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SYSTEMATIC REVIEW

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Social determinants of occupational injuries among US-based commercial fishermen: a systematic review

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Abstract

Background Commercial fishing is a multibillion-dollar industry that supports job growth, small- to large- businesses, and port and city revenue. The commercial fishing industry continues to be one of the most dangerous in the US, with a fatality rate nearly 40 times higher than the national average. Dangers of the fishing industry are multi-faceted and include hazardous working conditions, strenuous labor, long work hours, and harsh weather. Moreover, a vast majority of fishermen suffer from economic insecurity, including safe and affordable housing and food insecurity.

Methods We followed the recommendations and standards set by the Campbell and Cochrane Equity Methods Group and the Measurement and Evidence Knowledge Network. The review covered 1992–2022 to assess the state of research and to identify new barriers of and facilitators to injury prevention among commercial fishermen using a social determinants of health lens.

Results Of 292 articles identified, 27 studies met our inclusion criteria. Out of 27 articles reviewed, social determinants of health factors included the built environment, social & community factors, economic stability, health care access, and educational attainment. A major finding was the inability for fishermen to access primary care services, which was often rooted in being a low-wage, im/migrant, or transient worker, and can further escalate injuries. A secondary finding related to injury was a feedback loop where fishermen's unsafe environments led to a culture of accepting risk and downplaying injury, which further created unsafe environments.

Conclusion Our review shows how injury is connected to social factors, such as a lack of health care access, as well as political-economic factors, such as a lack of sick leave benefits.

Keywords Social determinants of health, Migrant workers, Commercial fishermen, Health equity, Health care access, Paid sick leave

Introduction

Commercial fishing is a multibillion-dollar industry that supports job growth, small- to large- businesses, and port and city revenue. US commercial fishing, seafood industry, and recreational fishing annually generated approximately $208 billion in sales impacts, contributed $97 billion to the GDP, and supported 1.6 million jobs in 2017 [1]. In 2017, the commercial fishing industry harvested over 9.9 billion pounds of seafood and earned $5.4 billion

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[2]. The total number of workers in the commercial fishing industry is estimated at approximately 40,000 people, which is undoubtedly an underestimate given the vast number of vulnerable workers in the industry, including those who are low-income, aging, im/migrants, or refugees [3, 4].

The commercial fishing industry continues to be one of the most dangerous in the US, with a fatality rate nearly 40 times higher than the national average [3]. Dangers of the fishing industry are multi-faceted and include hazardous working conditions, strenuous labor, long work hours, and harsh weather [3]. There is an average of 114 deaths per 100,000 workers in the commercial fishing industry compared to an average of 4 deaths per 100,000 workers among all US workers [3]. About 80% of fatal injuries are related to water vehicle transportation incidents, with 53% from vessel disasters and 36% from falls overboard [5]. Despite preparedness requirements, as well as increases in dockside inspections and worker trainings [6], the injury and fatality rate among US fishermen remains alarmingly high.

Moreover, a vast majority of fishermen suffer from economic insecurity, including safe and affordable housing and food insecurity. These social determinants of health (SDOH), which we define as the way political-economic systems directly or indirectly impact physical or mental health, may interact with work-related stress and injuries and influence individual decision-making processes and family dynamics. Despite the importance of this industry and the harmful conditions that fishermen often encounter, research has been limited in this population. The current literature is mixed with respect to individual, community, and structural barriers and facilitators to injury prevention. Therefore, we conducted a systematic review to assess the state of research and to identify new barriers of and facilitators to injury prevention among commercial fishermen using a SDOH lens.

Methodology

We followed the recommendations and standards set by the Campbell and Cochrane Equity Methods Group and the Measurement and Evidence Knowledge Network [7]. We conducted an electronic search in CINAHL, Ovid, and Scopus between 1992–2022, developing and testing a range of terms on commercial fishermen, injury, social determinants of health (SDOH), and health. The dates were chosen based on numerous fishery policies that were implemented in the mid-1990's, including the American Fisheries Act (1998) and Sustainable Fisheries Act (1996), as well as to give a broad range of articles over the past two decades that represent the commercial fishing industry. The search for "injury and SDOH" revealed a limited number of relevant results and did not capture research on broader health outcomes that are indirectly related to injury. Subsequently, we expanded our search strategy to "commercial fishermen AND health". No language or publication restriction was applied. In addition, we hand-searched relevant journals and websites, and checked references of all articles meeting study inclusion for additional studies. To be included, studies had to be: 1) primary empirical research (any study design), secondary data analysis, or reviews categorizing, describing, or explaining health among commercial fishermen in the US and 2) provide data on the health status or outcomes of US-based commercial fishermen. Specific coastal regions in the US were not excluded because most maritime policy is federal-, not state-based. These criteria were broad to include all study designs and prevention strategies, though we did limit to the US given the differences in international policy.

All studies were initially screened on title, and then the abstract of relevant studies that met inclusion criteria were screened. Full text screening was done independently by five study team members and the first author/PI. Articles were screened to identify papers that met the following objectives: 1) population: article evaluates male or female, US-based commercial fishermen; 2) study: article evaluates how to improve health outcomes that target SDOH; 3) control: article may or may not use a control group to evaluate the effectiveness of an intervention; 4) outcome: article evaluates the effectiveness of an intervention or study at improving health outcomes of commercial fishermen; and 5) article is published in English. Then, the PI reviewed the texts using the same criteria, as well as the study team's annotated bibliographies to make the final determination of which articles would be included in the systematic review.

Data were extracted on study characteristics, sampling and recruitment, theoretical framework, methods, and results. Studies were reviewed, and those meeting criteria were inputted into a spreadsheet to collect information on study characteristics, topic and focus, and theoretical background. Non-medical factors which contributed to health were coded as barriers or facilitators against a predefined list based on the Health People 2030 definition of SDOH (i.e., educational attainment, health care access, social & community factors, economic stability, and built environment) [8]. Because the review aimed to describe a body of literature, and not the size of an effect, no risk of bias assessment was needed. All search strategies were saved using systematic review best practices [9]. Studies were stored, screened, and keyworded using Microsoft Excel (Microsoft Corp., Redmond, WA). To ensure that the methods and search strategies were exhaustive and to be consistent with systematic review guidelines [3, 10],

the final protocol was reviewed by three relevant experts in systematic reviews and library science.

Results

Of 292 unique titles, 95 relevant articles were downloaded for further abstract screening, 57 studies were included in the full text screen, and 27 studies met inclusion criteria. Out of 27 articles reviewed, 9 were mixed methods, 6 were qualitative, and 6 were quantitative studies, while 5 were reviews and 1 was a secondary data analysis. SDOH factors included the built environment ($n=19$), social & community factors ($n=14$), economic stability ($n=10$), health care access ($n=7$), and educational attainment ($n=7$). For more detailed information, see Table 1.

Economic stability

Lack of economic stability ($n=10$) was seen as a factor for increased injuries due to how it affected risk-based decision making. Natural disasters, like oil spills, contributed to long-term economic instability as fishermen become limited in their ability to work post disaster [11–13]. For instance, fishermen's settlement claims after the Gulf of Mexico oil spill were often denied or substantially reduced, often forcing them to work multiple jobs, as well as risk oil and chemical dispersant exposure [11].

Health care access

Health care expenses and access to health care ($n=11$) manifested through a lack of health insurance, which was directly connected to fishermen's reduced income. Their work also impacted their access to a clinic and the ability to take time off from fishing [11, 14–19]. Cultural and language barriers were linked to health care access and a lack of trust in the healthcare system, as well as a lack of proper navigation knowledge and skills regarding vessel signaling and radio communication in times of emergency [17, 19, 20]. There were also limited health care resources immediately available in commercial fishing settings, which increased the impact that injuries had on the already-limited, remote, and harsh nature of the workplace [21]. Their lack of accessible and cost-effective health care solutions, in addition to the financial disincentive to miss work (i.e., presentism), created recurrent patterns of addiction and opioid misuse among crewmembers, often related to the self-medication of work-related chronic pain [16, 18, 22].

Built environment

The workplace environment ($n=12$) was associated with poor job satisfaction, which led to issues with mental health and family violence [23]. Physical activity related to the type of work resulted in overall poor health, such as poor sleep, susceptibility to injury, and musculoskeletal disorders [22]. A fear of liability and potential vessel investigation also led to the underreporting of nonfatal injuries, which reinforced a certain culture of workplace attitudes that minimized the impact of work-related injuries, exhaustion/overexertion, the acceptance that injuries were part of the job, and "risk diffusion" (i.e., coping with risks led fishermen to underestimate the need for safety equipment) [24, 25]. Finally, the conditions found in the work environment, such as extreme fishing regulations [25] oil spills [12, 13, 26, 27] and COVID-19 [25] led to decreased income, isolation, a lack of social support, and disregarding safety protocols.

Social and community factors

Social and community factors ($n=14$) play an important role in safety and injury outcome, especially related to a certain identity and social awareness that comes from being a fisherman. Costliness of comfortable, functional safety equipment and social stigma and superstitions around the use of safety equipment were reported [25]. This included aspects such as the perception of "freedom" to wear safety equipment, and pride at independence which comes with little regulation on the job [25]. Additionally, there was an underestimation of risk and desensitization to occupational hazards reported [16] and a difficultly enforcing safety measures [17]. For example, one particular group that found an underestimation of risk in fishing were individuals who came from a family of fishermen [28].

Educational attainment

Educational attainment was also seen as a social determinant of health that affected occupational injuries ($n=7$). Less educated fishermen were more likely to underestimate the risk involved in fishing [28]. Stress and depression, both which are associated with decision-making skills, were also found to be higher in those with lower educational attainment [14].

Suggestions to decrease occupational injuries

Two major themes identified in the review that could address the SDOH associated with fishermen's higher-than-average injuries included 1) better health care access ($n=8$) and 2) safety regulations or trainings ($n=13$). Other suggestions included clear risk communication ($n=2$) [17, 27] and better surveillance ($n=3$) [17, 26, 29] of the industry, including oil and gas companies and monitoring restrictive fishing regulations.

For health care access, suggestions were focused on increasing health promotion programs, provider's knowledge of the fishing industry (including language and cultural barriers of fishermen), health screening

Table 1 Systematic review findings

Systematic Review Study Characteristics							
Reference & purpose		**Methods**			**Results**		
Author(s), Title, Journal	**Theoretical framework/Purpose**	**Characteristics**	**Study Design**	**Themes**	**SPDOH factors**	**Barriers to health care**	**Facilitators to health care**
Cherry, Lyon,et al., "After the BP Deepwater Horizon Oil Spill: Financial and Health Concerns Among Coastal Residents and Commercial Fishers," *Current Psychology*	Examining lived experiences coping with stressors related to technological disaster	(Group 1) 64 participants; fishermen mainly, also oil industry; exposed to oil spill; experienced losses from Katrina & Rita (Group 2) 84 participants; indirectly aTected by oil spill; non-fishermen	Qualitative	Economic impact on industry; financial hardships on fishermen; corporate responsibility; threats to health and cultural heritage	Economic stability; Social & community factors; built environmen t	Unable to work; product costs down, decreasing their income; forced to work multiple jobs; settlement claims denied/forgotten/ inadequ ate; exposure to oil and chemical dispersants	Vessels of Opportunity Program (short- term employment to a small selection of fishermen)
Smith, Jacob et al.. "After the Florida Net Ban: The Impacts on Commercial Fishing Families," *Society & Natural Resources*	Assessed stress and coping processes in commercial fishing families and the community after a net ban referendum in Florida in 1994	(Time 1) 95 participants; (Time 2) 44 participants; Commercial fishing families; involved in inshore gill net production	Mixed- methods	Environmental justice ("racial, ethnic, and/ or class discrimination in the allocation, use, and protection of natural resources"); mental health and financial impact on commercial fishing families	Social & community factors; economic stability; built environmen t; healthcare access	Decreased income leading to reduced/ eliminated expenses for health care, health insurance, or food; women's employment (increased family strains and decreased marital satisfaction); perceived stress and family stress; perceived change in the industry	Women's employment (reduced financial strain); increased reporting of self- esteem (decreased anxiety scores in women, decreased depression scores in men and women); education
Kincl, Nery et al., "Dungeness crab commercial fishermen's perceptions of injuries inform survey development," *American Journal of Industrial Medicine*	Focus groups to review reported injuries, discuss risk factors, and identify content to inform future Fishermen Led Injury Prevention Program (FLIPP) research activities	19 participants; mostly male Dungeness crab fishermen (90%);	Qualitative	Fear of liability and investigation leading to underreporting of nonfatal injuries; working with community members as research partners	Social & community factors; built environmen t	Fear of liability and investigation (underreporting of nonfatal injuries); culture of work (attitudes that minimized impact of work-related injuries, exhaustion/overexertion); acceptance of minor injuries as being part of the work	Fishing operations (Coast Guard safety regulations); technology (improved navigation and safety)
Bovbjerg, Vaughan et al., "Non-Fatal Injuries and Injury Treatment in the West Coast Dungeness Crab Fishery," *Journal of Agromedicine*	Characterized injuries in the US Dungeness crab fishery using the Fishermen Led Injury Prevention Program (FLIPP)	426 participants; mostly male (98%); fishermen from 23 ports in California, Oregon, and Washington	Mixed- methods	Majority of injuries were acute and non- life- threatening (sprains/ strains and localized wounds; injuries perceived as part of the job	Healthcare access; built environmen t	Injuries limited work; remote/harsh nature of the workplace; limited resources immediately available in commercial fishing setting	First aid training

Table 1 (continued)

Systematic Review Study Characteristics							
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Author(s), Title, Journal	**Theoretical framework/Purpose**	**Characteristics**	**Study Design**	**Themes**	**SPDOH factors**	**Barriers to health care**	**Facilitators to health care**
Brown & George, "Perceptions of opioid misuse and chronic pain: A qualitative assessment of Rhode Island commercial fishing captains," *Journal of Opioid Management*	Examined how the contextual circumstances and lifestyle of commercial fishermen influence their access to healthcare and potentially contribute to the use and misuse of opioids	15 participants; full-time employed or self-employed comercial fishing captains in Point Judith, Rhode Island	Qualitative	Recurrent patterns of addiction and opiate use among crewmembers; chronic pain and injury as common constructs of life in the fishing industry; insuTicient pain management resources; practical barriers to obtaining primary healthcare; perceived lack of support from state government	Social & community factors; healthcare access; built environmen t; economic stability	Opioid misuse among crewmembers; work- related chronic pain; inadequate healthcare access; financial disincentives (opportunity cost of missing work); expensive healthcare insurance; stigma around fishing industry and distrust around medical establishment; medical appointment scheduling issues and fragmented care	N/A
Boucquey N., "The "nature" of fisheries governance: narratives of environment, politics, and power and their implications for changing seascapes," *Journal of Political Ecology*	Political–ecological narrative analysis to examine the complex negotiations over meanings and their implications for material changes in the coastal seascape and in the lives of fishermen	74 participants (30 commercial fishers, 30 recreational fishers, and 14 managers); ***this study also used other materials: 427 Fisher- generated photos (from interviewees), 29 records from Fisheries Commission meetings, and 551 newspaper articles***	Qualitative	Narratives competing for influence; political and cultural constructions of nature; management of resources	Social & community factors; built environmen t	N/A	N/A

Table 1 (continued)

Systematic Review Study Characteristics							
Reference & purpose		**Methods**			**Results**		
Author(s), Title, Journal	**Theoretical framework/Purpose**	**Characteristics**	**Study Design**	**Themes**	**SPDOH factors**	**Barriers to health care**	**Facilitators to health care**
Weil, Pinto et al., "The Use of Personal Flotation Devices in the Northeast Lobster Fishing Industry: An Examination of the Decision- Making Process," *American Journal of Industrial Medicine*	Examined the influence of culture, personal values, and past experiences on safety decisions	72 participants; initial participants (25 total) were drawn from Fishing Partnership Support Services (FPSS) database and included 22 captains (20 M, 2F) and 3 crew members (2 M, 1F); additional participants (42 M, 6F) were recruited from lobster association meetings	Qualitative	Costliness of safety activities/equipme nt; the impact of fishing culture on safety decisions; coping with risks of commercial fishing	Social & community factors; built environmen t; economic stability	Costliness of comfortable/functional safety equipment; social stigma around use of safety equipment; superstition around use of safety equipment; "risk diTusion" (coping with risks led fishermen to underestimate the need for safety equipment)	Improved safety product design (greater comfort & function, decreased hazard); decreased safety product cost; improved risk messaging
Lucas & Case, "Work-related mortality in the US fishing industry during 2000–2014: New findings based on improved workforce exposure estimates," *American Journal of Industrial Medicine*	Calculated statistics for US fishing industry fatality rates from 2010–20014 and examined changes in patterns of fatalities and risks from 2000–2014	Decedents had average age of 44; 98% were male; 50% were deckhands; the majority (75%) died of drowning; most fatal incidents were vessel disasters (43%) or falls overboard (30%); region with the most deaths was the East Coast (32%)	Quantitativ e	Occupational fatalities; characteristics of fatalities associated with diTerent geographic regions; hazards associated with environment; hazards associated with gear/equipment	Built environmen t	Dangerous environment; dangerous equipment (vessel instability, gear entanglement, etc.); alcohol/drug use	N/A
Walker, Pavia et al., "Communicati on Practices for Oil Spills: Stakeholder Engagement During Preparedness and Response," *Human and Ecological Risk Assessment: An International Journal*	Reviewed current practices concerning oil spill preparedness and response and proposed several risk management practices for improvement	N/A	Review	Risk management; risk communication; disaster response; human health risks; stakeholder engagement; media coverage	Social & community factors; built environmen t	Oil spills; insuTicient communication of risks to health	Clear risk communication

Table 1 (continued)

Systematic Review Study Characteristics							
Reference & purpose		**Methods**			**Results**		
Author(s), Title, Journal	**Theoretical framework/Purpose**	**Characteristics**	**Study Design**	**Themes**	**SPDOH factors**	**Barriers to health care**	**Facilitators to health care**
Scott Crosson, "The ATordable Care Act and Opportunities for Change in North Carolina's Commercial Fisheries," *Marine Resource Economics*	Investigated the relationship between fishermens' finances/situations/demograp hic characteristics and purchase of private health insurance	All participants were commercial fishermen in North Carolina; 149 inshore fishermen, 170 ocean fishermen	Mixed- methods	Lack of health insurance; occupational injury; fishing capital (economic investment into fishing equipment); risk perception	Healthcare access; economic stability	Lack of health insurance; high cost of health insurance	Access to health insurance
Mary E. Davis, "Perceptions of occupational risk by US commercial fishermen," *Marine Policy*	Examined factors impacting fishermen's risk perception	Commercial fishing vessel captains surveyed from across the Maine coastline; almost all white and male; most "raised in a fishing family;" 1/3 pursued some education after high school	Mixed- methods	Risk perception; risky behaviors; occupational risk; safety decisions; safety practices	Educational attainment, social & community factors	Underestimation of risk; desensitization to occupational hazards associated with fishing	Improved safety training/awarene ss programs
Doza, Bovbjerg et al., "Health- Related Exposures and Conditions among US Fishermen," *Journal of Agromedicine*	Identified variable factors and healthcare outcomes of commercial fishermen compared to individuals employed in other fields	Utilized responses to national surveys and participants were categorized into 1. fishermen 2. agricultural workers 3. employed adults	Secondary data analysis	Psychosocial occupational exposures; lifestyle eTects; chronic health conditions; musculoskeletal conditions	Healthcare access; economic stability	Absence of health insurance; alcohol/ tobacco use; irregular work schedules; physical activity associated with fishermen lifestyle; marijuana and tobacco use	Health promotion programs; better healthcare access
Hawkes, Roy et al., "Health and Safety Issues Relating to Maine's Fishing Industry," *Journal of Agromedicine*	Utilized literature discussing fatalites and other topics of interest regarding the fishing industry, held health screenings, and hosted focus groups to obtain more information about the unmet needs of fishermen	Fishermen in Maine and their families	Mixed- methods	Types of fishing casualties; acute and chronic health conditions associated with fishermen lifestyle	Economic stability; built environmen t; healthcare access	Lack of health insurance; lack of income; lack of access; cultural barriers; unable to take time oT from fishing; lack of trust; physical activity associated with lifestyle; diTicult to enforce safety measures	Increasing surveillance, increasing providers' knowledge about the fishing industry; encouraging communication between agencies that provide health information to fishermen; dissemination of safety messages; First Aid kits; health screenings; encouraging self-responsibility

Table 1 (continued)

Systematic Review Study Characteristics							
Reference & purpose		**Methods**			**Results**		
Author(s), Title, Journal	**Theoretical framework/Purpose**	**Characteristics**	**Study Design**	**Themes**	**SPDOH factors**	**Barriers to health care**	**Facilitators to health care**
Levin, Gilmore et al., "Helping Gulf Shrimpers Adopt Safety Measures: Importance of Partnerships and Research to Practice," *Journal of Agromedicine*	A research to practice paper that implemented a model to expand the knowledge and skills of Vietnamese fishermen to ensure they had proper safety training in times of emergencies	535 Vietnamese participants (80% were Asian, and 73.1% were older than 40 years of age)	Quantitativ e	Language barriers and their impact on safety training; implementation of educational training models	Educational attainment; social & community factors;	Cultural barriers; language barriers; lack of proper navigation knowledge and skills in regards to signaling and radio communication in times of emergency	Acknowledgmen t of language/cultura l barriers and implementing methods to overcome those and increase safety training
Catalina M. Arata, J. Steven Picouz, G. David Johnson, T. Scott McNally, "Coping with Technological Disaster: An Application of the Conservation of Resources Model to the Exxon Valdez Oil Spill," *Journal of Traumatic Stress*	Determined the prevalence of symptoms of anxiety, depression, and PTSD in commercial fishermen aTected by the Exxon Valdez oil spill, examined factors that were associated with stress- responses to the disaster, and analyzed the role of coping methods	125 participants who filled out mailed surveys that were aTected by the oil spill; 86.4% were male, 91.2% were white, 13.6% were women, and 5.6% were Alaskan Natives. 88% owned their own fishing vessels	Mixed- methods	Mental health impact on commercial fishers; financial hardships on fishermen after disasters; resource (personal and materialistic) loss and impact on mental health	Social and community factors; economic stability	Fishing industry impacted leading to reduced income; having to work multiple jobs; isolating themselves and lacking social support	Mental health focus on fishermen and assistance
Judith Layzer, "Fish Stories: Science, Advocacy, and Policy Change in New England Fishery Management," *The Policy Studies Journal*	Analyzed diTerent fisheries in New England to demonstrate how stakeholders with diTerent interests and perspectives influence policy decisions and outcomes, and argued that successful fisheries management requires a collaborative and inclusive approach that takes into account the diverse perspectives and interests of all stakeholders involved	N/A	Review	Stakeholder involvement; risk management; collaboration;	Social & community factors; built environmen t	Extreme fishing regulations leading to decreased source of income	Less restrictive fishing regulations

Table 1 (continued)

Systematic Review Study Characteristics							
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Author(s), Title, Journal	**Theoretical framework/Purpose**	**Characteristics**	**Study Design**	**Themes**	**SPDOH factors**	**Barriers to health care**	**Facilitators to health care**
Pollnac &. Poggie, "Job Satisfaction in the Fishery in Two Southeast Alaskan Towns," *Human Organization*	Analyzed job satisfaction among commercial fisherman, fish plant workers, and charter boat operators and explored interrelationships between job satisfaction and occupation and individual characteristics	135 participants; commercial fishers, charter boat operators, and fish plant workers from Craig, Alaska and Petersburg, Alaska, which are both fishing ports in Southeast Alaska	Quantitativ e	Job satisfaction, mental health and longevity, social issues, and fishery management	Social and community factors; built environmen t	Poor job satisfaction in the fishing industry can lead to issues with mental health and longevity, as well as social issues such as family violence	Increased self- actualization and control, improved job safety and factors that positively influence job satisfaction
Remmen, Heiberg et al., "Work-related Musculoskelet al Disorders Among Occupational Fisherman: A Systematic Literature Review," *Occupational Environmental Medicine*	Determined the prevalence of musculoskeletal disease (MSD) among occupational fisherman and risk factors for work-related MSD	N/A	Review	Occupational risk and its relation to the health of fishermen	Social and community factors; healthcare access; built environmen t	Straining environmental factors in fishermen job routines result in poor sleep, susceptibility to injury, musculoskeletal disorders, and overall poor health	Improvements to risk-management, time oT, sleep schedules, and healthcare access for workers in the fishing industry
Rouse, Hayes et al., "Commercial Fisheries Losses Arising from Interactions with OTshore Pipelines and other Oil and Goas Infrastructure and Activities", ICES Journal of Marine Science	Determined spatio-temporal trends of fishery losses due to oil and gas infrastructure and provided a guide for pipeline management and interactions between oil and gas and fishing industries	N/A	Quantitativ e	Risk management; eTects of fishery- infrastructure interactions; oTshore industry management; types of fishery incidents due to interactions with oil and gas infrastructure	Built environmen t	Incidents between fisheries and pipeline infrastructure poses a safety threat for workers in the fishing industry	Increased pipeline integrity monitoring and enhanced data sharing practices between oil and gas and fishing industries to prevent incidents
Harold F. Upton, "The Deepwater Horizon Oil Spill and the Gulf of Mexico Fishing Industry," Impacts of the Gulf Oil Spill on Fishing and Wildlife	Summarized data on direct and indirect damages the fisheries and the Gulf ecosystem caused by the 2010 Deepwater Horizon oil spill and eTorts to resolve these damages	N/A	Review	Environmental eTects of oil and gas; oil and gas infrastructure interactions with fisheries; risk management;	Built environmen t	Oil spills aTect seafood safety, coastal ecosystems and water quality. Oil spills also aTect the fishing economy, which negatively impacts workers in the fishing industry	Improved safety standards and risk management in the oil and gas industry for oTshore pipelines

Table 1 (continued)

Systematic Review Study Characteristics							
Reference & purpose		**Methods**			**Results**		
Author(s), Title, Journal	**Theoretical framework/Purpose**	**Characteristics**	**Study Design**	**Themes**	**SPDOH factors**	**Barriers to health care**	**Facilitators to health care**
Sorensen, Echard et al., "The Impact of Covid-19 on Commercial FIsheries Workers," *Journal of Agromedicine*	Determined impacts of Covid- 19 on fishermen health, the fishing market, and occupational risk from various first-hand accounts by fishermen, fishing experts, health and safety advisors, and advocates	Fishermen, fishing industry experts, health and safety advisors, and advocates	Mixed- methods	Commercial fishermen's safety and health; occupational risk; economic and health consequences of Covid-19 pandemic	Economic stability; social & community factors; built environmen t	Work environments for fishermen are not conducive to social distancing and preventing the spread of Covid-19. Economic challenges due to Covid-19 lead to cut corners on safety guidelines	Improved resources for dealing with mental eTects of pandemic, guidance for how to quarantine and handle fishermen getting sick while at sea, policy for safety regulations

opportunities for fishermen, and communication between agencies that provide health information to fishermen [15, 17–20, 30]. Mental health was also identified, especially the mental health impact of the COVID-19 pandemic [12, 31].

Additionally, safety was a main theme in many of the suggestions to improve the fishing industry, which typically focused on increased trainings [17, 19, 21, 28, 32–34]. Within safety trainings, there were specific calls to focus on first aid training, disseminate safety messages, and improve safety training and awareness programs. In addition to safety trainings, researchers focused on improvements to risk management, such as sleep schedules [13, 30], fishing operations/policy and Coast Guard safety regulations [24, 31], and improved technology for navigation and safety, including safety product design (e.g., greater comfort and function of a personal flotation device; decreased safety product cost) [25, 35].

Discussion

A major finding from our systematic review was the inability for many fishermen to access health care services, whether for primary care or to treat occupational injuries, which was often rooted in being a low-wage, im/migrant, or transient worker [11, 12, 14–18, 21]. Through a SDOH lens, our examination of the high rates of fatal and non-fatal injury among commercial fishermen shows how injury is connected to social factors, including lack of health care access, social isolation, language and cultural issues, physical location, and food insecurity [11, 12, 14–19, 21, 22, 24, 25, 27, 28]. At the same time, political-economic factors such as decreased income, health care costs, lack of sick leave benefits, and work environment play a significant role in the high rates of fatal and non-fatal injury among commercial fishermen [13, 15, 17, 18, 22, 23, 26, 29–31]. To treat occupational injuries and improve intermediary determinants (e.g., access to health care) [36], practitioners may consider bringing clinical services to fishermen via mobile clinics [37], ensuring language services are available [38], or employing community health workers to assist them in applying for government programs or health care coverage [39].

A secondary finding related to occupational injury was a feedback loop where fishermen's unsafe environments led to a culture of accepting risk and downplaying injuries, which further created unsafe environments and exacerbated occupational injuries. Based on someone's social status, there are individual differences in exposures and vulnerabilities to illness and injury (i.e., intermediary determinants) [36]. Coping with financial pressures and the dangerous workplace of commercial fishing led to "risk diffusion" where fishermen underestimated the importance of safety decisions [25, 28, 31]. Moreover, illness or injury can create a "feedback loop" by compromising someone's economic position [24]. For example, employment opportunities could be compromised if someone was sick or injured, which could reduce their income and further stratify them within social hierarchies. This is particularly evident with fishermen who chose to ignore, delay, or self-medicate their illness and injury [16, 21, 24].

In our systematic review, safety trainings were a primary response to dangerous workplace environments, yet the results point towards safety being connected to larger systemic factors that are outside the scope of traditional safety training programs [17, 19, 21, 24, 25, 28, 30]. For example, traditional safety measures (like first aid and personal flotation devices) are inadequate on their own because they fail to address deeper systemic and SDOH issues like financial instability or lack of health care, which exacerbate injury risks. To prevent occupational injuries, we advocate that public health practitioners, academic researchers, and policymakers adopt a SDOH framework to address the self-reinforcing cycle of commercial fishing environments facilitating a culture of risk acceptance and injury downplay.

Implications for practice

Implementing prevention strategies to reduce fatal and non-fatal injury among commercial fishermen in the Gulf of Mexico is often described as a problem [6, 20]. Therefore, we conducted a systematic review to assess the state of research in this area and to identify prevention strategies. Uniquely, our study examined the impact of the SDOH, which we defined as the way political-economic systems directly or indirectly impacted fishermen's physical or mental health. SDOH factors above contributed to health care barriers for fishermen, which included 1) decreased income secondary to a range of issues (e.g., oil spills, net bans), 2) language and cultural issues, which arose from largely im/migrant shrimping fleets, and 3) physical location, namely fishermen living in rural areas or at sea for extended periods. These barriers increased health care costs and food inaccessibility for fishermen, as well as decreased their ability to properly communicate with health care providers or maintain equipment.

For future interventions to be equitable, we must have a research agenda that looks at occupational health holistically, including economic costs of safety equipment, vulnerabilities of low-wage work, prioritizing of safe work by employers, and regulatory environments. Our systematic review, which took a SDOH lens to examine the fishing

industry and the high rates of fatal and non-fatal injury among commercial fishermen, shows how injury is connected to social factors, such as a lack of health care access as well as political-economic factors, such as a lack of sick leave benefits. Therefore, more practical and actionable solutions with a SDOH framework to bridge the gap between fishermen and access to health care need to be implemented.

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Authors' contributions
S.GW wrote the main manuscript. L.KP.W and B.TF provided manuscript feedback and revisions. All authors participated in the systematic review process and reviewed the manuscript.

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Data availability
The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The project was deemed exempt from IRB review by the University of Texas Medical Branch.

Competing interests
The authors declare no competing interests.

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