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OCCUPATIONAL DISEASES IN FISH PROCESSING INDUSTRY WORKERS: AN INTEGRATIVE REVIEW

DOENÇAS OCUPACIONAIS EM TRABALHADORES DA INDÚSTRIA DE PROCESSAMENTO DE PESCADOS: UMA REVISÃO INTEGRATIVA

ENFERMEDADES PROFESIONALES EN TRABAJADORES DE LA INDUSTRIA PROCESADORA DE PESCADO: UNA REVISIÓN INTEGRADORA

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ABSTRACT
The evolution of the fish processing industry, with technological innovations and organizational changes, contrasts with the scarce information on the health problems that can affect workers. In this sense, this study analyzes the main occupational diseases in the fish processing industry production sector. To this end, we conducted an integrative review, collecting information from the databases Lilacs, Medline/PubMed, SciELO, CINAHL, Embase, ScienceDirect, Scopus, and Web of Science. The guiding question was, "What are the main diseases affecting workers in the production sector of the fish processing industry?" We selected 41 articles that met the selection criteria, and the results and discussion were presented descriptively for their analysis, with diseases grouped into major groups. We observed that the studies ranged from reports of symptoms and health complaints to the diagnosis of occupational diseases. Furthermore, we identified that workers are affected by several health problems, such as respiratory and ocular diseases, musculoskeletal disorders, dermatoses, injuries, and less documented diseases such as hearing loss, hypothermia, hernia, and Raynaud's syndrome. Evidently, respiratory symptoms and musculoskeletal complaints were the most frequently reported in the findings. We concluded that workers are exposed to different risk agents in the industry and that there are still few studies on the environmental and organizational conditions and the illness of workers in this production sector. We underscore the importance of expanding research and implementing prevention policies to protect workers' health.

Keywords: Fishing Industry. Fish Processing. Professional Diseases. Occupational Diseases. Occupational Hazards.

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RESUMO
A evolução da indústria de pescados, com inovações tecnológicas e mudanças organizacionais, contrasta com a escassez de informações sobre os agravos de saúde que podem acometer os trabalhadores. Nesse sentido, objetiva-se analisar as principais doenças ocupacionais no setor de produção da indústria de processamento de pescados. Para tanto, efetuou-se uma revisão integrativa, com coleta de informações nas bases de dados Lilacs, Medline/PubMed, SciELO, CINAHL, Embase, ScienceDirect, Scopus e Web of Science. Tendo como questão norteadora: quais são as principais doenças que acometem os trabalhadores do setor de produção da indústria de beneficiamento de pescados? Foram selecionados 41 artigos que atendiam aos critérios de seleção e, para sua análise, os resultados e a discussão foram apresentados de forma descritiva, com as patologias agrupadas em grandes grupos. Observou-se que os estudos abrangiam desde o relato de sintomas e queixas de saúde até o diagnóstico de doenças ocupacionais. Os trabalhadores são acometidos por diversos problemas de saúde, como doenças respiratórias, oculares, distúrbios musculoesqueléticos, dermatoses, lesões e por doenças menos documentadas, como a perda auditiva, hipotermia, hérnia e síndrome de Raynaud. Além disso, os relatos de sintomas respiratórios e queixas musculoesqueléticas foram os mais frequentemente relatados nos achados. Conclui-se que os trabalhadores estão expostos a diferentes agentes de risco na indústria e que ainda há poucos estudos sobre as condições ambientais, organizacionais e o adoecimento dos trabalhadores envolvidos neste setor de produção. Ressalta-se a importância de ampliar as pesquisas, bem como a implementação de políticas de prevenção para proteger a saúde dos trabalhadores.

Palavras-chave: Indústria Pesqueira. Processamento de Pescados. Doenças Profissionais. Doenças Ocupacionais. Riscos Ocupacionais.

RESUMEN
La evolución de la industria pesquera, con innovaciones tecnológicas y cambios organizacionales, contrasta con la información sobre los problemas de salud que pueden afectar a los trabajadores. Este estudio tuvo como objetivo analizar las principales enfermedades profesionales en el sector productivo de la industria pesquera. Para ello, se realizó una revisión integrativa, recopilando información de Lilacs, Medline/PubMed, SciELO, CINAHL, Embase, ScienceDirect, Scopus y Web of Science. La pregunta guía fue: ¿cuáles son las principales enfermedades que afectan a los trabajadores del sector productivo de la industria pesquera? Se seleccionaron 41 artículos que cumplieron con los criterios de selección, y para su análisis, los resultados y la discusión se presentaron de forma descriptiva, con las enfermedades agrupadas en grandes conjuntos. Los estudios abarcaban desde informes de síntomas y quejas de salud hasta el diagnóstico de enfermedades profesionales. Se identificó que los trabajadores se ven afectados por diversos problemas de salud, como enfermedades respiratorias y oculares, trastornos musculoesqueléticos, dermatosis, lesiones y enfermedades menos documentadas, como pérdida auditiva, hipotermia, hernia y síndrome de Raynaud. Se evidenció que los informes de síntomas respiratorios y molestias musculoesqueléticas fueron los más frecuentes en los hallazgos. Se concluye que los trabajadores están expuestos a diferentes agentes de riesgo en la industria y que aún existen pocos estudios sobre las condiciones ambientales y organizacionales, así como sobre las enfermedades de los trabajadores involucrados en este sector productivo. Se destaca la importancia de ampliar la investigación, así como las políticas de prevención para proteger la salud de los trabajadores.

Palabras clave: Industria Pesquera. Procesamiento de Pescado. Enfermedades Profesionales. Enfermedades Laborales. Riesgos Laborales.

1 INTRODUCTION

Fish is a food with high nutritional value, rich in protein, vitamins, minerals, essential fatty acids and low in fat. Due to these characteristics, they bring health benefits, such as lowering total cholesterol and the risk of coronary heart disease.

The Food and Agriculture Organization (FAO) reports that from 1961 to 2019, per capita consumption of aquatic food (excluding algae) increased at an average annual rate of 3% (FAO, 2020). This increase was due not only to the growth of the world population, but also to the awareness of healthier eating habits (FAO, 2022).

Approximately 89% of the fish traded worldwide is intended for human consumption and is marketed mainly fresh, frozen, preserved or cured. Fish is also used in other sectors, transformed into fish meal and oil. The importance of processing fish by-products has been growing due to the diversity of products generated, particularly pharmaceutical products and animal feed, such as cattle, sheep and domestic animals (FAO, 2022).

In 2018, 179 million tons of fish were produced worldwide, with an estimated value of US$ 401 billion. China stands out and leads the ranking, accounting for 35% of total production, surpassing the production of Asia (34%), the Americas (14%), Europe (10%), Africa (7%) and Oceania (1%) (FAO, 2022).

The Brazilian industry is still incipient compared to European or even Latin American countries, such as Chile and Peru, producing about 700 thousand tons/year (FAO, 2018). However, it also shows a growing trend, despite the fact that fishing and aquaculture statistics in Brazil are weak due to a deficient data collection system, with fragmented and outdated information on marine fisheries production and underestimation of catches in inland waters (rivers, lakes, dams and aquifers).

Since 2016, the IBGE has been providing official statistical data on aquaculture. At the same time, the Brazilian Fish Farming Association (ABP) also presents estimates, although the numbers differ slightly from the official data. An assessment by Seafood Brasil (2019), which combines data from these sources, indicated in 2018 a production of over 1.6 million tons of fish. In 2023, the production of farmed fish alone reached 860,355 tons. Since ABP made its statistics official in 2014, farmed fish production has increased by 48.6% (ABP, 2023).

The industrial fish processing sector has evolved a lot, impacting the entire production chain, from capture to transformation inside the factories. This sector has a great diversity in technological levels, ranging from small workplaces with manual fish handling to modern highly automated companies. In these places, the activities developed are diverse, depending on the type of fish and the final product to be prepared; and include evisceration, skinning, filleting, cutting, salting, drying, smoking, cooking, frying, freezing, canning of raw materials, grinding of fishmeal and bagging (Ogawa, Maia, 1999). It should be noted that the term fish refers to any aquatic animal caught, such as fish, crustaceans and mollusks, since the sector uses different types of raw materials (FAO, 2014).

Since the Industrial Revolution, the sector has experienced the emergence of technological innovations, changes in the mode of production and organization of work, which have added value to the product, improved the quality and profitability of companies (Bombardelli, Syperreck, Sanches, 2005; Amaral et al., 2017). However, it also resulted in new management modalities, outsourcing, rationalization of production; intensification, deterioration, flexibilization of work and industrial relocations. In addition, this evolution allowed industrial fishing, carried out far from the coast and with large catches of fish, which in addition to generating environmental impacts, such as degradation of fish stocks and pollution (Diegues, 1983; Lara, 2011; Pitcher, Lam, 2015; Silva, Bernardo, 2018).

In the context of workers' health, there was an intensification of the exploitation of the workforce, associated with exhaustion, to the detriment of working conditions (Lara, 2011; Previtali, Fagiani, 2014; Nag, Vyas, Nag, 2016). These situations arise from different exposures in the work environment, such as long working hours, intense pace, noise and intense cold and lifting loads (ILO, 1999).

Over the years, the techniques and procedures used have been modified, with full use of the products, which has altered or accentuated the existing risk agents. Exposed workers may have occupational diseases or be affected by accidents, which leads to work disability, absenteeism and leaves (Pino, 2000; Elias, Navarro, 2006; Araújo, Morais, 2017; Benfatti, Dantas, 2017; WHO, 2017). It is observed that this sector presents an increase in the notification of health problems (Jeebhay, Robins, Lopata, 2004).

Howse, Jeebhay and Neis (2012) highlight the scarcity of research on occupational health and safety in the fish processing industries, pointing out the need for studies on the consequences of the expansion and changes in global seafood markets, associated with the degradation of resources and ecological changes that interact with the precariousness of employment and impact the health and quality of life of workers. Thus, this work aims to analyze the main occupational diseases and discuss the main risks of illness at work in the production sector in fish processing industries.

2 METHODOLOGY

As it is an exploratory study, it provides an overview of the investigated theme. With regard to the procedures, this is an integrative literature review, with a qualitative approach, since it enables the synthesis and analysis of the scientific knowledge produced, in a systematic and orderly manner, in addition to pointing out gaps in knowledge to be filled for further studies.

The stages of the integrative review developed by Cooper (1989) were followed: formulation of the guiding question of the research, collection, evaluation, analysis and interpretation of data and presentation of the results. Thus, the following question was asked: what are the main diseases that affect workers in the production sector of the fish processing industry?

The databases that *contain the largest* number of indexed journals in the health area were used: Latin American and Caribbean Literature on Health Sciences (Lilacs), International Literature on Health Sciences (Medline/PubMed*), Scientific Electronic Library Online* (SciELO), *Cumulative Index to Nursing and Allied Health Literature (*CINAHL*), Embase, ScienceDirect*, *Scopus* and *Web of Science.*

The Health Sciences Descriptors (DeCS) of the Virtual Health Library/BIREME and the Medical *Subject Headings* (MESH) descriptors of the *U. S. National Library of Medicine* were used. In addition to the Boolean operators to combine the search terms, resulting in the following search expressions: (food industry OR food industry) AND (fishes OR fish OR seafood OR marine food) AND (occupational diseases OR occupational diseases) and ("food industry") AND (fishes OR fish OR seafood OR "marine food") AND ("occupational diseases" OR "occupational diseases").

The inclusion criteria were: articles published in Portuguese, English, and Spanish, from 1995 to 2020; whose abstracts were available in the databases; publications on occupational diseases, injuries and accidents among workers in the fish industries, including those working in factories or processing plants located on dry land; and articles available in full.

The exclusion criteria were: abstracts, editorials, preliminary notes and letters to the editor; duplicate articles; of a general nature; those not related to the theme of the study or that did not answer the research question.

The search was carried out in December 2022. Each article found was imported into the *EndNote software,* through which the repetitions between the databases were excluded.

After this, they were transferred to the Excel-Windows 10 Program, with the objective of confirming the correlation to the studied theme. The titles and abstracts were read; and then , the full reading and selection of the articles, based on the established criteria, to obtain the synthesis sample.

An information collection instrument was developed in order to facilitate the analysis and characterization of the sample, with the following information: identification of the article and authors; country of study; type of study; Goals; design and synthesis of the results. The presentation of the results and their discussion was done in a descriptive way.

3 RESULTS AND DISCUSSION

Initially, 648 studies were found in the databases: 223 in Embase, 181 in Medline, 153 in Scopus, 66 in Science Direct, 22 in WoS, 3 in CINAHL, 0 in SciELO and 0 in Lilacs. 117 that were duplicates were excluded. After reading the titles and abstracts and after applying the eligibility criteria and reading the articles in full, another 490 articles were excluded. Thus, the sample consisted of 41 articles. The selection process is shown in Figure 1.

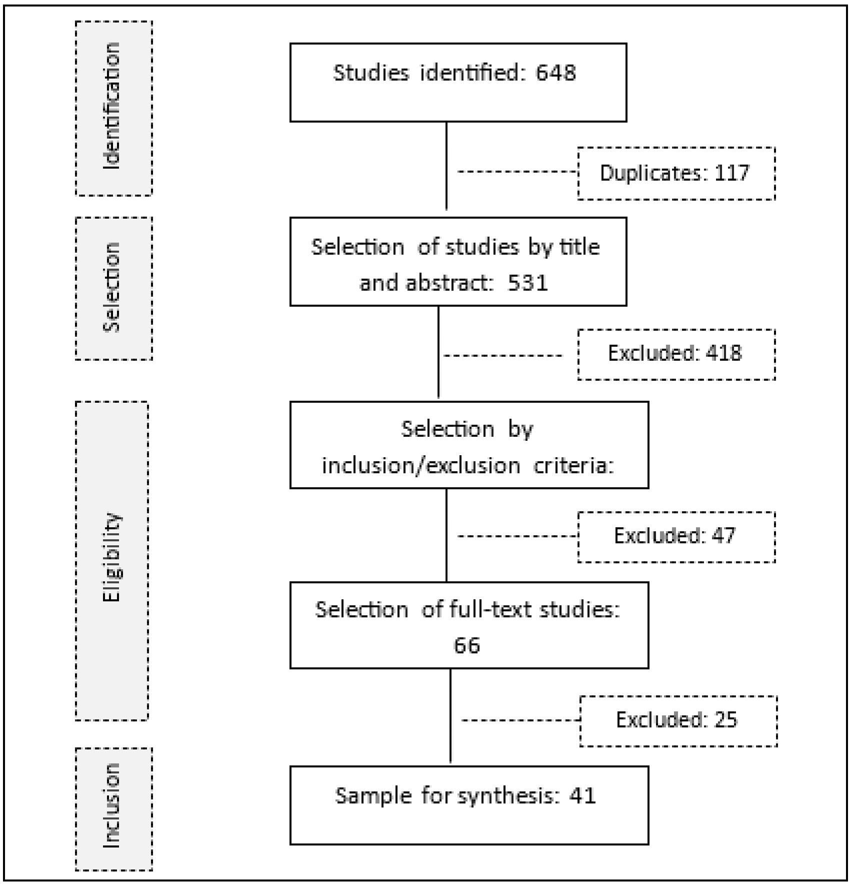
It was observed that 142 authors were responsible for the studies identified for the synthesis. Of these, 108 published only 1 article. Most of the studies presented notes on health problems (diseases, symptoms and health complaints) and their respective risk agents, reflecting a broader understanding of the subject; since the investigation of risk agents helps to prevent health problems that may result from work activity (Machado, 1997). 95% of the productions consisted of co-authored studies, while only 2 (5%) had single authorship.

Figure 2 shows the distribution of studies over the study period.

It is noted that there is a lack of studies on the health of workers in the fish processing industry. However, the years 2010 and 2012 showed an increase in scientific production, as pointed out by Jeebhay and Cartier (2010), due to the increase in reports of health problems. These authors emphasized an increase in cases of work-related respiratory allergies and asthma, due to the increase in global consumption of fish and seafood.

Figure 1

Article selection process



Source: Prepared by the authors.

Figure 2

Distribution of production by year of publication

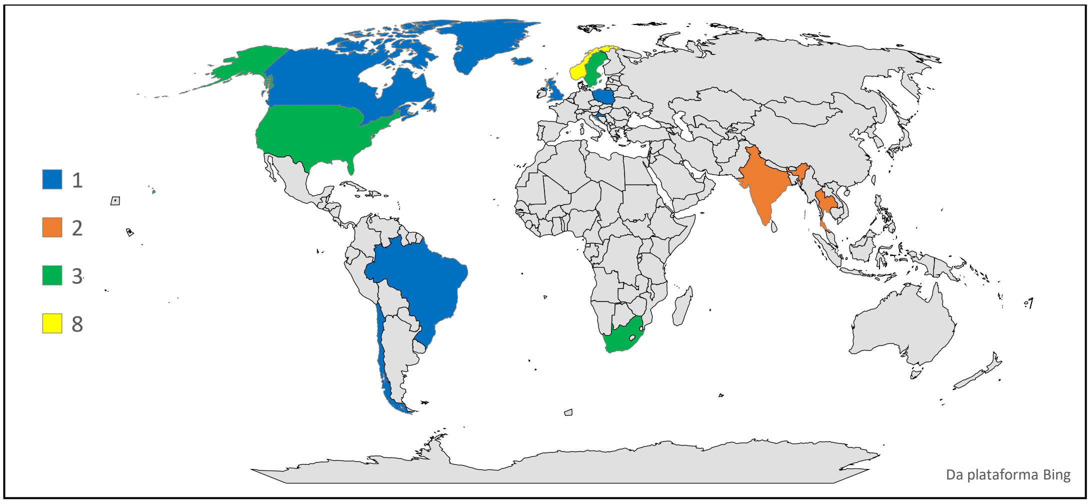
Source: Prepared by the authors.

The identified articles were published in 20 different journals, with a predominance of publications in the English language (97.5%). Three of these journals totaled 18 articles: *American Journal of Industrial Medicine* (8 articles), *Occupational Medicine* (6 articles), and *Occupational and Environmental Medicine* (4 articles). The remainder was made available in 17 journals related to Health Sciences, in various areas of knowledge, demonstrating the interdisciplinarity of research.

Figure 3 shows the distribution of studies according to the country of study.

Figure 3

Number of publications by country



Source: Prepared by the authors.

In only 29 studies it was possible to identify the study site. Norway recorded the highest number, reflecting the country's overpower in relation to the diversification and export of commercial products from fisheries, demonstrating the dynamics of international fish trade, attributed to developed countries, which carry out commercial transactions mainly among themselves (Farias, Farias, 2018). This country, in the FAO report, ranked 10th in fish production by catch in 2020 and was the world's largest producer of captive salmon in the Atlantic (FAO, 2022). In addition, Norway has had a labor legislation since 1977, on occupational safety and the work environment, which requires companies to set goals; such as the identification, assessment and control of risks, in addition to monitoring and reviewing the management system (Norway, 2005).

Regarding the study design, 24 were cross-sectional (59%), 8 were literature reviews (20%), 3 were ecological studies (7%), 3 were reports or case series (7%), 1 cohort study

(2%), and 1 case-control study (2%). A research (2%) with a mixed design was also identified, with the initial adoption of a cross-sectional design and then the application of a nested case-control study.

As most of the published studies were cross-sectional, where exposures and outcomes were analyzed simultaneously to estimate the prevalence of diseases (Rothman, Greenland, Lash, 2011), there may have been a selection bias, which underestimates the occurrence of health problems. This is the phenomenon described as the "healthy worker effect". When quantifying the prevalent cases of diseases in a work environment, the effects of exposure can be underestimated, since symptomatic workers are usually relocated from their activities or away from work, and since the prevalent cases are used to study the exposure-disease association, these cases may be atypical, that is, there is an analysis of relatively healthier workers (Jeebhay *et al.*, 2001; Chowdhury, Shah, Payal, 2017). This is a bias identified in the studies by Jeebhay, Lopata and Robins (2000), Ortega *et al.* (2001), Jeebhay *et al.* (2001), Shiryaeva *et al.* (2010), Tomita *et al.* (2010), Bønløkke *et al.* (2012) and Thomassen *et al.* (2017), which may have led to the underreporting of health problems.

The investigation of health problems led to the identification of 26 articles (63%) on occupational diseases and injuries and 20 articles on symptoms and health complaints (49%).

With regard to possible occupational diseases, the articles investigated a variety of health issues described in Table 1.

Table 1

Occupational diseases and injuries identified

Occupational diseases and injuries		*References*
Respiratory problems	*Asthma*	*Douglas et al., 1995; Jeebhay et al., 2001, 2008; Jeebhay, Robins, Lopata, 2004; Barraclough et al., 2006; Steiner et al., 2008; Cartier, 2010; Gautrin et al., 2010; Jeebhay, Cartier, 2010; Quirce, Bernstein, 2011; Wiszniewska et al., 2013; Lukács, Schliemann, Elsner, 2016*
	Respiratory infection	*Jeebhay, Robins, Lopata, 2004*
	Hypersensitivity pneumonitis	*Jeebhay, Robins, Lopata, 2004*
	Organic toxic dust syndrome	*Jeebhay, Robins, Lopata, 2004*

	Rhinitis	*Jeebhay et al., 2001; Gautrin et al., 2010; Jeebhay, Cartier, 2010; Bønløkke et al., 2012; Wiszniewska et al., 2013; Lukács, Schliemann, Elsner, 2016*
	Rhinoconjunctivitis	*Jeebhay et al., 2001, 2008; Jeebhay, Robins, Lopata, 2004; Jeebhay, Cartier, 2010*
Problems Muscle-Skeletal	*Musculoskeletal disorders (general)*	*Pålsson et al., 1998; Ilardi, 2012; Nag et al., 2012; Soe et al., 2015; Syron et al., 2017, 2019*
	Epicondylitis	*Nordander et al., 1999; Jeebhay, Robins, Lopata, 2004; Syron et al., 2019*
	Back pain, low back pain and back pain	*Jeebhay, Robins, Lopata, 2004; Tomita et al., 2010; Jakobi et al., 2015; Soe et al., 2015; Syron et al., 2017, 2019*
	Joint and musculoskeletal syndromes	*Nordander et al., 1999; Jeebhay, Robins, Lopata, 2004; Van Rijn et al., 2009, 2010; Syron et al., 2019*
	Peritendinitis and tendonitis	*Nordander et al., 1999; Van Rijn et al., 2010; Syron et al., 2019*
	Synovitis and tenosynovitis	*Nordander et al., 1999; Jakobi et al., 2015*
	Pain in different regions of the body (wrist, elbow, neck, etc.)	*Jeebhay, Robins, Lopata, 2004*
Skin problems	*Dermatitis*	*Jeebhay et al., 2001; Jeebhay, Robins, Lopata, 2004; Aasmoe et al., 2005; Bønløkke et al., 2012; Jeebhay, Cartier, 2010*
	Urticaria	*Jeebhay, Robins, Lopata, 2004; Aasmoe et al., 2005; Jeebhay, Cartier, 2010; Wiszniewska et al., 2013; Lukács, Schliemann, Elsner, 2016*
Eye problems	*Conjunctivitis*	*Jeebhay et al., 2001; Bønløkke et al., 2012; Wiszniewska et al., 2013; Lukács, Schliemann, Elsner, 2016*
Injuries	*Strains, sprains, tears (ruptures), fractures, bruises and abrasions (hand, wrist, arm, shoulder, leg, foot, etc.)*	*Jeebhay, Robins, Lopata, 2004; Jakobi et al., 2015; Syron et al., 2017, 2019*

	Electrocution	*Jeebhay, Robins, Lopata, 2004*
	Hand trauma (cuts, wounds, punctures, lacerations, infections, and amputations)	*Pålsson et al., 1998; Jeebhay, Robins, Lopata, 2004; Nag et al., 2012; Jakobi et al., 2015; Nag, Vyas, Nag, 2016; Syron et al., 2017, 2019*
Other health problems	*Facial pain, inflammation, and irritation, especially in the eye area (splashes of dirty water, particles, fish, and chemicals in the eyes)*	*Jeebhay, Robins, Lopata, 2004; Syron et al., 2019*
	Stress related to depression, anxiety, fatigue, digestive problems and insomnia	*Jeebhay, Robins, Lopata, 2004; Jakobi et al., 2015*
	Hernia	*Jakobi et al., 2015*
	Hypothermia	*Jeebhay, Robins, Lopata, 2004*
	Hearing loss	*Jeebhay, Robins, Lopata, 2004*
	Raynaud's Syndrome	*Jeebhay, Robins, Lopata, 2004*

Source: Prepared by the authors.

The pathologies were grouped into large groups for analysis. As some studies describe only symptoms, without diagnosis, they were not included in Table 2, but throughout the text the reported manifestations and health complaints were discussed.

3.1 MUSCULOSKELETAL PROBLEMS

It is observed that musculoskeletal and respiratory problems were the ones that most affected workers in the production sector of the fish processing industry - 48.1% of the reports of health problems in the 26 articles identified (50% and 46%, respectively).

FAO data from 2022 reported a world fish production of around 178 million tons in 2020, with 89% of production destined for human consumption, which is equivalent to an annual supply of 20.2 kg *per capita*, demonstrating a 124.5% increase in aquatic food consumption from 1961 to 2020. This expansion has led to an increase in jobs and a precariousness in working conditions.

12 articles identified discussed musculoskeletal problems, such as: tendinitis, tenosynovitis, epicondylitis, syndromes and other disorders of the musculoskeletal system. These pathologies are the result of the effort of workers to perform routine activities, with inadequate or static postures and gestural repetitiveness. The movements are usually

vigorous and accelerated, with the application of force with the hand or fingers; localized mechanical stress and vibration; which depending on the position of the object in relation to the body, may require respectable efforts, even if this object is light. The effort exerted by the hands and joints can also be increased by the use of gloves and the resistance of the products handled when they are under low temperatures, generating a high prevalence of work-related musculoskeletal disorders (WMSD) (Pålsson *et al.*, 1998; Nordander *et al.,* 1999; Jeebhay, Robins, Lopata, 2004; Van Rijn *et al.*, 2009, 2010; Tomita *et al.*, 2010; Ilardi, 2012; Nag *et al.*, 2012; Jakobi *et al.*, 2015; Soe *et al.*, 2015; Syron *et al.*, 2017, 2019). Symptoms included pain, lack of sensation, weakness, stiffness, swelling, and numbness. Among the 20 studies that investigated health symptoms and complaints, 7 (30%) identified these types of symptoms (Ólafsdóttir, Rafnsson, 1998; Nordander *et al.*, 1999; Bang *et al.*, 2005a; Aasmoe *et al.*, 2008; Ilardi, 2012; Soe *et al.*, 2015; Nag, Vyas, Nag, 2016).

The highest prevalence of musculoskeletal diseases among workers in fish processing plants (salmon deboning and cod and herring filleting) and shrimp processing plants was in the shoulder, elbow and hands. Wrist complaints have been described in the deboning sectors of the salmon industry and in a shrimp factory, involving manual activities. Other affected regions included the neck (filleting sector in a fish factory), arm (deboning sector in a salmon factory) and the back (shrimp factory) (Nordander *et al.*, 1999; Aasmoe *et al.*, 2008; Ilardi, 2012).

Other musculoskeletal discomforts have been described by Nag, Vyas and Nag (2016) in fish processing industries in India. Pain in the knees, forearms, shoulders, neck, and hands has been reported; associated with the execution of tasks with repetitive hand movements and prolonged standing. The activities were carried out in environments with humid floors and low temperatures.

Cold and humidity are risk agents regularly observed in the fish processing industries. Among the studies identified on the relationship between cold and muscular, respiratory and skin symptoms, the study conducted by Bang *et al. stands out.* (2005a) among Norwegian workers. Among those who reported feeling cold, there was a higher prevalence of muscle symptoms in the neck/shoulder, wrist/hands/back, and leg regions; in addition to respiratory symptoms such as: wheezing, coughing, runny nose, and frequent sneezing; and dermatological symptoms, particularly itching, dry skin, cracked skin, and chronic wounds. In addition, the authors highlighted the high levels of humidity, with peaks of 97% due to the constant use of water.

Soe *et al.* (2015) examined the prevalence of musculoskeletal symptoms and their relationship with sociodemographic characteristics, lifestyle, and working conditions in seafood factories in Thailand. 45.1% of workers had symptoms of musculoskeletal disorders in at least one region of the body. Working hours longer than 8 hours and bending or twisting movements of the hands were statistically significant for the occurrence of these disorders, while repetitive hand movements and manual handling of materials with exposure to heavy loads were related to cases of low back pain and wrist/hand pain.

Among the specific diagnoses, low back pain was the most frequent (3 articles) (Jeebhay, Robins, Lopata, 2004; Tomita *et al.*, 2010; Soe *et al.*, 2015). In the studies conducted by Tomita *et al.* (2010) and by Soe *et al.* (2015) in workers in seafood processing plants in Thailand, the incidence of low back pain was 28.5%. Associated risk factors were identified, such as: age over 40 years, poor health conditions, history of injuries, vigorous repetitive movements, torso twisting due to inadequate posture, slips and falls due to slippery surfaces.

Pålsson *et al.* (1998), Nordander *et al.* (1999), Jeebhay, Robins and Lopata (2004), Tomita *et al.* (2010), Ilardi (2012), Nag *et al.* (2012), Soe *et al.* (2015) and Syron *et al.* (2017, 2019) reinforced the findings on musculoskeletal disorders among workers in the fish and seafood processing industry, showing that it is a frequent problem. All studies have shown that conditions and workload in the fish and seafood industries are important factors in the onset and progression of musculoskeletal disorders. Repetitive movements, lifting and carrying loads, intense physical exertion, long working hours, bending or twisting of the hands, and inadequate posture were evidenced as risk agents.

Ilardi (2012) examined the relationship between quality, productivity and risk of occurrence of musculoskeletal disorders in the process of manual bone removal of salmon in Chilean factories. The companies set a goal of deboning 50 to 70 fillets/hour. Based on the author's assessment, 80% of the workers had musculoskeletal symptoms in the right hand/wrist, followed by the shoulder with 60% of the workers and arm/elbow with more than 50%. The data demonstrated a direct relationship between productivity and the risk of these disorders.

Nag *et al.* (2012) analyzed the risk factors for musculoskeletal disorders among women workers at manual processing plants for fish, shrimp and squid. They performed activities such as sorting, peeling and packing, where they remained standing for many hours, being exposed to cold and humidity. It was observed that 71% had musculoskeletal disorders, especially in the upper back (54%), lower back (33%), knee (35%), and shoulders (27%). The automation of production processes also influenced musculoskeletal complaints.

Ólafsdóttir and Rafnsson (1998) in a study in Iceland on fish processing plants, proved an increase in the prevalence of symptoms in the upper limbs and a decrease in the lower limbs. The results found were possibly due to the introduction of the flow line, which allowed work in the sitting position, the use of rubberized platforms when standing, the automation in loading loads and the use of non-slip boots, which contributed to the reduction of the physical load on the muscles during displacement in the work environment.

Tran *et al.* (2016) reported that musculoskeletal disorders in the seafood processing industries, especially shrimp, were related to the physical environment and poor work organization. The authors pointed out a prevalence of symptoms of musculoskeletal disorders of 77% in at least one part of the body and 20.1% in all regions. The most affected sites were the hips and lower limbs (77%), shoulders and upper limbs (42.6%) and neck (41.1%).

Nordander *et al.* (1999), when evaluating the impact of work and psychosocial factors, in men and women, of 13 fish processing industries in Sweden, for the emergence of musculoskeletal disorders, they showed that the functions performed resulted in different health conditions. Carpal Tunnel Syndrome (CTS) was diagnosed only in women (2%), and supraspinatus tendinitis affected men and women in proportions of 15% and 3%, respectively. Work tasks were heavily segregated. Despite the same position, women did not share the same tasks as men. Presumably due to their lower muscle strength, they were assigned to seemingly less heavy work tasks. Women were given repetitive tasks such as trimming and packing the fish, which required very restricted neck postures, while the men performed tasks of lifting and manually transporting the loads of fish. Both workers were given a physical workload normally associated with the multicausal factors present in the process of mental exhaustion, such as: lack of stimulus from one's own work, control of time and activities, requirements and goals.

Table 2 presents the studies that showed the prevalence of musculoskeletal disorders in the hand, wrist, elbow, shoulder, neck and chest among workers in the fish processing industry.

Table 2

Musculoskeletal disorders in the hand, wrist, elbow, arm, shoulder, neck and chest region

Location	Pathology	References
Hand and wrist	*Peritendinitis, synovitis, and tenosynovitis (including De Quervain's)*	*Nordander et al, 1999; Jakobi et al., 2015*
	Carpal Tunnel Syndrome	*Nordander et al, 1999; Jeebhay, Robins, Lopata, 2004; Van Rijn et al, 2009; Syron et al, 2019*
Elbow	*Lateral (tennis elbow) and medial (golfer's elbow) epicondylitis*	*Nordander et al, 1999; Jeebhay, Robins, Lopata, 2004; Syron et al, 2019*
Shoulder	*Bicipital, infraspinatus, and supraspinatus (or supraspinatus) tendinitis*	*Nordander et al, 1999; Van Rijn et al, 2010; Syron et al, 2019*
	Acromioclavicular syndrome (osteoarthritis), subacromial impingement syndrome (or shoulder impingement) syndrome, frozen shoulder syndrome (adhesive capsulitis)	*Nordander et al, 1999; Van Rijn et al, 2010*
Neck	*Cervical syndrome (neck pain or cervical tension syndrome)*	*Nordander et al, 1999*
Neck and chest	*Thoracic outlet syndrome*	*Nordander et al, 1999*

Source: Prepared by the authors.

Several studies have pointed to a high risk of development and high prevalence of CTS among workers in the fish industries. This syndrome develops due to compression of the median nerve of the wrist, due to exposure to high levels of hand-arm vibration, prolonged work with an extended or flexed wrist, high manual strength (> 4Kg), high repetitiveness and a combination of these factors, such as cutting fish into fillets, where there is a requirement for vigor, dexterity and speed (Kim *et al.*, 2004; Van Rijn *et al.,* 2009, 2010; Chammas *et al.*, 2014). They also highlighted the conditions in the neck or shoulder region among the workers, such as: infraspinatus tendinitis, acromioclavicular syndrome, adhesive capsulitis and subacromial impingement syndrome; due to repetitive work, physical exertion and raising of the arms or a combination of these (Nordander *et al.*, 1999; Van Rijn *et al.*, 2010; Syron *et al.*, 2019).

These disorders can result in implications, such as high costs for health systems and workers' compensation systems, as well as significant impacts on the quality of life of those affected (Punnett, Wegman, 2004; Soares *et al.*, 2019).

3.2 RESPIRATORY AND EYE PROBLEMS

12 articles (60%) addressed respiratory symptoms among workers (Jeebhay, Lopata, Robins, 2000; Ortega *et al.*, 2001; Bønløkke *et al.*, 2004; Bang *et al.*, 2005a, 2005b; Jeebhay *et al.,* 2008; Shiryaeva *et al.,* 2010, 2014, 2015; Dahlman-Höglund *et al.*, 2012; Žuškin *et al.*, 2012; Thomassen *et al.,* 2017). Among these, 6 highlighted the prevalent symptoms, categorized according to the type of product processed.

Shortness of breath and wheezing were identified in salmon, crab and shrimp processing plants; and in by-product factories (canned fish and fishmeal). In the fish filleting factories (cod and herring), frequent sneezing, runny nose and shortness of breath were observed. Sore throat or irritation has been reported in canneries and fishmeal factories and in the slaughtering and filleting sectors of salmon processing plants. Wheezing was observed only in shrimp factories (Bang *et al.*, 2005a, 2005b; Jeebhay *et al.,* 2008; Shiryaeva *et al.*, 2010, 2014; Thomassen *et al.*, 2017). Runny nose and dry cough were pointed out by Shiryaeva *et al.* (2015) as frequent symptoms among female workers in Norwegian salmon processing plants. Cough, in turn, was also reported by Thomassen *et al*. (2017), manifesting itself in a prolonged way among crab processing workers. This symptom deserves investigation, as it can indicate several pulmonary and extrapulmonary pathologies (Chung *et al*., 2022).

Respiratory symptoms may present acutely or chronically, as verified by Žuškin *et al.* (2012), in a study in Croatia, in a sardine processing industry. The authors detected acute symptoms, with acute cough, throat irritation, nasal discharge, nasal dryness and headache; and chronic symptoms, such as dyspnea, cough, phlegm, and chronic bronchitis. According to them, professionals in fish factories are prone to developing acute and chronic respiratory symptoms and changes in lung function and, therefore, these environments need preventive actions and technical measures to avoid the illness of their employees.

Bønløkke *et al.* (2004) investigated the prevalence of self-reported respiratory symptoms, such as wheezing and asthma, indicative of shortness of breath and wheezing, in workers processing herring (*Clupea harengus*). The study revealed a prevalence of 28% of respiratory symptoms and 13% of occupational allergy due to exposure to fish protein.

Asthma was the respiratory disease described in all 12 articles. It is a disease characterized by variable symptoms of wheezing, shortness of breath, coughing and/or chest tightness (wheezing) and by variable limitation of respiratory airflow (Gina, 2023). It was reported in the articles as occupational asthma and severe asthma.

Work-related asthma is a highly prevalent disease in the adult population and is associated with working conditions, and may be aggravated by environmental irritants (Sarti *et al.*, 1998; Roio *et al.*, 2021). It has 2 categories: occupational allergic and irritant-induced (or reactive airway dysfunction syndrome). The first is the most frequent, with a prevalence of 2 to 36% among workers in the fish industry, and occurs after a latency period of sensitization. The second, induced by irritants, manifests without a latency period and can appear after single or multiple exposures to high concentrations of nonspecific irritants (Jeebhay, Robins, Lopata, 2004; Jeebhay, Cartier, 2010; Jeebhay, Lopata, 2012; Wiszniewska *et al.*, 2013).

Studies have shown asthma symptoms among fish and seafood processing workers (especially mollusks) in South Africa and Poland after inhaling fish vapors, gas, dust, and smoke (Jeebhay, Robins, Lopata, 2004; Jeebhay *et al.*; 2008; Wisznieska *et al.*, 2013; Lukács, Schliemann, Elsner, 2016). Wisznieska *et al.,* (2013) highlighted the case in which a worker in Poland, after exposure to squid, presented rhinitis, conjunctivitis, contact urticaria and severe asthma. Severe asthma is considered an uncontrolled pathology, since it is difficult to treat, thus has high morbidity, mortality, and health costs (Levy *et al.*, 2023).

Mason *et al.* (2020) detected an average annual incidence rate of occupational asthma that was 24 times higher among workers in the seafood processing sector in the United Kingdom.

Jeebhay and Cartier (2010) suggested that in the fish processing industry, crustaceans are more responsible for causing occupational asthma than bony fish and molluscs; crab and shrimp being the predominant species. Ortega *et al.* (2001) identified among the workers involved in the processing of crabs in Alaska, in addition to asthmatic symptoms, bronchitic symptoms.

Dahlman-Höglund and Andersson (2020) demonstrated the prevalence of occupational asthma among workers involved in filleting, when compared to other workers in a fish industry in Sweden. Similar results were found by Shiryaeva *et al.* (2010) in Norway, among workers in the salmon industry. These studies reported daily use of high-pressure sprayers during the filleting process and poor use of respiratory protection, resulting in exposure to fine bioaerosols. Exposure to bioaerosols resulting from fish processing has also been related to cases of occupational asthma in several studies (Douglas *et al.*, 1995; Jeebhay *et al.*, 2001; Barraclough *et al.*, 2006; Cartier, 2010; Jeebhay, Cartier, 2010; Gautrin *et al.*, 2010; Shiryaeva *et al.*, 2010; Quirce, Bernstein, 2011; Dahlman-Höglund, Andersson, 2020).

Aerosols are small particles, measuring between 0.3 and 100 μm in diameter, which can have a microbial, animal, plant or chemical origin (Douwes *et al.*, 2003; Stetzenbach, 2009). Particles smaller than 5.0 μm are usually suspended in the air, while larger particles tend to deposit rapidly due to gravitational forces (Abadie, Limam, Allard, 2001).

The dispersion of aerosols can occur during the different stages of fish processing, such as slaughter, fractionation, heading, peeling, degreasing, cooking (or boiling), grinding, preparation of preserves, use of preservatives, bagging of fishmeal and cleaning of raw material, machinery and the environment. The extensive use of water, as well as machinery, generates particles and droplets, which can be transported through the air and inhaled by workers (Douglas *et al.,* 1995; Jeebhay *et al.*, 2001, 2008; Jeebhay, Robins, Lopata, 2004; Barraclough *et al.*, 2006; Steiner *et al.*, 2008; Cartier, 2010; Gautrin *et al.,* 2010; Jeebhay, Cartier, 2010; Quirce, Bernstein, 2011; Wiszniewska *et al.,* 2013; Thomassen *et al.*, 2016). Thus, the concentration of aerosols tends to be high, especially in wet processing areas, such as evisceration, packaging and cooking, where water splashes and the movement of raw material favor the formation and movement of aerosols. On the other hand, areas of manual shell processing have relatively lower concentrations, although they can still be significant (Jeebhay, Robins, Lopata, 2004; Aasmoe *et al.*, 2005).

Douglas *et al.* (1995) when examining the concentration of aerosols in the automated salmon processing industry in Sweden, they found high concentrations in the wet processing area and moderate concentrations in areas far from the evisceration machine, as there was air recirculation. Based on these findings, it was possible to adapt the air circulation system, which was previously closed, to an exhaust system, resulting in a decrease in the concentration of aerosols.

This same observation was made by Jeebhay, Robins and Lopata (2004) when studying cases of respiratory infection and pneumonitis due to hypersensitivity, resulting from exposure to a type of fungus, in a fish industry in South Africa. Dahlman-Höglund *et al.* (2012) also found these symptoms among workers in the fresh salmon filleting room, where the presence of mold spores (*Penicillum Notaturus, Aspergillus aspergillus* and *Cladosporium* *herbarum*) was detected; as well as parvalbumin (fish allergen) and endotoxins in low concentrations.

The studies by Thomassen *et al.* (2016, 2021) carried out on 2 Norwegian crab processing plants identified the presence of bioaerosols containing endotoxins and proteins, including trypsin, tropomyosin (cross-reactive allergen) and glucosaminidase (NAGase – a substance found in the crab exoskeleton that can trigger inflammatory responses in humans). The results revealed that the processing of crabs, raw or cooked, influenced the concentration of tropomyosin and the composition of other aerosols. Processing cooked crab generated higher tropomyosin concentrations than processing raw crab. However, the enzyme activity was higher in bioaerosols collected in raw crab processing than in cooked ones. Exposure levels also varied among different types of crab plants, due to organizational or ventilation characteristics. In addition, Dong and Raghavan (2022) highlighted that there are differences in allergic responses between fish and seafood. Bony fish, such as cod and salmon, are more often associated with cases of allergy in humans, when compared to cartilaginous fish, such as shark and ray.

Rhinoconjunctivitis was present among employees of the fish industry due to exposure to proteins from processed marine animals (shrimp, crab, fish and octopus) and in the manufacture of canned fish and fish meal. It was reported in 8 articles and was related to the presence of bacterial toxins (endotoxins and histamine) and mold in humid environments. Additionally, it was observed during the use of feed additives (garlic and spices) and in contact with fish parasites (*Anisakis simples*) during processing (Jeebhay *et al.*, 2001, 2008; Jeebhay, Robins, Lopata, 2004; Jeebhay, Cartier, 2010).

Crustaceans and mollusks are considered panallergens due to cross-reactivity. Recently, processing techniques, both thermal and non-thermal, have been improved to reduce allergenicity to fish and seafood, seeking to minimize losses in nutritional value and sensory quality (Dong, Raghavan, 2022).

Mason *et al.* (2020) pointed out the occurrence of allergic alveolitis and respiratory irritation associated with the handling of shrimp and lobsters, as well as incidents due to inhalation of irritating products (smoke from the smoking process, sulfur dioxide, metabisulfite, and chlorine) in seafood processing workers in the United Kingdom. The authors described cases of occupational asthma due to exposure to sodium metabisulfite, used in the preservation process. In 2008, Steiner *et al.* described a case of respiratory problems in a worker responsible for preparing sodium metabisulfite solution for shrimp immersion in a factory.

The risk of respiratory problems due to the inhalation of chemicals frequently used in the fish processing industries is exemplified by the study carried out by Shiryaeva *et al.* (2015) in Norway. Of all the causes pointed out by the 139 workers in salmon processing plants, the use of disinfectant was in 2nd place among the diagnosed and work-related causes, representing about 15% of the reports.

The chemical solutions used in routine extensive disinfection procedures in the processing areas are also risk agents for workers (Bang *et al.*, 2005b). Such compounds are used to inactivate microorganisms that may be present (Cabeça, Pizzolitto, Pizzolitto, 2012). They are often sprayed in the form of foams, all over the area, before washing with high-pressure water. These solutions can expose workers, either by inhalation or by direct contact.

The formation of aerosols can also be linked to factors such as: size of the environments, ventilation system, equipment used, handling procedures and quantity of fish processed (Jeebhay, Lopata, Robins, 2000).

Jeebhay *et al*. (2001, 2004) highlighted the importance of ventilation systems in industrial environments, specifically in fish processing industries, for the control of respiratory pathologies caused by irritation due to inhalation of aerosols of various origins. The study demonstrated that the inadequacy of these systems can lead to the dispersion of aerosols. He also stressed that constant humidity in a poorly ventilated environment favors the development of fungi and, in order to reduce aerosols, including the concentrations of fish and fungal antigens, improvements should be made in the ventilation system, in the machines and in the organization of work.

Although the use of adequate ventilation systems helps to control exposure to aerosols, other alternatives have been adopted, such as encapsulation of equipment, as observed in research conducted in automated processing plants for crabs and fish (Jeebhay, Robins, Lopata, 2004; Dahlman-Höglund *et al.*, 2013; Thomassen *et al.,* 2017), where there was a lower occurrence of respiratory symptoms compared to non-automated plants (Thomassen *et al.,* 2017).

There are also studies showing that the absence of personal protective equipment increases the risk of respiratory and dermal sensitization among workers (Jeebhay, Lopata, Robins, 2000). In addition, the main allergens in the fish processing industries have not yet been identified or their exposure limits have not been established (Bang *et al.*, 2005b; Bonlokke *et al.*, 2019).

3.3 SKIN PROBLEMS

Unlike respiratory allergies, there are few cases described in the literature of dermatological problems associated with fish (Jeebhay *et al.,* 2001; Jeebhay, Robins, Lopata, 2004; Jeebhay, Lopata, 2012). Cutaneous symptoms are related to exposure to fish or to the systemic response to inhalational exposures. The first symptoms may appear after 30 min. of contact with fish and trigger different reactions in the respiratory system (cough, shortness of breath, sneezing, runny nose and wheezing) and skin (rash, itching, redness and swelling) (Jeebhay *et al.*, 2001; Jeebhay, Robins, Lopata, 2004).

Among the studies identified (26), dermatoses represent 27% (7) of occupational health problems. The causes of occupational dermatoses are complex and multifactorial. Wet work can be a major causal factor in the development of hand eczema and can also promote skin dryness. During fish processing, skin symptoms may occur due to direct contact with fresh fish or shrimp or with the fluid released during processing, with the handling of the raw material being a relevant risk factor. Digestive enzymes such as pepsin and trypsin have been shown to be highly effective in degrading human epidermal keratin, suggesting a possible mechanism for the development of skin reactions (Aasmoe *et al.,* 2005). Thomassen *et al.* (2021) pointed to trypsin as associated with inflammatory and allergic responses, while tropomyosin as the main cross-reacting allergen, thermostable and abundant among crustaceans. In addition, the workers wash their hands several times and the water is also used to rinse the shrimps, fish, fish fillets and the work table. The fluid that surrounds fish, fillets and shrimp is actually a mixture of water and raw material, and sometimes also salt (Aasmoe *et al.,* 2005).

Among the findings of this review, reported cases of urticaria, contact urticaria, dermatitis and contact dermatitis were verified.

Aasmoe *et al.* (2005) investigated occupational skin problems among Norwegian workers in 101 fish processing industries. It was found that 55.6% of the workers had one or more skin symptoms, with a higher prevalence among women (60.2%) than men (50.1%). The study showed that men and women had different tasks in the industries. In general, the women carried out manual filleting activities, using thin gloves to be able to feel and remove small bones from the fillets. They worked in separate rooms and often had their sleeves rolled up due to the higher temperatures than in other processing rooms, exposing their forearms. Despite this, most workers reported skin problems on their hands or face. This can be explained by exposure to wet aerosols and splashing water.

The dermatitis reported by Aasmoe *et al.* (2005) is recognized as allergic contact dermatitis, however, in the literature, when this type of dermatitis is due to contact with proteins, it is called protein contact dermatitis (Jeebhay *et al.*, 2001; Jeebhay, Robins, Lopata, 2004; Lukács, Schliemann, Elsner, 2016).

Irritant contact dermatitis occurs when a toxic substance or chemical comes into contact with the skin and causes a direct damage to the skin. These substances can be chemical agents such as soaps used in hand hygiene and disinfectants and detergents used in cleaning utensils, equipment and the environment (Jeebhay, Robins, Lopata, 2004; Steiner *et al.,* 2008; Shiryaeva *et al.*, 2015)element.

Jeebhay, Robins and Lopata (2004), Aasmoe *et al.* (2005) and Syron *et al.* (2019) reported the development of irritations and inflammations on the skin of the hands or face, especially in the eyes due to splashes resulting from the cleaning processes of fish, equipment and the environment; and bioaerosols.

A study conducted by Sangaramoorthy (2019) exposed reports of dermatoses among female workers during crab processing in American industries. The study showed that the crab's daily hygiene activities generate cuts, scratches, dry skin and rashes, which can develop into serious infections.

2 studies identified skin symptoms from contact with elaborate products. They were skin rashes among shrimp and crab processing workers and in canneries and fishmeal workers. The reports of itchy hands were the result of shrimp processing (Jeebhay *et al.*, 2001; Jeebhay, Cartier, 2010).

Jeebhay *et al.* (2001), Jeebhay, Robins and Lopata (2004), Aasmoe *et al.* (2005), Jeebhay, Cartier (2010) and Bønløkke *et al.* (2012) report cases of dermatitis and urticaria in fish, shrimp and crab processing industries. But the authors did not categorize the nature, that is, whether or not it was inflammatory.

It is important to highlight the difference between urticaria and dermatitis. Both can occur through direct contact with external agents; However, contact urticaria is an immediate and non-eczematous reaction, while contact dermatitis represents a delayed and eczematous inflammatory reaction, which can become chronic. When workers come into direct contact with fish, without protection, they can develop contact urticaria (Jeebhay *et al.*, 2001; Jeebhay, Robins, Lopata, 2004; Wiszniewska *et al.*, 2013)element. Occupational health studies among squid (*Loligo vulgaris*) processing workers, by Wiszniewska *et al*. (2013) and Lukács, Schliemann and Elsner (2016), reported contact urticaria. In addition, they describe other symptoms among workers, such as severe asthma, rhinitis and conjunctivitis.

The presence of eczema on workers' hands may be related to contact, allergic, or irritant dermatitis (Höper *et al.,* 2023). In all, the rash ranges from mild, short-term redness to intense swelling and large blisters. The rash develops only in areas that come into contact with the substance. The difference between allergic contact dermatitis and irritant contact dermatitis is that in the latter there is more pain than itching and its symptoms usually decrease in intensity after 1 or 2 days, if there is no more exposure to the irritating substance. In allergic contact dermatitis, where there is more itching than pain, the symptoms can take 1 day or more to become noticeable and then increase in intensity.

3.4 INJURIES

There are several types of non-fatal injuries that can affect workers, which result from the nature of the activities carried out in the different stages of fish processing (Ribeiro, 2021). Only 7 articles (27%) reported injuries among these workers. However, Syron *et al.* (2019) highlighted that, although the risk of fatal injuries in the fish processing industry is low, the risk of non-fatal injuries and diseases remains high, highlighting the need for preventive measures aimed at health and safety. In addition, Jiaranai, Sansakorn and Mahaboon (2022), with the aim of developing a model for calculating the vulnerability factor for migrant workers in Thai seafood factories, showed that approximately 22% of them suffered accidents, while about 60% took sick leave due to health problems.

Trauma to the hand region was the most cited injury in the 7 articles identified. Workers use cutting equipment and there is the handling of quills present in some fish and shellfish, in repetitive and short-cycle tasks, causing an increased risk of accidents, such as cuts, wounds, perforations, lacerations, infections and even amputations (Pålsson *et al.*, 1998; Jeebhay, Robins, Lopata, 2004; Nag *et al.*, 2012; Jakobi *et al.*, 2015; Nag, Vyas, Nag, 2016; Syron *et al.*, 2017, 2019). This type of work accident can lead to exposure to biological material.

Syron *et al.* (2019) conducted a survey on compensation claims for work accidents, injuries and illnesses, in the period from 2014 to 2015, among workers in the seafood processing industry in Alaska. They found that 1/3 of the requests resulted from sprains, strains and ruptures and most frequently affected the trunk and upper limbs. The authors identified that 13% of the disabling indemnities were the result of injuries due to laceration, puncture, amputation and fractures, which occurred mostly in the upper limbs and head.

Scratches or abrasions can expose workers to substances found in fish and can result in infections, dermatitis, and allergic reactions. In general, fish have rays on their fins, which are pointed structures that can penetrate the skin, leading to infections, since these animals have microorganisms on the skin, kidneys and intestines, such as staphylococci and streptococci (Haddad Junior, 2004; Meron *et al.*, 2020). However, there are other biological agents that are often associated with human diseases, such as parasites and viruses transmitted by contact or ingestion (Shamsi, 2019; Meurens *et al.,* 2021). In addition, protozoa such as *Cryptosporidium* spp. are also considered to be at zoonotic risk. Several species *of Cryptosporidium* have been identified in marine, freshwater, farmed and ornamental fish worldwide (Golomazou *et al.*, 2021). But the main zoonotic agents of fish are bacteria (Gauthier, 2015).

In the processing industries, facilities are designed for rapid in-line production and then movement of the packaged product for storage and transportation. Processing, canning and freezing activities on the production line and transporting, stacking, packaging and handling activities; as well as repair, maintenance, and cleaning of equipment performed off-line were associated with a higher number of musculoskeletal injuries and diseases. The most common causes included strenuous and repetitive work, requiring awkward postures or staying in the same position for a long period of time, and intense physical exertion. Contact with fresh and frozen equipment and utensils, packaging/bags, fish, and seafood can lead to traumatic injuries to bones, nerves, and even the spinal cord, while the humid and slippery environment increases the risk of falls, bruises, and abrasions (Jakobi *et al*, 2015; Syron *et al*, 2018, 2019; Soares *et al*, 2019). In addition to the most common musculoskeletal injuries, an occurrence of inguinal hernia was recorded, which resulted in sick leave from work, as reported by Jakobi *et al.* (2015), evidencing the relationship between repetitive physical effort and occupational overload.

With regard to potentially fatal injuries, Jeebhay, Robins and Lopata (2004) describe the risk of electrocution, due to inadequate disposal and contact with electrical cables on wet surfaces.

3.5 OTHER HEALTH PROBLEMS

The occurrence of other health problems was observed in the studies analyzed, such as pain, inflammation and facial irritation, stress, hernia, hypothermia, hearing loss and Raynaud's syndrome, representing 11.2% of the findings (3 articles), which reflects the diversity of health problems faced by workers in the fish processing sector (Jeebhay, Robins, Lopata, 2004; Jakobi *et al.*, 2015; Syron *et al.,* 2019).

Pain, inflammation and facial irritation were associated, according to Jeebhay, Robins and Lopata (2004), with prolonged exposure to physical, chemical and biological agents present in the work environment. Among these agents are intense cold and humidity, which cause skin irritation; fish allergens and parasites that can trigger allergic and inflammatory reactions; and chemical substances such as formaldehyde and sulfites, used in industrial processes.

Stress and fatigue were also documented in the study by Jeebhay, Robins and Lopata (2004), manifesting themselves in episodes of anxiety, insomnia and digestive problems. These are symptoms related to psychosocial risks, which include incorrect organization of work and the need for speed in the execution of activities on production lines (Jeebhay, Robins, Lopata, 2004; Jakobi *et al.,* 2015; Syron *et al.,* 2019).

Psychosocial factors at work are associated with psychological and social variables that coexist and interfere in the environment and are related to health and mental illness (Binik, 1985). They refer to the interactions between the work environment, functions and the type of work; the organizational conditions, the capacity/ability of the workers and the individual and family characteristics of the workers. These factors can influence health, performance and job satisfaction, which can lead to exhaustion, suffering and illness (ILO, 1986).

In addition to these psychosocial factors, there are several physical risk agents present in the industrial environment, which act directly on the human body, such as cold, humidity and noise (Jeebhay, Robins, Lopata, 2004). To maintain the quality of the product, promptness is required during the processing of fish, since it is a highly perishable raw material that is easy to deteriorate. Fish and seafood need to be refrigerated for conservation and preservation of food quality and safety. In this way, workers are exposed to cold (Jeebhay, Robins, Lopata, 2004; Aasmoe *et al.,* 2005; Bang *et al.,* 2005a; Shiryaeva *et al.,* 2015; Nag, Vyas, Nag, 2016; Syron *et al.,* 2019) due to the need for air conditioning during the handling and preparation of fish, as well as access to cold storage during the storage or shipment of the product (Bang *et al.,* 2005a; Soares, Gonçalves, 2012).

Jeebhay, Robins and Lopata (2004) reported in their research cases of hypothermia and Raynaud's syndrome due to exposure to cold, the latter disease being also related to exposure to constant humidity and develops normally in the region of the hands (Kayser, Corrêa, Andrade, 2009).

Only 1 study reported hearing loss among workers exposed to high levels of noise generated by equipment and machinery used in industrial production lines (Jeebhay, Robins, Lopata, 2004).

The effects of noise may not be immediately noticeable, intensifying progressively over time and having the potential to cause irreversible hearing damage. The implications of noise go beyond the scope of hearing, negatively affecting the quality of life of workers. Its manifestation occurs through sleep disorders, stress, irritability, headaches, high blood pressure, cardiovascular diseases, and interference in tasks that require concentration, speed, and precision of movements, which can lead to accidents (Silva *et al.,* 2016).

4 CONCLUSION

Technological advances and organizational changes have altered the work environment and the profile of the activities performed in fish factories. The sector, marked by the need for constant agility in its processes and the high perishability of products, offers workers a range of risk agents, such as constant humidity and cold, contributing to the illness of workers.

The literature review allowed the identification of musculoskeletal disorders, respiratory diseases, dermatoses, injuries and other less frequent health problems, such as hypothermia, hearing loss, hernia and Raynaud's syndrome. The symptoms and complaints reported corroborate the profile of illness described, reinforcing the importance of investigations that help in the prevention and monitoring of workers' health.

The study contributed to gather and systematize in a critical way the available information on health problems and risks related to the processing of fish in industries. Thus, it is suggested the need to adopt preventive measures, such as the use of collective and individual protective equipment, adequacy of manufacturing environments, training of workers involved in production and constant health surveillance.

Gaps were also identified, especially with regard to the characterization of allergenic agents present in different fish, as well as the definition of safe limits of exposure to workers. It was also observed the predominance of cross-sectional studies, which may underestimate the real magnitude of the diseases due to the effect of the healthy worker. Thus, the need for longitudinal studies and analyses of environmental and organizational conditions is highlighted to deepen the understanding of the relationship between working conditions and illness.

Although there are several studies on respiratory problems, dermatoses related to contact with fish remain poorly documented, indicating possible underdiagnosis and the need for more detailed investigations. Similarly, hearing loss has been documented in only 1 article, and its underreporting may occur because it is generally a chronic problem.

In summary, workers who work in the production sector of the fish industry are exposed to different risk agents, which can still interact with each other and configure a complex scenario of occupational illness. It is necessary to expand scientific production on the subject and establish public policies and preventive actions that guarantee safe and healthy work environments, ensuring that the productive development of the sector is accompanied by the effective protection of workers' health.

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