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Special Report from the CDC: The association between social vulnerability and unintentional fatal drowning in the United States, 1999–2023

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Abstract

Introduction: Drowning is a major public health problem. There are about 4,500 fatal unintentional drownings in the United States each year, and more children ages 1–4 die from drowning than from any other cause. Some sociodemographic characteristics are associated with increased risk of unintentional fatal drowning. The purpose of this study was to better understand the association between county-level social vulnerability and unintentional fatal drowning.

Methods: This study used the 2014 Centers for Disease Control and Prevention and Agency for Toxic Substances and Disease Registry's (CDC/ATSDR) Social Vulnerability Index (SVI) and mortality data from the National Vital Statistics System from 1999–2023. Counties were ranked and categorized into tertiles across social vulnerability scores for all indicators of the SVI. Negative binomial regression was used to estimate crude rate ratios (RR) and 95% confidence intervals comparing county-level fatal drowning rates and the SVI indicators.

Results: County-level social vulnerability is associated with unintentional fatal drowning. Counties with high overall social vulnerability had fatal drowning rates 1.59 times as high as counties with low social vulnerability. These associations were most pronounced for the SVI indicators of socioeconomic status (RR=1.56), disability status (RR=1.49) and proportion of mobile homes (RR=1.62).

Conclusions: While the reasons for the associations between indicators of the SVI and higher rates of drowning are not fully understood, counties with high social vulnerability may be

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Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

CRediT Authorship Contribution Statement

Jill V. Klosky: Writing – original draft, review & editing, Validation. **Briana Moreland:** Data curation, Formal analysis, Methodology, Writing – review & editing. **Tessa Clemens:** Conceptualization, Supervision, Writing – review & editing.

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.

associated with reduced access to swimming pools, affordable swimming lessons and other evidence-based drowning prevention strategies.

Practical Applications: Communities can use the SVI and other indicators of risk to support drowning prevention program implementation, ensuring strategies reach and are tailored to populations most at risk of drowning.

Keywords

Drowning; Risk factors; Injury; Prevention; Sociodemographic

Introduction

Approximately 4,500 people die in the United States annually due to unintentional drowning.¹ Globally, sociodemographic risk factors for drowning differ by age, sex, occupation, socio-economic status, immigrant status, educational attainment, and rurality.^{2,3} In the United States, unintentional fatal drowning rates vary by age groups, geography, sex, and race and ethnicity.^{1,4–6} Drowning is the leading cause of death for children ages 1–4, and the second leading cause of unintentional injury death for children ages 5–14 in the United States. Drowning rates are approximately 35% higher in rural areas compared to urban areas.¹ Males consistently drown at higher rates than females, and drowning rates are highest among non-Hispanic Native Hawaiian and other Pacific Islander persons, African American/Black persons and American Indian and Alaska Native persons.¹

Social vulnerability is a community's susceptibility to harmful health consequences due to large-scale external stressors such as major disease outbreaks or catastrophic weather events. The Centers for Disease Control and Prevention and Agency for Toxic Substances and Disease Registry (CDC/ATSDR) developed the Social Vulnerability Index (SVI) as a disaster management tool for municipalities.⁷ The utility of the SVI has been investigated beyond disaster management to better understand social and environmental influences on health discrepancies, barriers to healthcare, and health outcomes.^{8,9}

Greater understanding of population-level factors associated with increased drowning risk could better inform the development of tailored drowning prevention interventions.⁵ This study examined the association between county-level social vulnerability and unintentional fatal drowning rates.

Methods

Data sources

We obtained United States mortality data for 1999–2023 from the National Vital Statistics System (NVSS) through a data use agreement with the National Center for Health Statistics (NCHS). NVSS derives mortality data from all registered death certificates in the United States. Unintentional drowning deaths were identified using the International Classification for Diseases, 10th revision (ICD-10) codes W65–W74, V90 and V92. The use of ICD-10 codes to specify the cause of death began in the year 1999; therefore, our study analyzed data starting from 1999 for consistency. Population estimates from 1999 to 2019 were

obtained from NCHS,¹⁰ and population estimates from 2020 to 2023 were obtained from the United States Census Bureau's 2023 July 1st estimates.¹¹

County-level social vulnerability for 3,142 counties was assessed using the 2014 SVI. The 2014 SVI was chosen as it uses 5-year American Community Survey estimates from 2010–2014, which is the approximate midpoint of the study period.⁷ During the span of the 25-year study period (e.g., 1999–2023), some counties were combined, divided, or renamed. Where possible for the analysis, we merged counties throughout the study period to match the counties available in the 2014 SVI. Overall, data exclusions were due to counties being divided or county lines restructured. As such, data from three counties in Alaska before 2014 were excluded, and all counties in Connecticut were excluded in 2022 and 2023.

The SVI percentile ranks counties from 0–1, with higher values indicating greater social vulnerability. The SVI indicators include overall social vulnerability, four themes (Socioeconomic Status, Household Composition and Disability, Minority Status and Language, Household Type and Transportation), and 15 corresponding social factors (Table).⁷

Data Analysis

Counties were categorized into tertiles (low, medium, high) by percentile ranks of the SVI indicators. Crude drowning rates and 95% confidence intervals were calculated by the decedent's county of residence. Rate ratios (RRs) comparing county-level drowning rates by the social vulnerability indicators were calculated using negative binomial regression. Counties with a low SVI level by each SVI indicator were the reference group. Data were analyzed using SAS version 9.4 (SAS Institute, Inc., Cary NC, USA). This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.

Results

During 1999 to 2023, there were 100,032 unintentional drowning deaths (1.29 per 100,000 population) in the United States. Among counties with high overall social vulnerability there were 1.43 drowning deaths per 100,000 population. Fatal unintentional drowning rates were 1.59 times as high in counties with high overall social vulnerability as in counties with low overall social vulnerability (Table). Counties with high vulnerability related to each of the four themes had higher rates of drowning compared to counties with low levels of vulnerability (Socioeconomic Status, RR=1.56; Household Composition and Disability, RR=1.49; Minority Status and Language, RR=1.17; Household Type and Transportation, RR=1.25).

Counties with high levels of vulnerability related to each of the four social factors comprising the Socioeconomic Status theme, had higher unintentional fatal drowning rates compared to counties with low vulnerability. The strength of association between each of the social factors and drowning rates was largely similar with RRs ranging from 1.41 to 1.49.

Counties with high vulnerability related to each of the four social factors of the theme Household Composition and Disability had significantly higher unintentional fatal drowning rates compared to counties with low vulnerability, except for the aged ≤ 17 years factor where rates were not significantly different. Among counties with high vulnerability for the social factor of disability status, drowning rates were 1.49 times as high as counties with low vulnerability.

For the theme Minority Status and Language, counties with high vulnerability for the social factor of racial and ethnic minority status had unintentional fatal drowning rates 1.34 times as high as counties with low vulnerability for this indicator. In contrast, drowning rates were lower in counties with high vulnerability for persons with limited English proficiency (RR=0.95) compared to counties with low vulnerability.

Results for the theme Household Type and Transportation were mixed. Counties with high vulnerability for three of the five corresponding social factors had higher unintentional fatal drowning rates compared to counties with low vulnerability. This was most pronounced among counties with high vulnerability related to the social factor of mobile homes, with drowning rates 1.62 times as high as counties with low vulnerability. In contrast, counties with high vulnerability related to multi-unit housing and group quarters had lower drowning rates compared to counties with low vulnerability (RR=0.70 and RR=0.91 respectively).

Discussion

This study found that county-level social vulnerability is associated with unintentional fatal drowning. Consistent with the extant literature, socioeconomic status was associated with unintentional fatal drowning rates at the county level.² This could be explained by economic barriers to drowning prevention strategies, such as access to swimming lessons.¹² Our study found increased drowning rates among counties with high vulnerability related to disability status. Although the reasons for this finding are unclear, they may be related to reduced access to or utilization of specific drowning prevention strategies that are recommended for people with certain underlying medical conditions, such as adaptive swim lessons,¹³ physical barriers to bodies of water (e.g., pool fencing), supervision from a capable adult, and swimming in settings with lifeguards.¹⁴

Counties with high vulnerability for the social factor of racial and ethnic minority status had higher rates of drowning compared to counties with low vulnerability. In the United States, the highest rates of drowning are among non-Hispanic Native Hawaiian and other Pacific Islander persons, African American/Black persons and American Indian or Alaska Native persons.¹ These differences may be explained by barriers to accessing basic swimming and water safety skills training.⁴ Similar to studies comparing SVI indicators and fatal injury, our study found counties with high vulnerability related to limited English proficiency had lower rates of drowning compared to counties with low vulnerability.^{8,9} While immigrant status is a risk factor for drowning globally,^{2,3} our finding aligns with research that found immigrants to the United States had lower prevalence of non-fatal injury, and were less likely to engage in behaviors that increase injury risk compared to people born in the United States.¹⁵

Rural communities experience higher rates of drowning compared to urban geographies.¹ Our study found lower rates of drowning among counties with high vulnerability related to multi-unit housing, as is more typical of urban communities.¹⁶ We also found higher rates of drowning in counties with high vulnerability related to the proportion of mobile homes. Mobile homes are a source of affordable housing that, when compared to other housing types, are more likely to be zoned in rural areas, exposed to flooding, and located further away from recreation centers which may provide access to swimming pools.^{17,18} Compared to other geographies, most disaster/weather-related fatal drowning among children happen in rural locations.¹⁹ These factors may help to explain higher rates of drowning due to increased risk of weather-related flooding and reduced access to basic swimming and water safety skills training.

Limitations

This study has at least four limitations. First, we described the association between county-level aggregate drowning rates from 1999 to 2023 to the 2014 SVI. The 25-year study period was used due to the relatively small number of drownings that occur annually at the county level. The social vulnerability level of counties may have changed over the 25-year study period and may not be reflected in the 2014 SVI rankings. Second, our analysis was limited to counties included in the 2014 SVI. The geography of some counties changed across the study period where some counties were combined, renamed, or divided. When possible, drowning and population estimates from counties that were renamed or combined into a single county in the 2014 SVI were combined throughout the study period. However, counties for which this was not feasible (e.g., counties that were divided), were omitted from the analysis. Third, because the SVI was designed for disaster resource management, there may be other county-level variables associated with drowning rates that were not considered. And fourth, as population variability exists within counties and the SVI uses county-level indicators, the associations this study found between social vulnerability and drowning may not translate to increased drowning risk at specific community or individual levels.

Conclusion

Overall, social vulnerability was associated with higher levels of unintentional fatal drowning at the county level. This association was highest for the Socioeconomic Status theme, and the social factors related to disability status and proportion of mobile homes. The association between social vulnerability and fatal drowning rates at the county level may be related to reduced access to and utilization of drowning prevention strategies. While evidence-based drowning prevention strategies exist ([Preventing Drowning | Drowning Prevention | CDC](#)), future research focused on community-level implementation science is needed to enhance uptake of drowning prevention interventions in communities at greatest risk.

Practical Applications

Associations between county-level social vulnerability and unintentional fatal drowning stress the essential role of community engagement in the co-development and implementation of effective drowning prevention strategies. For communities with high vulnerability related to socioeconomic status, drowning prevention efforts could focus on

enhancing local access to affordable basic swimming and water safety skills training through supporting aquatic infrastructure and programs that resonate with community members. To counter exposure to flood disasters, research could explore weather-related drowning and drowning prevention, especially in counties with higher vulnerability due to proportion of people living in poverty or mobile homes. For example, rural communities could tailor weather-related drowning prevention interventions, such as emergency alerts and educational messaging, to be situationally specific and relevant to community members.¹⁹ Community-level engagement is vital to increase access to evidence-based drowning prevention strategies that are tailored to persons most at risk.

Biographies

Jill V. Klosky, MPH, PT is a drowning prevention researcher at the CDC Foundation. She graduated from Rollins School of Public Health at Emory University. As a former ORISE Fellow at the Division of Injury Prevention at CDC's National Center for Injury Prevention and Control, she also studied older adult fall prevention. Jill has clinical experience as a board-certified clinical specialist in orthopedic physical therapy.

Briana Moreland, MPH is a Health Scientist in the Division of Injury Prevention at CDC's National Center for Injury Prevention and Control. Her research focuses on drowning surveillance and prevention. She received her MPH in epidemiology from the Mailman School of Public Health at Columbia University.

Tessa Clemens is a passionate drowning prevention researcher focused on improving drowning surveillance and identifying effective strategies for preventing drowning. Her work includes understanding drowning among persons at increased risk and supporting the implementation of effective interventions among underserved populations. Dr. Clemens completed a PhD in Kinesiology and Health Science at York University and a postdoctoral fellowship in global child health at the Hospital for Sick Children Research Institute in Toronto, Canada.

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Table.

Crude rate ratios for unintentional fatal drowning* in medium and high social vulnerability counties compared with rates in low social vulnerability counties†

SVI Metric	Crude Rate Ratios with 95% Confidence Interval		
	Low SVI	Medium SVI RR (95% CI)	High SVI RR (95% CI)
Overall Social Vulnerability	Ref	1.25 (1.19 to 1.31)	1.59 (1.51 to 1.66)
Theme 1: Socioeconomic Status	Ref	1.18 (1.13 to 1.24)	1.56 (1.49 to 1.63)
Persons below poverty level	Ref	1.21 (1.16 to 1.27)	1.49 (1.42 to 1.56)
Unemployment	Ref	1.12 (1.07 to 1.18)	1.41 (1.34 to 1.48)
Per capita income	Ref	1.17 (1.12 to 1.22)	1.46 (1.39 to 1.53)
No high school diploma	Ref	1.17 (1.12 to 1.23)	1.45 (1.38 to 1.52)
Theme 2: Household Composition & Disability	Ref	1.26 (1.20 to 1.32)	1.49 (1.43 to 1.56)
Age ≥ 65 years	Ref	1.01 (0.97 to 1.06)	1.15 (1.09 to 1.20)
Age ≤ 17 years	Ref	0.94 (0.89 to 0.98)	1.02 (0.97 to 1.07)
Disability status	Ref	1.21 (1.16 to 1.27)	1.49 (1.43 to 1.56)
Single-parent household	Ref	1.00 (0.95 to 1.05)	1.19 (1.14 to 1.25)
Theme 3: Minority Status and Language	Ref	1.10 (1.05 to 1.16)	1.17 (1.11 to 1.23)
Racial and ethnic minority status	Ref	1.07 (1.02 to 1.13)	1.34 (1.27 to 1.41)
Limited English proficiency	Ref	0.96 (0.91 to 1.01)	0.95 (0.90 to 0.99)
Theme 4: Household Type and Transportation	Ref	1.12 (1.07 to 1.18)	1.25 (1.19 to 1.32)
Multi-unit housing	Ref	0.86 (0.82 to 0.90)	0.70 (0.67 to 0.73)
Mobile homes	Ref	1.32 (1.26 to 1.37)	1.62 (1.55 to 1.69)
Crowded housing	Ref	1.13 (1.08 to 1.18)	1.43 (1.36 to 1.50)
No vehicle	Ref	1.09 (1.04 to 1.14)	1.17 (1.11 to 1.23)
Group quarters	Ref	0.97 (0.92 to 1.02)	0.91 (0.87 to 0.96)

Abbreviations: Ref=reference; RR=Rate Ratio; CI=confidence interval; SVI=social vulnerability index; ATSDR=Agency for Toxic Substance and Disease Registry.

* Mortality data were obtained from the National Vital Statistics System, United States 1999–2023

† County-level social vulnerability data were obtained from the 2014 CDC/ATSDR SVI