



Published in final edited form as:

Inj Prev. ; 32(3): 495–497. doi:10.1136/ip-2024-045597.

Unrealised potential of pool fencing and life jackets to prevent US drownings

Cora Peterson¹, Elizabeth Ayangunna², Briana Moreland¹, Michael F Ballesteros¹, Curtis Florence¹, Tessa Clemens¹

¹Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, USA

²CDC Foundation Inc, Atlanta, Georgia, USA

Abstract

Background: Drowning causes more than 4500 deaths annually and is the leading cause of death among children aged 1–4 years old in the USA. Isolation pool fencing (ie, four-sided fencing to limit access from all adjoining areas including residences and yards) and use of US Coast Guard-approved life jackets while boating can prevent drowning, but preventable deaths still occur. This study aimed to estimate the annual health and economic burden of drowning likely attributable to inadequate pool fencing and not wearing life jackets while boating to highlight the unrealised value of these known prevention strategies.

Methods: A simple mathematical model used the most recent annual number of drowning deaths by decedent age in combination with previous study data to estimate the number of drowning deaths that might have been prevented through: (1) adequate isolation fencing for swimming pools among children aged <5 years old and (2) use of life jackets while boating for people of all ages. Prevention effectiveness estimates of pool fencing and life jackets were based on previous studies. Unit costs for drowning-related medical spending and avoidable mortality using the value of statistical life were from existing sources.

Results: Proper use of swimming pool isolation fencing and always wearing a life jacket while boating could prevent an estimated 348 US drowning deaths and an economic cost of US\$4.5 billion per year.

Conclusions: Highlighting the effectiveness of drowning prevention strategies can help inform public attention to this issue and support cost-effective public health decision-making.

INTRODUCTION

In 2022, drowning caused more than 4500 deaths in the USA and remains the leading cause of death among children aged 1–4 years old.¹ Unintentional drowning rates increased after

Correspondence to: Dr Cora Peterson; cora.peterson@cdc.hhs.gov.

Contributors CP is the guarantor. CP, EA and BM conducted and verified data analysis. CP drafted the manuscript. All authors contributed to study design, interpretation of results, edited the manuscript and approved the final manuscript as submitted.

Competing interests None declared.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

the COVID-19 pandemic era, perhaps affected by limited access to supervised swimming settings during that time.² Two known strategies—pool fencing and wearing a life jacket while boating—have both prevention effectiveness data and related mortality coding to estimate whether these factors were in place prior to a drowning death.^{3 4} The effectiveness of other critically important drowning prevention strategies such as basic swimming and water safety skills training and enhanced child supervision can benefit from further estimation, and the presence of those factors related to a drowning death is not identifiable in publicly available US mortality data. This brief report aimed to estimate the annual health and economic burden of drowning deaths likely attributable to inadequate pool fencing and not wearing life jackets while boating to highlight the unrealised value of these known prevention strategies.

METHODS

This cross-sectional study of the US population followed CHEERS reporting guidelines, used publicly available data and did not require institutional review board approval (45 CFR §46). A simple mathematical model used the most recent year of final US drowning data (2022) from the Centers for Disease Control and Prevention's (CDC) WONDER data system in combination with prevention effectiveness estimates from previous studies and CDC's Web-based Injury Statistics Query and Reporting System (WISQARS) data on the economic cost of injuries to estimate the average annual number of drowning deaths and economic cost that might be prevented annually through: (1) adequate swimming pool fencing to prevent drowning among children aged <5 years and (2) wearing life jackets while boating to prevent drowning among people of all ages.^{1 5}

Deaths among children aged 0–4 years with ICD-10 codes indicating drowning in a swimming pool (W67, W68) were assumed potentially susceptible to prevention by adequate pool fencing (table 1). Adequate pool fencing has a minimum 4 ft height, separates the pool from residences and yards (four-sided fencing), has a self-closing and self-latching gate and is maintained in good condition—as described in the Consumer Product Safety Commission's Safety Guidelines for Residential Pools.⁶ The most recent investigation of this issue in the USA estimated that 19% of swimming pool drowning deaths among children aged <5 years could be prevented by adequate fencing (table 2).⁷ Deaths among people of all ages with ICD-10 codes indicating watercraft-related drowning (V90, V92) were assumed potentially susceptible to prevention by life jackets (table 1). It was assumed 87% of such deaths could be prevented by life jackets, based on the most recent annual data from the US Coast Guard indicating 87% of people who drowned while boating were not wearing a life jacket (table 2).⁸ The CDC's WISQARS Cost of Injury website was queried in October 2024 for average medical spending related to drowning deaths (ie, in the case that medical assistance was available prior to death) (table 2).⁹ Avoidable mortality was assessed using the value of statistical life (VSL)—a monetary estimate of the collective value placed on mortality risk reduction as derived in research studies through revealed preferences (eg, observed wage differences for dangerous occupations) or stated preferences from surveys of individuals' willingness to pay for mortality risk reduction—as applied in CDC WISQARS (table 2).^{10 11} That data source uses the societal perspective with lifetime horizon and undiscounted inflation-adjusted constant 2021 US dollars (at study time).⁹

RESULTS

Based on drowning-related ICD codes, there were 4509 US drowning deaths (table 1). This included 840 deaths in swimming pools and 341 deaths related to watercraft. Adequate swimming pool isolation fencing could prevent an estimated 51 drowning deaths per year, and always wearing a life jacket while boating could prevent an estimated 297 drowning deaths per year, or a total of 348 preventable deaths and an economic cost of US\$4.5 billion per year (table 2).

DISCUSSION

Increased adherence to adequate pool fencing and always wearing a life jacket while boating could avert a substantial number of deaths and enormous economic cost each year in the USA. These known strategies are already helping to prevent drowning incidents, but there remains a substantial unrealised potential for saving more lives. Most fatal and non-fatal drownings involving children less than 5 years old occur in pools owned by family, friends or relatives.⁶ Approximately 75% of American households with pools reported adequate pool fencing in the most recent available studies (based on telephone surveys in 1994 and 2001–2003).^{7 12} Laws regarding pool fencing in newly installed pools vary by jurisdiction, and unfortunately, there is not an authoritative source on new pool fencing regulations nationwide, nor is there more recent robust data on the prevalence of adequate fencing among existing pools. Laws regarding life jacket use also vary by state. An observational study of boaters in Washington State reported only 31% wore life jackets, although life jackets were more frequent among boaters required by state law to wear life jackets such as children, personal watercraft users and people being towed (eg, water-skiers).¹³ Factors associated with reduced life jacket wear include adult age, being male, consumption of alcohol, and perceived discomfort, cost, accessibility, and swimming ability.¹⁴

Limitations

The benefits of other critical prevention strategies such as basic swimming and water safety skills training and enhanced child supervision were not addressed.¹⁵ Limitations of CDC WISQARS cost data are detailed elsewhere.¹⁶ Cost estimates here addressed medical spending and VSL, but not other important costs related to drowning such as search and rescue. This study used available ICD-10 cause of death codes indicating drowning to make simple but conservative assumptions about recent drowning deaths that were likely susceptible to prevention by adequate pool fencing and wearing life jackets while boating—coding errors or non-specific codes could have caused undercounting. Coroner reports are not systematically and publicly available for US drowning deaths. Child Death Reviews occur for a majority of drowning deaths, but such data are collected at various jurisdictional levels and reporting on key measures for assessing prevention effectiveness—such as the presence of adequate child supervision and the swimming ability of the decedent—is incomplete.¹⁵ Building the evidence base for drowning prevention effectiveness, particularly among children, will benefit from ongoing data modernisation and aggregation efforts. This study did not address non-fatal drowning events and analysed only the most recent data year;

however, use of a longer 5-year average timeline for contributing data would have yielded similar results (data not shown).^{5 17}

The best available prevention effectiveness estimate for adequate pool fencing (19% of child drowning deaths) specific to the USA is decades old (published 1998)⁷ and is lower than previous similar estimates—a study of Australian and New Zealand drownings in the 1970s estimated instead that 40%–70% of pool drownings could be prevented through adequate fencing.¹⁸ High-quality data on the prevalence of adequate pool fencing in the USA are important for drowning prevention and merits attention in future research. This study assumed that life jackets could have prevented all boating-related drowning deaths among people who were not wearing a life jacket, which might be an overestimate. However, the number of boating-related drowning deaths reported in this study's data source, CDC WONDER, was 23% lower during 2018–2022 compared with data from the US Coast Guard; using the higher number of deaths from the US Coast Guard would have increased this study's estimates of preventable deaths and economic cost.¹⁷ This study did not address non-watercraft related drowning deaths that occurred in natural water as being susceptible to prevention by wearing life jackets—this is another source of underestimation. Communities with lower median income and lower educational attainment have higher drowning rates, and drowning risk is higher among non-Hispanic American Indian or Alaska Native persons and Black or African-American persons, as well as children with autism spectrum disorder.^{19–21} Due to available data, this study did not address prevention effectiveness with respect to these factors.

CONCLUSIONS

Despite the long-term known effectiveness of pool fencing and life jackets to prevent drowning, many preventable deaths still occur. The US National Water Safety Action Plan recommends drowning prevention actions for individuals and institutions, including four-sided isolation pool fencing and increasing life jacket use.²² Continuing to highlight the benefits of these known interventions can help inform public attention and support cost-effective public health decision-making.

Funding

EA is supported by Bloomberg Philanthropies (51606) through the CDC Foundation.

REFERENCES

1. CDC National Center for Injury Prevention and Control. Web-based injury statistics query and reporting system (WISQARS). 2024. Available: www.cdc.gov/injury/wisqars
2. Clemens T, Moreland B, Mack KA, et al. Vital Signs: Drowning Death Rates, Self-Reported Swimming Skill, Swimming Lesson Participation, and Recreational Water Exposure - United States, 2019–2023. *MMWR Morb Mortal Wkly Rep* 2024;73:467–73. [PubMed: 38781109]
3. Laksham KB. Life Jacket Usage and Effectiveness in Drowning Prevention. *Prev Med* 2024;1:10–5.
4. Thompson DC, Rivara FP. Pool fencing for preventing drowning in children. *Cochrane Database Syst Rev* 2000;1998:CD001047.
5. Centers for Disease Control and Prevention. CDC wonder. 2024. Available: <https://wonder.cdc.gov>

6. U.S. Consumer Product Safety Commission. Safety barrier guidelines for residential pools (publication 362). Bethesda, MD U.S. Consumer Product Safety Commission; 2012.
7. Logan P, Branche CM, Sacks JJ, et al. Childhood drownings and fencing of outdoor pools in the United States, 1994. *Pediatrics* 1998;101:E3.
8. United States Coast Guard. Recreational boating statistics 2023 (commandant publication p16754.37). Washington, DC United States Coast Guard; 2024.
9. Peterson C, Rice KL, Williams DD, et al. WISQARS Cost of Injury for public health research and practice. *Inj Prev* 2023;29:150–7. [PubMed: 36396442]
10. U.S. Department of Health and Human Services Office of the Assistant Secretary for Planning and Evaluation. Guidelines for regulatory impact analysis. Washington, DC U.S. Department of Health and Human Services; 2016.
11. Office of Child Care (OCC), Administration for Children and Families (ACF), Department of Health and Human Services (HHS). Child care and development fund (CCDF) program. Final rule. *Fed Regist* 2016;81:67438–595. [PubMed: 27726322]
12. Gilchrist J, Mack K. Prevalence of Pools and Adequate Pool Fencing in the United States, 2001–2003. *IJARE* 2008;2:16–26.
13. Chung C, Quan L, Bennett E, et al. Informing policy on open water drowning prevention: an observational survey of life jacket use in Washington State. *Inj Prev* 2014;20:238–43. [PubMed: 24513564]
14. Peden AE, Demant D, Hagger MS, et al. Personal, social, and environmental factors associated with lifejacket wear in adults and children: A systematic literature review. *PLoS ONE* 2018;13:e0196421. [PubMed: 29718971]
15. Center for Fatality Review and Prevention. Review of drowning fatalities. Okemos, MI Michigan Public Health Institute; 2024.
16. Peterson C, Miller GF, Barnett SBL, et al. Economic Cost of Injury - United States, 2019. *MMWR Morb Mortal Wkly Rep* 2021;70:1655–9. [PubMed: 34855726]
17. United States Coast Guard. Accident statistics. Washington, DC: United States Coast Guard; 2024. Available: https://uscgboating.org/statistics/accident_statistics.php
18. Fergusson DM, Horwood LJ. Risks of drowning in fenced and unfenced domestic swimming pools. *N Z Med J* 1984;97:777–9. [PubMed: 6593628]
19. Dai D, Zhang Y, Lynch CA, et al. Childhood drowning in Georgia: A geographic information system analysis. *Appl Geogr* 2013;37:11–22.
20. Clemens T, Moreland B, Lee R. Persistent Racial/Ethnic Disparities in Fatal Unintentional Drowning Rates Among Persons Aged ≤29 Years - United States, 1999–2019. *MMWR Morb Mortal Wkly Rep* 2021;70:869–74. [PubMed: 34138831]
21. Moreland B, Ortmann N, Clemens T. Increased unintentional drowning deaths in 2020 by age, race/ethnicity, sex, and location, United States. *J Safety Res* 2022;82:463–8. [PubMed: 36031277]
22. US National Water Safety Action Plan. US national water safety action plan—2023–2032. Washington, DC US National Water Safety Action Plan; 2023. Available: https://www.watersafetyusa.org/uploads/7/0/6/0/70608285/usnwsap_v7.pdf

WHAT IS ALREADY KNOWN ON THIS TOPIC

- Pool fencing and life jackets prevent drowning.

WHAT THIS STUDY ADDS

- The burden of drowning likely attributable to inadequate pool fencing and not wearing life jackets while boating in the USA remains high—available data are imperfect but approximately 350 deaths and an economic cost of \$4.5B per year might be averted through better use of these well-known prevention strategies.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE, OR POLICY

- Highlighting the effectiveness of drowning prevention strategies can help inform public attention to this issue and support cost-effective public health decision-making.

Table 1.
Drowning by age group and ICD-10 code, United States—2022

ICD-10	ICD-10 Title	0–4 years	5–17 years	18+ years	All ^(c)
W65	Drowning and submersion while in bathtub	75	21	636	732
W66	Drowning and submersion following fall into bathtub				
W67 ^(a)	Drowning and submersion while in swimming pool	267	98	474	840
W68 ^(a)	Drowning and submersion following fall into swimming pool				
W69	Drowning and submersion while in natural water	93	177	1,730	2,001
W70	Drowning and submersion following fall into natural water				
W73	Other specified drowning and submersion	62	30	503	595
W74	Unspecified drowning and submersion				
V90 ^(b)	Accident to watercraft causing drowning and submersion	NR	17	321	341
V92 ^(b)	Water-transport-related drowning and submersion, without accident to watercraft				
All	All (%)	500 (11)	343 (8)	3,664 (81)	4,509 (100)

Notes. Source: CDC Wonder (<https://wonder.cdc.gov/>) Multiple Cause of Death files, accessed 9/19/2024.

^(a) Assumed susceptible to prevention by pool fencing.

^(b) Assumed susceptible to prevention by life jackets.

^(c) Includes unknown age.

NR=not reported due to cell size <10.

Model parameters

Table 2.

Measure	Value	Source
US annual drowning deaths	4,509	CDC Wonder (2022)
• Susceptible to prevention by pool fencing	51	Estimate: 19% (Logan, 1998) ⁷ of age <5 years old drownings due to inadequate fencing, applied to ICD-10 W67, W68 drownings (n=267) (Table 1)
• Susceptible to prevention by life jackets	297	Estimate: 87% (U.S. Coast Guard, 2024) ⁸ of all ages boating accident drowning victims were not wearing a life jacket, applied to ICD-10 V90, V92 drownings (n=341) (Table 1)
Medical spending per drowning	\$9,877	CDC WISQARS Cost of Injury (2021 USD)
Value of statistical life		Peterson (2023) ⁹
• Child	\$18.3 M	
• Adult	\$11.6 M	
Unrealized annual economic potential		Calculated
• Pool fencing	\$0.9 B	
• Life jackets	\$3.6 B	
• Total	\$4.5 B	

B= billion; M= million