1 °C increase in maximum air temperature was associated with a 7.1% (CI: 4.7–9.5%) increase in the risk of unintentional drowning. However, when alcohol intoxication was suspected, risk increased by 22% (CI: 9.5–36%) for each additional 1 °C.

When air temperature was treated as a categorical variable, there was no significant increase in unintentional drowning risk for days where temperature reached 10–14.9 °C compared with days <10 °C. However, drowning risk was significantly elevated on days where air temperature reached 15–19.9 °C, 20–24.9 °C, and ≥ 25 °C. Coefficients and ORs are presented in Table 3. Precipitation showed no significant association with unintentional drowning risk in any of the models (OR: 1.00–1.02).

Table 1
Characteristics of unintentional fatal drowning cases in the UK 2012–2019 (*n* = 1945).

Category	Number of cases	% of sample
Sex		
Male	1597	82.1
Female	310	15.9
Not recorded	38	2.0
Age		
0 to 2	33	1.7
3 to 5	19	1.0
6 to 12	24	1.2
13 to 18	136	7.0
19 to 35	555	28.5
36 to 60	681	35.0
Over 60	393	20.2
Not recorded	104	5.3
Intoxication status		
None	1380	71.0
Alcohol	444	22.8
Alcohol/drugs	71	3.7
Drugs	50	2.6
Day of the week		
Monday	260	13.4
Tuesday	232	11.9
Wednesday	231	11.9
Thursday	233	12.0
Friday	230	11.8
Saturday	405	20.8
Sunday	354	18.2
Month		
January	180	9.3
February	116	6.0
March	140	7.2
April	175	9.0
May	195	10.0
June	184	9.5
July	270	13.9
August	235	12.1
September	134	6.9
October	107	5.5
November	100	5.1
December	109	5.6

Note: classifications are taken from the relevant fields in WAID.

Table 2
Descriptive statistics for weather conditions on case days and control days for unintentional fatal drowning in the UK 2012–2019 (n = 1945).

	Maximum air temperature (°C)	Precipitation (mm)
Case day	15.36 (±6.31)	2.54 (±5.58)
Control day: Seven days previous	14.88 (±5.99)	2.31 (±4.66)
Control day: 14 days previous	14.73 (±5.89)	2.61 (±4.96)

Note: data are presented as mean and standard deviation.
A case day is defined as the date on which a given drowning event occurred.

4. Discussion

This case-crossover study examined the association between weather conditions (i.e., daily volume of precipitation and maximum air temperature) and the risk of unintentional drowning in the UK. A significant positive relationship existed between maximum air temperature and the odds of unintentional drowning. Indeed, a 1 °C increase in daily maximum air temperature was associated with a 7.2% increase in

Table 3
Association between weather characteristics and unintentional fatal drowning risk in the UK 2012–2019 (n = 1945).

Temperature modelled as continuous					
	Odds ratio (95% confidence intervals)				
	All sexes	**Males**	**Females**	**Alcohol intoxication suspected**	**No alcohol intoxication suspected**
Maximum air temperature (°C)	*1.072 (1.052, 1.092)* **	*1.076 (1.054, 1.099)* **	1.039 (0.990, 1.091)	*1.220 (1.095, 1.360)***	*1.071 (1.047, 1.095)***
Precipitation (mm)	1.006 (0.995, 1.017)	1.006 (0.993, 1.0128)	1.002 (0.976, 1.029)	1.010 (0.928, 1.100)	1.002 (0.989, 1.016)
Temperature modelled as categorical					
	Odds ratio (95% confidence intervals)				
	All sexes	**Males**	**Females**	**Alcohol intoxication suspected**	**No alcohol intoxication suspected**
Maximum air temperature < 10 °C	Reference	Reference	Reference	Reference	Reference
Maximum air temperature 10–14.9 °C	1.093 (0.898, 1.331)	1.003 (0.807, 1.245)	1.608 (0.967, 2.673)	1.471 (0.595, 3.639)	1.098 (0.857, 1.408)
Maximum air temperature 15–19.9 °C	*1.748 (1.330, 2.297)* **	*1.703 (1.261, 2.300)* **	*2.456 (1.220, 4.945)**	*16.564 (2.862, 95.859)**	*1.660 (1.191, 2.313)**
Maximum air temperature 20–24.9 °C	*1.872 (1.365, 2.568)* **	*1.844 (1.303, 2.611)* **	2.163 (0.9635, 4.856)	*34.786 (4.845, 249.768)***	*1.719 (1.174, 2.313)**
Maximum air temperature ≥ 25 °C	*4.671 (3.124, 6.985)* **	*5.347 (3.422, 8.356)* **	2.548 (0.921, 7.047)	*75.367 (3.957, 1435.336)**	*4.493 (2.774, 7.276)***
Precipitation (mm)	1.006 (0.995, 1.018)	1.007 (0.995, 1.020)	1.000 (0.974, 1.027)	1.015 (0.936, 1.100	1.003 (0.989, 1.016)

*: Significant association at the $p < 0.05$ level, **: Significant association at the $p < 0.001$ level.

unintentional drowning risk. Risk was substantially elevated (OR: 1.75–4.67) on days where air temperature reached at least 15 °C compared with days colder than 10 °C. In agreement with a consensus amongst water safety experts (Johnston et al., 2023), these findings suggest that warm weather may be a substantial risk factor for accidental drowning in the UK. This study therefore supports recent recommendations that suggest routinely recording air temperature on drowning days would represent a valuable addition to WAID data recording practices (Hills et al., 2021).

This study reflects existing evidence which has shown a positive association between air temperature and drowning risk. For instance, positive relationships between air temperature and drowning risk have been reported in regions of Canada (Chauvin et al., 2020; Fralick et al., 2013). In children aged 0–19 living in Quebec between 1989 and 2015, the odds of being hospitalised for drowning were 2.65 times higher for maximum temperatures between 20 and 24.9 °C, 5.30 times higher for air temperatures between 25 and 29.9 °C, and 9.36 times higher for temperatures ≥30 °C when compared with temperatures of 15 °C (Chauvin et al., 2020). Fralick et al. (2013) also conducted a case-crossover study and reported that the risk of outdoor drowning in residents of Ontario increased by 69% (OR: 1.69) on days where air temperature exceeded 30 °C, compared with when the air was cooler than 30 °C. In the current study, an OR of 4.67 (5.35 for males) was observed for temperatures ≥25 °C compared with when temperatures were < 10 °C. Acknowledging the limited number of observations in the higher temperature categories, such findings support the notion that in western countries such as Canada, Australia, and the UK, warmer days are associated with substantially increased risk of death by unintentional drowning.

Whilst neither the current study nor the analyses in Canada can conclusively determine the precise reasons underpinning the strong positive relationships observed between air temperature and drowning risk, it seems likely that warmer temperatures cause people in countries such as the UK and Canada to voluntarily spend more time in and around aquatic spaces. As greater exposure to risk environments is associated with greater rates of drowning and non-fatal drowning (Gulliver and Begg, 2005), such behavioural responses likely contribute to the increased risk observed with increasing daily temperatures. Moreover, alcohol consumption in aquatic spaces is a known risk factor for drowning (Hamilton et al., 2018; Mott and Latimer, 2016) and ∼ 26% of cases in the current sample involved suspected alcohol intoxication. As on- and off-premises alcohol sales may increase on days that people perceive to be warm and/or sunny (Hughes et al., 2004), it is possible that temperature-induced changes in alcohol consumption (and thus risk behaviours) partly explain the relationships observed. Whilst these data must be interpreted with caution due to the relatively small number of cases in the different temperature categories (see supplementary table 1), comparing ORs from the models stratified by intoxication status suggests that increasing temperature is associated with a substantially greater elevation in drowning risk amongst intoxicated people, when compared with when no intoxication is suspected.

Compared with females, it is well established that males display greater exposure to aquatic environments, engage in more activities that carry greater risk (e.g., swimming at night, not wearing lifejackets, etc.), are more likely to drink alcohol in aquatic spaces, and have more confidence in their ability to swim (Gulliver and Begg, 2005; Hamilton et al., 2018; Howland et al., 1996; Leavy et al., 2022). These factors contribute to the substantially elevated rates of drowning typically observed in males and may mean that males are particularly susceptible to the increased risks associated with warmer weather conditions. Whilst caution must be exercised when interpreting date based on female data contributing just 16% of the sample, the current study observed a 7.6% increase in drowning risk per 1 °C increase in maximum air temperature for males, compared with a smaller increase of 3.9% in females. Similarly, the OR for days where air temperature reached at least 25 °C for males was more than twice that calculated for females (OR: 5.35 vs 2.55). Moreover, the increase in unintentional drowning risk in males is substantially higher at 25 °C compared with increase seen in the 20 - 24.9 °C category. Notably, thermal comfort is achieved in unclothed humans in still air at a temperature of 26–28 °C, leading to a reduced need to retain the insulation provided by clothing in the conditions of the present study (Gagge et al., 1967; Guéritée and Tipton, 2015). Clothing aids buoyancy by trapping air between layers on accidental immersion and provides thermal protection on prolonged immersion thereby reducing drowning risk (Barwood et al., 2011; Bowes et al., 2016). Above an air temperature of 28 °C, humans experience a sensation of being hot and uncomfortable, thereby increasing the likelihood of entering water to relieve thermal discomfort and for recreational reasons (e.g., swimming) (Gagge et al., 1967; Guéritée and Tipton, 2015). The magnitude of the cold shock response is associated with the rate and extent of skin cooling (Tipton, 1989) and hence this set of environmental conditions increases the threat posed to persons who become accidentally immersed.

It is important to note that although similar relationships have been observed in Canada, the results of the current study are likely specific to the UK and cannot necessarily be extrapolated to places with different climates or cultural norms (Chauvin et al., 2020; Gallinger et al., 2015). Indeed, data from Fiji indicated no significant relationship between air temperature and drowning risk when controlling for the amount of precipitation (Murray and Carter, 2017). Whilst the sample used in the aforementioned study was relatively small ($n = 187$) and data were aggregated into monthly totals, it is notable that in Fiji a positive association was observed between drowning rates and the amount of rainfall recorded per month (Murray and Carter, 2017). Whilst specific patterns may differ between countries, consistent findings of relationships between weather conditions (specifically warm temperatures and/or rainfall) and elevated drowning risk highlight particular cause for concern given the palpable evidence of global climate change (Dale, 1997; Sindall et al., 2022).

A key strength of this study is the fact that an individual-matched case-crossover design was used, which controls for several factors that are known to influence drowning risk, such as victims' age, sex, and socioeconomic status, whilst also removing the influence of the day of the week and time of year (Chauvin et al., 2020; Mittleman and Mostofsky, 2014). We respond to calls in the wider evidence base to more robustly investigate associations between environmental influences and major public health challenges (Desjardins et al., 2023; Hobbs and Atlas, 2019). Whilst strong positive associations were observed between daily maximum air temperature and the risk of unintentional drowning in the UK, this study cannot be used to establish a direct causal link between the two. That said, the relationships observed align with existing literature and it is likely that warmer weather leads to behaviours that elevate the risk of drowning, such as increased exposure to aquatic environments and/or greater engagement with risky behaviours in such spaces (e.g., swimming along and/or in dangerous bodies of water, consuming alcohol near water). Moreover, the sample contained only ~16% females. Because the vast majority of unintentional drownings in the UK occur in males (Hills et al., 2021), it is possible that the limited number of females may have contributed to the non-significance of some of the relationships observed within the female sub-sample. Nevertheless, it is evident that the pattern in odds ratios when data are stratified by sex is different for females and does not show the same magnitude of increase in risk or direction of change when air temperature exceeds 25 °C. Due to the availability of accurate and reliable data in the UK, this study considered only fatal drownings. Further reliable collection and analysis of 'near-miss' water-based incidents would add further context to this area of research and allow evaluation of current water safety practices.

5. Conclusion

In a multiyear, nationwide, and validated dataset of unintentional drownings within the UK (WAID), this study identified positive associations between daily maximum air temperature and the risk of unintentional fatal drowning. Whilst similar analyses with larger samples is needed to enable firm conclusions, the risk was particularly pronounced in males and when alcohol intoxication was suspected. Identifying such relationships highlights the value of considering weather conditions when evaluating environmental risk factors for drowning and may be an important factor in informing water safety policy interventions, messaging campaigns, and resource allocation.

Funding

This work was supported by internal funding from Bournemouth University (Acceleration of Research & Networking grant).

CRediT authorship contribution statement

Samuel P. Hills: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Matthew Hobbs:** Writing – review & editing, Writing – original draft, Supervision, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Paul Brown:** Writing – review & editing, Writing – original draft, Software, Resources, Formal analysis, Data curation. **Mike Tipton:** Writing – review & editing, Writing – original draft, Supervision, Investigation. **Martin Barwood:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization.

Declaration of Competing Interest

None.

Data availability

The authors do not have permission to share data.

Acknowledgments

The authors would like to thank Mr. David Walker (Royal Society for the Prevention of Accidents) for granting data access and providing guidance. The authors would also like to thank the members of the National Water Safety Forum.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2023.107832.

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