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ORIGINAL ARTICLE

Occupational injuries and diseases in aquaculture in Southern Brazil

Lissandra Souto Cavalli[1]*, Andréa Ferretto da Rocha[1], João Alfredo de Oliveira Sampaio[2]

Abstract – This study investigates the occupational hazards and health risks associated with aquaculture in Rio Grande do Sul, Brazil. Data were collected utilizing a questionnaire distributed both in-person and online to registered participants. The study, conducted in 2023, involved 114 respondents who provided insights into work-related injuries and illnesses within the aquaculture industry. Findings indicate that most injuries occurred among male workers. A significant number of injuries were reported from small-scale farms, typically family-operated. The study identified various types of injuries, including falls, fish bites, cuts, and electric shocks. Additionally, participants reported infections, sun exposure-related conditions, and ergonomic issues. The study emphasizes the necessity for enhanced safety measures and improved health monitoring in the southern Brazilian aquaculture industry, aiming to enhance worker safety and reduce the incidence of work-related injuries and illnesses.

Keywords: Aquaculture. Occupational health and safety. Workers' health.

Lesões e doenças ocupacionais na aquicultura no Sul do Brasil

Resumo – Este estudo investiga os riscos ocupacionais e de saúde associados à aquicultura no Rio Grande do Sul, Brasil. Os dados foram coletados utilizando um questionário distribuído tanto presencialmente quanto online para participantes registrados. O estudo, realizado em 2023, envolveu 114 entrevistados que forneceram informações sobre lesões e doenças relacionadas ao trabalho na indústria de aquicultura. Os resultados indicam que a maioria das lesões ocorreu entre trabalhadores do sexo masculino. Um número significativo de ocorrências foi relatado em pequenas propriedades, tipicamente operadas por famílias. O estudo incluiu vários tipos de lesões, incluindo quedas, mordidas de peixe, cortes e choques elétricos. Além disso, os participantes relataram infecções, condições relacionadas à exposição solar e problemas ergonômicos. O estudo destaca a necessidade de melhorias nas medidas de segurança e monitoramento de saúde na indústria de aquicultura no sul do Brasil, com o objetivo de aumentar a segurança dos trabalhadores e reduzir a incidência de lesões e doenças relacionadas ao trabalho.

Palavras-chave: Aquicultura. Saúde e segurança ocupacional. Acidente de trabalho.

[1] Secretaria de Agricultura, Pecuária, Produção Sustentável e Irrigação do Rio Grande do Sul, Porto Alegre, RS, Brazil.
*Corresponding author, e-mail: liscavalli@gmail.com
[2] EMATER, Porto Alegre, RS, Brazil.

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Introduction

Aquaculture plays a crucial role in ensuring global food security and contributing to economic development, offering a sustainable source of protein for millions of people worldwide. However, despite its undeniable benefits, aquaculture is increasingly recognized as a high-risk occupation (Watterson *et al.*, 2020). Workers are frequently exposed to physical and safety hazards such as heavy machinery, slippery surfaces, and harsh weather conditions, which can lead to injuries ranging from minor cuts to severe musculoskeletal disorders (Ngajilo; Jeebhay, 2019). Additionally, the use of chemicals and exposure to waterborne pathogens pose significant health risks, including skin irritations, respiratory issues, and infectious diseases. The combination of these factors makes the identification and mitigation of occupational hazards in aquaculture a critical area of research.

The risks associated with aquaculture are complex and multifaceted, which underscores the importance of identifying, assessing, and mitigating these hazards. Brazil, the second-largest aquaculture producer in the Latin American and Caribbean (LAC) region, has experienced rapid growth in farmed fish production. The production increased from 172,000 tonnes in 2000 to 629,300 tonnes in 2011 (Marques *et al.*, 2020). The southern region of Brazil, particularly Rio Grande do Sul, plays a crucial role in the country's aquaculture sector, accounting for 32 % of national production, with approximately 30,000 fish farmers operating in the state (Rocha *et al.*, 2024). According to data from the Brazilian Aquaculture Association, the main aquaculture products in Rio Grande do Sul include tilapia, native species, carp, trout, and pangasius (Associação Brasileira da Piscicultura, 2023). Supporting this information, a recent survey (Rocha *et al.*, 2024) of 1,770 aquaculture producers in Rio Grande do Sul revealed that approximately 90 % of the production is dedicated to carp farming, which is the main species for 70 % of the producers. Tilapia, on the other hand, is the main species for 20 % of the surveyed fish farmers. The polyculture system was mentioned by about 70 % of the respondents (Rocha *et al.*, 2024).

Despite the updated data on aquaculture production in Rio Grande do Sul, a notable gap remains in understanding the working conditions and risks faced by aquaculture workers in the state. Brazilian data, presented in workplace accident statistics between 2013 and 2017, reported that the number of injuries and illnesses in Brazilian aquaculture totaled 873 cases (Cavalli; Marques; Watterson, 2019). Although research has been conducted globally to address safety and health in aquaculture, specific data from southern Brazil remains scarce (Cavalli *et al.*, 2019). Therefore, this study aims to identify the primary risks and hazards in aquaculture in this region.

Material and Methods

Data for this study were collected in collaboration with EMATER (Company for Technical Assistance and Rural Extension in Rio Grande do Sul). Participants were selected from EMATER's registry and directly contacted by the institution's technicians. All participants are residents of the State of Rio Grande do Sul, located in the extreme South of Brazil. The recruitment process, managed by EMATER, involved contacting producers in advance to explain the study objectives and obtain their consent. Data collection took place in 2023 through questionnaires administered either in person or online, depending on participants' availability and preference. Responses were gathered via a Google Forms questionnaire managed by EMATER. No personal data was collected, ensuring participant anonymity and confidentiality.

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The questionnaire comprised 14 questions designed to collect information on illnesses and work-related injuries in aquaculture, from a previous study of Brazilian workplace hazards (Lenz *et al.*, 2025). The survey covered respondent details (role and involvement in the incident), farm characteristics (location, size, and number of employees), and specific details about the injured person (gender, age, job category, activity during the incident, and farm type). It also gathered information on the accident or illness, including its description, potential cause, and affected body part. Some questions allowed multiple responses, such as activity at the time of injury and type of farm. Open-ended questions on injuries and causes enabled participants to provide unrestricted descriptions, ensuring a more comprehensive data collection.

Participation was voluntary, anonymous, and unpaid. Exclusion criteria included refusal to participate in the study and lack of information about injuries or illnesses in aquaculture, respecting the principle of autonomy. The study questionnaire underwent review and approval by the Research Ethics Committee (CEP/UFRGS), under protocol number 4.524.753, ensuring adherence to ethical and scientific standards in Brazil.

Results and Discussion

The questionnaire includes questions to qualify the respondent, the injured person, and the accident. Some informants reported more than one type of injury per accident, which affects the total number of reported injuries and potentially exceeds the number of responses.

The study interviewed 114 participants who reported being aware of work accidents in aquaculture. Participants who reported not knowing diseases or workplace accidents in aquaculture were excluded from the analysis, as well as two (2) respondents whose responses indicated that the accident occurred in a location outside the State of Rio Grande do Sul, Southern Brazil. Some respondents reported more than one type of injury per accident, which affects the total number of reported injuries and potentially exceeds the number of responses.

Among the 114 informants, 38.6 % were workers, and 28.1 % were researchers. The remaining informants included colleagues, friends, or family members of the injured farmers, and industry consultants. Fifty-five percent (55 %) of the participants reported personal experiences of injury. Regarding farm size, where the injury occurred, 93 % of the reports indicated farms with fewer than 5 employees, suggesting that the properties may be family-owned or operated by small-scale farmers.

Injured workers

Most injuries occurred among male workers (87.7 %), followed by female workers (11.4 %), and those who preferred not to answer (0.8 %). These data are consistent with a study from Finland, which found that the majority of injuries in fish farms from 1996 to 2015 involved men (Kaustell *et al.*, 2019). According to Kaustell *et al.* (2019), the injured individuals were predominantly male (87.2 %), aged 45 to 54 years (39.1 %), and worked in coastal areas (49 %).

Most injuries were reported among individuals aged 36 to 60 years, accounting for 64.6 % of all incidents. Specifically, 14.16 % of cases involved individuals aged 36 to 40, 11.50 % aged 41 to 45, 15.04 % aged 46 to 50, 11.50 % aged 51 to 55, and 12.39 % aged 56 to 60. The age groups with the lowest percentage of accidents are 16-20 years and 70 years or older, each accounting for 1.7 % of the incidents. Interestingly, official Brazilian statistics report that

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injury rates among workers aged 16–34 years in freshwater aquaculture are 4.5 times higher (Cavalli; Marques; Watterson, 2019). Similarly, a study conducted in Brazil reported that workplace injuries were more frequent among male workers (73.7 %), with the majority occurring in individuals aged 21 to 35 years (73.7 %), followed by those aged 36 to 55 years (26.3 %) (Lenz *et al.*, 2025).

Only one report included a shrimp production site, while the others (99.1 %) referred to fish farms. Injured persons included owner/farmers (78.9 %), workers at owner service (15.8 %), owner's family member (2.6 %), researcher (0.9 %), students (0.9 %), and farmers association member (0.9 %).

Total of illnesses and injuries reported

The interviewees reported a total of 116 incidents, consisting of accidents (90.4 %), illnesses (8.8 %), and one fatal event (0.9 %) (Table 1). The illnesses reported by the study participants included infections and injuries sustained while handling fish and during related activities, as well as heatstroke due to sun exposure. Additional conditions reported include rheumatic pain and tendonitis, along with cases of urinary infection, leptospirosis, herniated discs, fatigue, and spinal and lower limb injuries.

The reported accidents included falls, fish bites, wounds and cuts, being struck by fish, electric shocks, one case of liquid aspiration, a tractor accident, and entanglement in harvesting nets. Participants also expressed concern regarding the lack of use of personal protective equipment (PPE) during activities, which may contribute to an increased risk of occupational diseases. Table 2 summarizes the reports from industry participants regarding injuries encountered in aquaculture operations. The injuries are categorized into four main types: fish impact injuries, cut injuries, electric shock injuries, and injuries from external objects. Each category includes specific descriptions of the injury and the underlying causes. Fish impact injuries, for example, are caused by fish jumping during harvesting or handling, resulting in cuts, bruises, and sometimes more severe trauma, such as facial injuries or broken teeth. Cut injuries are associated with handling sharp objects or fish processing equipment, often resulting in cuts to the hands, feet, or other body parts. Electric shock injuries occurred due to improper maintenance or handling of electrical equipment, while injuries from external objects were mainly caused by collisions with tools, platforms, or other materials in the working environment.

In the following sections, we will provide a description of the injuries and illnesses reported by the participants, based on the information they provided during the survey. These data offer insights into the nature and specific circumstances of the reported incidents.

The distribution of injuries across different body parts showed that the most frequent injuries were reported on the legs, from the hip to the ankle (21.89 %), followed by injuries to the feet and toes (18.34 %), and hands and fingers (18.34 %). The head, excluding the eyes, accounted for 13.61 % of cases, while the back and spine were affected in 10.65 % of reports. Injuries to the eyes and arms, from the shoulder to wrist, had the same incidence (5.33 %), while internal organs were affected in 2.96 % of cases. The neck was the least affected region (1.18 %), and multiple body parts were simultaneously injured in 2.37 % of reports.

Injuries related to animal handling

Participants reported accidents involving workers struck by fish included events where, during handling or harvesting, the fish jumped and struck the worker, most

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often in the head region, including the eyes. Some of these injuries caused facial cuts that required stitches. One accident resulted in a worker being struck in the mouth by a fish that escaped from the net, causing cuts and breaking all the front teeth, requiring medical attention. According to the informant, the event involved a carp weighing approximately 8 kg, and the worker was unable to hold onto it after removing it from the harvesting net. There was also a report of a worker who was bitten on the hands by a trahira during harvesting.

Some species of farmed fish, such as trahira (*Hoplias malabaricus*; *Hoplias* spp.), South American silver catfish (*Rhamdia quelen*), and others, are capable of causing serious accidents due to stings or bites (Silva *et al.*, 2010). Reports involving injuries caused by fish handling have been described in the literature, with an incidence of 43%. In contrast, injuries caused by hazardous aquatic animals and sharp shells in the water have an incidence of 54% (Ngajilo; Jeebhay, 2019). These data support the findings of our study, as injuries caused by animal handling, including being struck by fish, injuries from handling, and bites, account for more than 50% of the reports. Similar reports are found in the literature, where a worker was struck by a pirarucu fish (*Arapaima gigas*) under similar conditions, with the note that the pirarucu is a large fish, resulting in more severe accidents, including the death of the worker (Lenz *et al.*, 2025).

Table 1. Injuries and illnesses reported by participants, according to its classification.

Type of Risk	Classification of Incidents	N	%*
Safety	Hit by object	1	0.86
	Hit by fish	26	22.41
	Electric shock	2	1.72
	Fatal electric shock	1	0.86
	Cut	19	1.38
	Injury	34	29.31
	Bite	4	3.45
	Fall	12	10.34
	Entanglement /Sucction (machinary)	2	1.72
	Entanglement (net)	1	0.86
	Tractor	1	0.86
Biological	Infection (i.e. lepstospirose, urinary infection)	5	4.31
Physical	Sun exposure	1	0.86
	Cold/water exposure	1	0.86
Ergonomic	RSI (repetitive strain injury)	4	3.45
	Fatigue	1	0.86
Chemical	Aspiration of boiler coolant liquid	1	0.86
Total		116	100.00

*Percentages were calculated and show slight differences due to rounding to two decimal places.

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Table 2. Type of injury, description and potential cause reported in the study.

Injury Type	Description	Potential Cause
Fish Impact Injuries	Head cut	Fish jumped and hit the worker's head.
	Rib injury	Fish jumped and hit the helper's ribs.
	Facial bruise and tooth fracture	Fish jumped and hit the worker's face.
	Eyebrow cut	Fish jumped and hit the helper's face, requiring 8 stitches.
	Shin bruise	Carp hit the worker's leg, causing swelling.
	Eye trauma	Fish hit directly in the worker's eye.
	Head-on collision between fish and worker	Occurred during the fish's attempt to escape.
	Rib bruise	Fish jumped and hit the worker's ribs, requiring medical exams.
	Tooth fracture	Fish hit the helper's mouth, breaking all front teeth.
	Severe facial injury	Carp jumped and caused an 18-stitch facial cut and eye injury.
Cut Injuries	Cuts on feet and hands	Handling fish and sharp materials.
	Hand cut with knife	During fish filleting.
	Foot cut	Stepped on a snail shell in the pond.
	Foot cut due to stone	Stepped on sharp stone during harvesting.
	Leg cut from wood	Worker was hit by a wooden splinter.
	Finger puncture from tilapia dorsal fin	During fish removal for slaughter.
	Hand cut with fillet skinning machine	Accident during operation.
	Cuts on feet and shins	Lack of proper PPE.
	Finger cut with knife	During filleting, requiring stitches.
	Superficial foot cut	Stepped on sharp object in mud.
Electrical Shock Injuries	Electric shock	Improper maintenance of electric heater in water.
	Electric discharge in 220V circuit	Careless handling of electrified cable.
	Fatality due to electric shock	Electrical safety failure.
External Object Injuries	Abrasions	Worker hit by water pipe shard.
	Dislocation and leg cuts	Wooden platform broke under the worker.
	Compression of lower limb	Poorly fixed water tank fell on the leg.
	Foot injury	Worker stepped on sharp object barefoot.
	Puncture with tilapia spines	Infection from puncture by fish spines.
	Injury from stump in water	Injury during harvesting.

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A safety measure that could be applied to aquaculture to reduce fish-related injuries involves educating the community about prevention and first aid for injuries. This was achieved through distributing educational pamphlets and holding discussions on the subject with fishing workers. The campaign led to a reduction in accidents and injuries, suggesting that this initiative could be beneficial if replicated in aquaculture farms (Haddad Junior, 2018).

Falls

The reported falls were due to slips in ponds and fish hatcheries. The injuries also included falls from a one-meter height on fish unloading platforms, falls from fish tank ramps, and falls from the sluice gate that regulates the water level of the tank. One injured person slipped on the stones of the dam and punctured their body with branches from a bush. Another fall resulted in a broken leg when slipping from the hatchery ramp during fish feeding. In this study, slips and falls resulted in knee and ankle sprains, muscle strains in the shoulder, dislocations, broken bones, shoulder injuries, and tendon ruptures. Consequently, one of the workers reported being away from work for 15 days.

Slips and falls can lead to sprains, strains, and fractures (Ngajilo; Jeebhay, 2019). Myers (2010) found substantial evidence linking falls from heights, sprains and strains, and falls into five-foot-deep raceways (Myers, 2010). Many of these events are linked to a lack of fall protection.

Electrical shock

Three electrical shocks were reported. One resulted in the individual's death, while another worker experienced an electric shock from a 220V power source while handling an electrified cable connected to a motor pump. The third incident occurred during the maintenance of an electric heater that was plugged in and submerged in water.

Electrical shocks are common in aquaculture (Myers, 2010; Ngajilo; Jeebhay, 2019). Fatalities are associated with electrical shocks due to electrical contact, electrocution from contact with overhead power lines, broken electrical conduits (Myers, 2010), electrocutions from handling pumps or aerators (Ngajilo; Jeebhay, 2019), and accidents involving oyster washing machines and high-pressure water washers (Guertler *et al.*, 2016). In aquaculture, powered machinery is frequently used near water or in wet environments (Moreau; Neis, 2009). Electric shocks in wet areas are more likely to be fatal (Workers Compensation Board of PEI, 2023). In Norway, electric shock is among the four most frequently reported injuries in the industry and is often associated with serious injuries (Holen *et al.*, 2018).

Tractor-related injuries and rollover risks

An injury reported in this study involving a tractor resulted in the equipment running over part of the worker's body, causing severe bodily injuries and internal organ damage. Tractors are used on aquaculture farms primarily for pond cultivation (Myers *et al.*, 2009). Ponds present rollover risks due to the slopes of the embankments and slippery conditions (Myers *et al.*, 2009). Tractor accidents can be fatal, involving vehicle rollovers (Myers, 2010). Therefore, protection is provided to the tractor operator when a rollover protection structure (ROPS) is fitted to the tractor (Myers *et al.*, 2009).

Water suction-related accidents

A participant reported attempting to unclog a 150 mm pipe when the water pressure pulled on their foot, causing a cut. According to the worker, the incident was

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caused by water pressure and the lack of suitable footwear. A similar accident was reported by Durborow *et al.* (2011), in which a farmer suffered a fatal incident after being immediately sucked into a drainage pipe in the US (Durborow *et al.*, 2011). This accident occurred because a gate valve was inadvertently left open while the farmer was attempting to unclog the drain of a large-diameter pond. The clogged drain opening was submerged and covered by a screen encrusted with barnacles. In an effort to allow water to flow through, the farmer cut the obstructed screen, leading to fatal consequences (Durborow *et al.*, 2011).

Diverse workplace injuries

Different injuries were reported by a small number of participants. This included inhalation of boiler coolant, entanglement in fishing nets, and injury from being trapped by a water tank. No further details were provided regarding the inhalation incident or the specific internal organs affected.

One worker reported becoming entangled in a harvesting net, resulting in an injury from the hip to the ankle. Accidents involving nets were also reported in a study with fishers (Garrone Neto; Cordeiro; Haddad Jr., 2005), where most participants (46.4 %) were injured while removing fish from the nets.

Another accident involving entrapment (compression of the lower limb by a water tank) occurred when a water tank, which was not properly secured to the truck bed, shifted during transport and compressed the worker's leg. This incident resulted in injuries to the workers' legs, particularly the foot and toes. According to the participant, the inadequate securing of the load was a key factor in the accident, highlighting the importance of safety measures to prevent unexpected movements of heavy objects.

Illness reported

Table 3 summarizes the types and causes of illnesses reported by participants in the aquaculture industry. The reported conditions range from infections caused by fish handling injuries and environmental exposure to musculoskeletal disorders resulting from physical strain and repetitive tasks. Additionally, thermal stress-related illnesses, such as sunstroke and joint pain from cold water exposure, were also documented. The following sections will provide a detailed description of the reported illnesses.

Infections

Infections related to cuts and punctures were observed during fish handling and the harvesting process. However, participants did not report the type of infection acquired or the associated microorganism. A review study found that infections among aquaculture workers are often linked to contact with fish contaminated by animal feces, zoonotic pathogens such as *Mycobacterium marinum*, and bacterial infections caused by fish spines and other aquatic organisms (Myers, 2010). These microorganisms can lead to wound infections and, in some cases, progress to sepsis (Ngajilo; Jeebhay, 2019). Infections resulting from animal handling, skin diseases, and other infections have also been reported among Brazilian aquaculture workers (Lenz *et al.*, 2025). Another study in Brazil found that 100 % of respondents reported exposure to fish blood and potentially harmful microorganisms (Viana, 2013). Participants reported cases of leptospirosis acquired due to the presence of rodents in ponds and tanks. Exposure to leptospirosis has also been associated with various aquaculture farms, such as those producing salmon, trout, catfish, and tilapia, which may potentially lead to fatalities among workers (Ngajilo; Jeebhay, 2019).

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In our study, a case of urinary infection was reported, associated with prolonged exposure to water with sludge. The prevalence of bacteria in aquaculture operations that can cause meningitis and urinary tract infections was reported in a case study (Xie *et al.*, 2024). However, literature on urinary infections among aquaculture workers remains limited, despite their frequent exposure to water and the bacteria present in ponds, which may increase the risk of infection.

Diseases associated with solar exposure

Participants reported cases of sunstroke due to prolonged solar exposure. Southern Brazil also experiences significant temperature variations. As a tropical country, temperatures remain high for most of the year, often exceeding 40°C. Consequently, rural workers face intense thermal discomfort and extreme solar radiation. Prolonged exposure to heat and sunlight can result in sunstroke, dehydration, heat exhaustion, fainting (Cavalli; Marques; Watterson, 2019) and an increased risk of skin cancer. Frequent exposure to ultraviolet radiation from the sun can also cause headaches, first- and second-degree burns, cataracts, heatstroke, and dermatitis. Similarly, catfish and crayfish farmers in the southern U.S. endure extreme heat and humidity, heightening their risk of heat exhaustion and sunstroke (Fry *et al.*, 2019). According to Viana (2013), workers exposed to solar radiation, humidity, and high temperatures must consistently use appropriate personal protective equipment (PPE) (Viana, 2013).

Effective control and prevention measures for heat and sun exposure involve both administrative practices and the use of personal protective equipment (PPE). One approach is to eliminate or mitigate environmental risks by conducting work in shaded or covered areas that are protected from direct sunlight. This can significantly reduce the impact of solar radiation on workers, although it is not always possible in aquaculture activities. In addition to environmental adjustments, administrative strategies include rotating work shifts to minimize prolonged exposure to the sun (Guertler *et al.*, 2016, 2021). Regular rest periods in shaded or cooler areas are essential to ensure workers have time to recover from thermal discomfort. The consistent use of personal protective equipment, such as sunscreen, hats, and sunglasses, is highly recommended to protect against harmful UV radiation and reduce the risk of heat-related illnesses (Cavalli; Marques; Watterson, 2019).

Diseases associated with water exposure

Rheumatic pain in the finger joints of the upper limbs was reported by participants as being caused by excessive exposure to cold water without adequate protection. A study compiled results from research in Turkey (Soykan, 2023), showing that joint diseases (such as rheumatism) were among the most prevalent occupational diseases among fishery engineers, and joint pain was also common among workers in marine fish hatcheries.

Ergonomic injuries

Participants reported ergonomic injuries related to handling and harvesting activities, including tendinitis, repetitive strain injuries (RSI), and spinal injuries. A herniated disc was reported and associated with physical strain from activities such as fish loading during harvesting, feed transportation, and equipment use. Fatigue was reported and associated with back pain.

Ergonomic data are consistent with the literature, which associates physical strain from fish loading, feed transportation, and technical activities with equipment with low back, neck, and shoulder pain, as well as

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tendinitis, tenosynovitis, bursitis, and carpal tunnel syndrome (Ngajilo; Jeebhay, 2019). The transportation of heavy loads for fish feeding, improper posture, and prolonged working hours were identified as major ergonomic risks observed on a fish farm in northern Brazil (Frazao *et al.*, 2019). Similarly, Guertler *et al.* (2016) found that many workers experience muscle pain in the shoulders, lower back, hands, wrists, and fingers (Guertler *et al.*, 2016). The analysis of activities involved prolonged physical effort, improper postures, excessive dynamics, and repetitive movements.

Table 3. Description of illnesses reported by participants.

Illness Type	Description	Potential Cause
Infectious diseases	Fish fin puncture infections	Infection caused by fish fins during handling.
	Foot puncture infection	Foot puncture inside the tank during fish harvesting.
	Urinary tract infection	Prolonged contact with water and sludge.
	Leptospirosis	Presence of rodents in the pond during fish handling.
Musculoskeletal Disorders (MSDs)	Disc hernia	Physical strain from carrying fish, transporting feed, and technical tasks with equipment.
	Fatigue	Excessive physical effort.
	Repetitive strain injury (RSI)	Years of repetitive work processing fish, leading to nerve compression in hand.
	Tendonitis	Effort from removing dead fish from ponds and feeding them.
	Spinal and foot injury	Repetitive movement in equipment handling and lack of PPE in ponds.
Environmental Exposure Disorders	Rheumatic joint pain	Excessive exposure to cold water without proper equipment.
	Sunstroke	Sun exposure during fish handling tasks.

Injuries reported and Brazilian worker legislation

The results of this study indicate the occurrence of occupational accidents at various stages of aquaculture production, many of which could have been prevented through the adoption of measures recommended by Brazilian occupational health and safety legislation. The analysis of the reported accidents reveals that most incidents occurred during routine operational activities such as animal feeding and handling, management of farming structures, cargo

transport, and tank cleaning. Reports included the absence or improper use of Personal Protective Equipment (PPE), as well as deficiencies in the signage of hazardous areas and in the technical training of workers. These gaps underscore the need for enhanced compliance with Brazilian legislation, particularly with regard to established regulatory standards (Oliveira *et al.*, 2017).

In Brazil, the Regulatory Standards (Normas Regulamentadoras – NRs) fall under the responsibility of the Ministry of Labor and Employment (Ministério do Trabalho e Emprego – MTE). These are legal instruments that guide and regulate the application of labor legislation concerning workplace safety and health. NR-31 establishes specific guidelines for agricultural activities, including aquaculture, with a focus on accident prevention and promoting workers' health (Brasil, 2020c). This regulation emphasizes that safety should be ensured not only through the provision of equipment but also through the proper organization of the work environment and the preparation of workers to deal with the risks inherent to the activity.

Furthermore, the nature of the accidents described—such as falls, repetitive strain injuries, and musculoskeletal disorders—highlights the relevance of NR-17, which addresses ergonomic risks (Brasil, 2020b). Situations involving lifting weights above recommended limits, lack of regular breaks, and inadequate working postures can be mitigated with the proper application of this standard.

The content of NR-1, by establishing the Occupational Risk Management (Brasil, 2020a), reinforces the importance of a preventive and integrated approach to workplace safety, involving the mapping, evaluation, and systematic control of risks present in productive activities. This model guides not only the actions of employers but also the development of an organizational culture focused on collective protection, the safe planning of tasks, and the promotion of workers' health at all stages of the aquaculture production process.

Therefore, the application of Brazilian regulations should be understood not only as a legal requirement but also as a strategic tool to improve working conditions, protect workers' health, and strengthen the social sustainability of the aquaculture production chain.

Final thoughts

This exploratory study provides preliminary insights into the occupational hazards reported by stakeholders in Southern Brazilian aquaculture. To the best of our knowledge, this is the first study to investigate injuries and diseases related to aquaculture in Rio Grande do Sul, southern Brazil. This study fills a critical gap in the literature by providing a comprehensive analysis of occupational health issues within this industry. The findings are particularly relevant for authorities, industry stakeholders, farmers, and health professionals in Rio Grande do Sul. Additionally, this research establishes a baseline for future studies, enabling comparisons over time.

This study highlights the significant risks and challenges associated with work in aquaculture in South Brazil, particularly in small-scale, family-operated farms. The findings reveal a high incidence of work-related injuries and illnesses among male workers. Most incidents involved injuries, such as cuts, falls, and electric shocks, with a notable occurrence of accidents related to fish handling.

The lack of use of personal protective equipment (PPE) and inadequate safety measures were commonly reported contributing factors. The study also underscores the importance of addressing ergonomic risks and providing proper training and education on

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safety practices to reduce the incidence of injuries. Implementing preventive measures, such as the use of PPE, educating workers on first aid, and improving workplace conditions, could significantly enhance safety and reduce the risk of accidents in aquaculture.

Although frequently mentioned by the injured workers, the use of PPE is not the most effective control measure for preventing workplace accidents. This is because PPE, while important, is the last line of defense in risk control. More effective control measures involve the elimination or substitution of hazards, the implementation of engineering controls that isolate people from dangers, and the adoption of administrative controls that modify how work is performed (Myers; Durborow; 2011; Watterson *et al.*, 2020). For example, improving the design of equipment and facilities, as well as conducting regular and targeted training for workers, are strategies that can significantly reduce risks.

In this study, we observed frequent occurrences of injuries related to fish handling, along with a lack of use of PPE and safety measures. Similar to other Brazilian studies (Marques *et al.*, 2019), the results further indicate that risk management in aquaculture remains a significant challenge in low-income countries. These preliminary findings are consistent with previous research in aquaculture farms worldwide, highlighting the need for targeted interventions to enhance occupational health and safety in the aquaculture industry. Aquaculture farmers should be encouraged and supported in adopting measures and appropriate technologies to mitigate risks in Brazilian aquaculture, thereby protecting workers' health and safety.

The results also highlight the importance of reflecting on how Brazilian Regulatory Standards are being applied and adapted to the context of aquaculture (Oliveira et al., 2017). Although Brazil has a solid regulatory framework for occupational safety, its effectiveness in rural settings and small-scale aquaculture can still be improved and supported. The gaps identified in this study—particularly regarding access to training, prevention strategies, and ergonomic care—suggest there are opportunities to better align regulations with the realities faced by workers and farmers. Strengthening dialogue between public policies, regulatory bodies (such as the ILO and FAO), scientific research, the productive sector, labor unions, and workers may significantly contribute to promoting health and safety in aquaculture (Cavalli, 2024).

Our exploratory research highlights the occupational health and safety challenges faced by workers in the Southern Brazilian aquaculture sector. Lenz *et al.* (2025) aimed to address similar issues by sharing stakeholders' experiences, emphasizing the importance of evidence-based policies to protect workers' well-being. Moving forward, promoting collaboration among industry stakeholders, policymakers, and researchers is essential to strengthening occupational health and safety practices in aquaculture.

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Conflict of Interests

The authors declare that the research was conducted in the absence of any potential conflicts of interest.

Ethical Statements

The authors confirm that the ethical guidelines

adopted by the journal were followed by this work, and all authors agree with the submission, content and transfer of the publication rights of the article to the journal. They also declare that the work has not been previously published nor is it being considered for publication in another journal.

The authors assume full responsibility for the originality of the article and may incur on them any charges arising from claims, by third parties, in relation to the authorship of the article.

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ORCID

Lissandra Souto Cavalli
https://orcid.org/0000-0001-8531-7362
Andréa Ferretto da Rocha
https://orcid.org/0000-0002-0445-1277
João Alfredo de Oliveira Sampaio
https://orcid.org/0009-0008-1990-8576

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