

## PHYSICAL, CHEMICAL AND BIOLOGICAL HAZARDS TO PORT WORKERS AND THEIR POTENTIAL TO CAUSE RESPIRATORY DISORDERS\*

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**ABSTRACT:** The present study aimed to identify the sources of chemical, physical and biological hazards to which temporary port workers are exposed in the work environment, which may cause respiratory disorders. Quantitative and exploratory study with direct nonparticipant observation of workers from a maritime port in Southern Brazil. Data was collected from July to December 2014, and 87 observations of 66 workers were made. Descriptive statistics was performed with absolute and relative frequencies (percentage). The predominant sources of physical hazards were cold, moisture and non-ionizing radiation. The sources of chemical hazard were associated with the handling of grains, fertilizers and combustible gases, and the biological hazard observed was the presence of pigeons. Port workers are exposed to occupational hazards that pose respiratory health risks, depending on the type of cargo, activities and workplace.

**DESCRIPTORS:** Occupational risks; Respiratory diseases; Occupational health; Nursing; Environmental Risks.

### RISCOS FÍSICO, QUÍMICO E BIOLÓGICO EM PORTUÁRIOS E POTENCIALIDADES PARA ALTERAÇÕES RESPIRATÓRIAS

**RESUMO:** Objetivou-se identificar as fontes de exposição dos trabalhadores portuários avulsos aos riscos químico, físico e biológico no ambiente laboral, com potenciais para alterações da função respiratória. Estudo de caráter quantitativo, exploratório, com técnica observacional não-participante e direta de trabalhadores de um porto naval do sul brasileiro. A coleta de dados ocorreu de julho a dezembro de 2014, sendo realizadas 87 observações de 66 trabalhadores. Realizou-se análise descritiva dos dados, por meio de frequência absoluta e percentual. As fontes predominantes de exposição ao risco físico foram frio, umidade e radiação não ionizante. As fontes de exposição ao risco químico decorreram da movimentação de grãos, fertilizantes e gases combustíveis, e o risco biológico observado foi a presença de pombos. O trabalhador portuário está exposto a fontes de riscos ocupacionais à saúde respiratória que variam conforme as cargas, atividades laborais e locais de trabalho.

**DESCRIPTORIOS:** Risco ocupacional; Doenças respiratórias; Saúde do trabalhador; Enfermagem; Riscos Ambientais.

### RIESGOS FÍSICO, QUÍMICO Y BIOLÓGICO EN PORTUARIOS; Y POTENCIALIDADES DE ALTERACIONES RESPIRATORIAS

**RESUMEN:** Se objetivó identificar las fuentes de exposición de trabajadores portuarios expuestos a riesgos químico, físico y biológico en su ámbito laboral, con potenciales de alteración de la función respiratoria. Estudio cuantitativo, exploratorio, aplicando técnica observacional no participante y directa de trabajadores de un puerto naval del sur brasileño. Datos recolectados de julio a diciembre de 2014, habiendo sido realizadas 87 observaciones de 66 trabajadores. Se realizó análisis descriptivo de los datos, mediante frecuencia absoluta y porcentual. Las fuentes predominantes de exposición al riesgo físico fueron: frío, humedad y radiación no ionizante. Las fuentes de exposición al riesgo químico derivaron del traslado de granos, fertilizantes y gases combustibles; y el riesgo biológico observado fue la presencia de palomas. El trabajador portuario está expuesto a fuentes de riesgos laborales para su salud respiratoria, los cuales varían en función de las cargas, actividades laborales y lugares de trabajo.

**DESCRIPTORIOS:** Riesgos Laborales; Enfermedades Respiratorias; Salud Laboral; Enfermería; Riesgos Ambientales.

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## ● INTRODUCTION

Damage to the respiratory system may be related to exposure to various occupational hazards, as well as to the workers' health status and smoking habit<sup>(1)</sup>. The main sources of hazardous air pollutants are industrial facilities and motor vehicles<sup>(2)</sup>, and this socioenvironmental condition has a negative impact on workers' health.

Identification of the abovementioned conditions by nursing professionals is key to the recognition and assessment of the occupational characteristics that have or may have a positive or negative impact on the health-disease process of different kinds of workers. Moreover, it is necessary to identify the sources of hazards that interfere with the worker's body, in order to plan interventions aimed to prevent and/or minimize health problems.

The reported hazards include physical hazards such as wind, rain, moisture and non-ionizing radiation; chemical hazards, such as the formation of dust and combustible gases; and biological hazards, such as viruses and bacteria. Also, some hazards can be associated with specific characteristics of several work environments. In the present study, we analyzed the hazards faced by port workers. More than 320.9 million tons of goods were handled in port facilities in Brazil only in the first half of 2016<sup>(3)</sup>. Thus, the port industry plays a crucial role in economic integration and development in the country.

Port activities are developed by workers with a permanent employment relationship or by Temporary Port Workers (TPA). Temporary workers are regulated by the Labor Management Department for Temporary Port Work (OGMO) of the respective port or labor union<sup>(4)</sup>, and are the focus of this study. National<sup>(5-6)</sup> and international<sup>(7-8)</sup> studies highlight the impact of social and environmental conditions of the workplace on the health of port workers exposed to different sources of environmental hazards that may impact their health.

Therefore, nurses, with their clinical expertise, in cooperation with the Specialized Service in Port Worker Safety and Health (SESSTP), should be able to recognize the different sources of hazards and develop strategies to discontinue or minimize them. The SESSTP is disciplined by Regulatory Standard 29 on Safety and Health in Port Work (NR-29), and is responsible for the assessment of safety issues in port operations, in order to detect and subsequently eliminate or neutralize hazardous agents<sup>(9)</sup>.

Port activities in Brazil are developed by workers from six different occupational activities: shore handling, cargo repairmen and block workers, who work on shore; stevedoring and cargo checkers, who carry out activity on board the ship; and watchmen, who perform their activities in both environments. Port work can also be performed in the internal and external environment<sup>(4)</sup>.

Regarding on board activities, they are performed by the stevedores in the ship's hold where the cargoes are stored, as well as in other sections of the vessels. In turn, on shore activities are developed in warehouses and in the mechanical workshop (for welding). The external activities are performed at the pier (shipberthing and cargo loading) as well as in the caryard where cars transported in car-carrier trucks are reloaded and unloaded<sup>(4)</sup>.

On ship board and in the external environment, the work activities are conducted on the deck (e.g. workers who perform winch and crane operations and signaling in the ramps for access to vessels). These are exposed to dust produced from the loading of bulk cargoes and gases from the burning of fuel originating from port handling and the movement of cars and machinery<sup>(4)</sup>.

According to a study conducted by the Occupational Safety and Health Administration (OSHA), port workers, heavy equipment operators and truck drivers are exposed to diesel particulate matter, which includes soot primarily formed by carbon, sulfates and silicates. These substances may cause symptoms such as headache and eye and throat irritation, in the short term. The length of exposure to these pollutants may increase the risk for cardiovascular, cardiopulmonary and respiratory diseases<sup>(10)</sup>.

The fertilizer most widely handled in the port facility where the study was conducted was urea (NH<sub>3</sub>), a nitrogen compound that, when inhaled, may irritate the respiratory system causing coughing and sneezing<sup>(11)</sup>. Symptoms can be exacerbated when workers are also exposed to toxic gases, which

worsens respiratory problems<sup>(12)</sup>.

It should be stressed that temporary port workers are exposed to gases like nitrogen oxide. In contact with the respiratory epithelium, this gas stimulates the formation of free radicals of oxygen and nitrogen, inducing oxidative stress, a mechanism that causes local and systemic inflammation in the airways, which may lead to Chronic Obstructive Pulmonary Disease (DPOC)<sup>(10,12)</sup>.

Therefore, the present study aims to provide nurses with the necessary knowledge to identify possible clinical disorders and health problems arising from the work environment of Temporary Port Workers (TPA), in order to make them more capable of delivering care to workers with respiratory health problems. According to NR-29, the SESSTP regulates the activities performed by occupational health nurses. These professionals are required in institutions/companies employing more than 751 workers.

Thus, the present study aims to identify sources of chemical, physical and biological hazards to which temporary port workers are exposed, in the workplace, with potential to cause respiratory problems.

## ● METHOD

Quantitative observational study conducted in a maritime port of southern Brazil. The site of the study was Porto Novo, (New Port) which includes the public wharf and the area for roll-on/roll-off vessels, (used to carry wheeled cargo), shipbuilding and repair. It has 1,952m of mooring berth, an internal area for operations of approximately 60,000sqm comprising 20 warehouses to stock goods. The cargoes include cellulose, wind blades, dry bulk such as soy, wheat, and chemicals, such as fertilizers<sup>(4)</sup>.

Data collection was done through nonparticipant observation of temporary port workers during their work activities, focusing on the sources of physical, chemical and biological occupational hazards, which may cause respiratory disorders in these workers.

Observation was based on a checklist instrument tailored to the port environment. The instrument includes sociodemographic information, as well as closed questions regarding the working tools used, sources of biological, chemical and physical hazards and types of cargo transported. Regulatory Norms (NR), specifically NR-29 and NR-15, of the Ministry of Labor and Employment, related to Safety and Health in Port Work and Unhealthy Activities and Operations, respectively, governed by the Consolidation of Labor Laws (CLT), were consulted<sup>(9,13)</sup>.

Observation was direct, without participation and/or influence in the activities performed by the temporary port workers, made by members of the research group Laboratory of Study and Socioenvironmental Processes and Collective Health Production. Data collection of each worker was done by two observers (in pairs), in order to obtain as much information as possible about the worker's activity and to assure greater reliability and accuracy in data collection.

Nonparticipant observation aimed to collect information from the various work environments and activities. Data collection was made in weekdays, in the morning and afternoon shifts (overnight observation was not possible because there was no Labor Safety team available for monitoring) from July to December 2014, for 8 to 9 hours daily.

Eighty-seven (87) observations were made, and the total number of workers observed was 66. The participants could be observed at different times and performing different activities because individuals with the same occupation may carry out different activities in different environments in port facilities. All workers met the inclusion criteria, that is, they were performing work activities during observation.

The occupations observed were shore handling (involves activities related to the handling of goods, such as cargo reception, checking, internal transportation, loading and unloading cargo from vessels, among others), stevedoring (involves placement, removal and arrangement of cargo in holds and decks of vessels) and cargo checking (activity of counting volumes, taking notes of characteristics, origin or destination of cargoes, checking the status of goods and other operations related to the state of the goods and other actions related to the operations of loading and unloading of vessels). All these activities are performed at the pier.

No information was collected from port workers who had other occupations because either they were not performing their activities at the time of the observation, or access to the work environment was not possible. The variables observed were the sources of chemical, physical and biological hazards, the cargoes handled by the workers and the place where the activity was performed.

Descriptive statistics of data was performed with absolute and relative frequencies of the variables investigated using the Statistical Package for Social Sciences software (SPSS), version 21.0. Ethical guidelines for research involving human beings were observed according to the recommendations of Resolution No. 466 of the National Health Council, of December 12, 2012<sup>(14)</sup>. The project was approved on July 16, 2013 by the Research Ethics Committee in Healthcare of Universidade Federal do Rio Grande, under No. 118/2013.

## ● RESULTS

In the study, 66 temporary port workers (TPA), all of them were males, selected by convenience sample, were observed. The total number of observations was 87. The observations occurred throughout the entire period during which the workers performed their activities, and sometimes one or more observations had to be made in one shift. The criterion established for the observation was observing the workers perform all the different activities of their occupations at least once. Shore handling prevailed in the observations as this is the occupation of most port workers, and the activities are mostly performed at the pier, the site where the greatest part of port operations are developed.

The mean age was 51.7 years (standard deviation - SD  $\pm$  8.36), with a minimum of 37 years and a maximum of 73 years. The average length of time working in the profession was 15.35 years (SD  $\pm$  1.85), with a minimum of 5 years and a maximum of 17 years. Regarding skin color, most self-declared as white (n = 49; 74.7%) and, regarding marital status, (n = 37; 56%) were married. The other sociodemographic data are presented in Table 1.

Table 1 - Locations and activities observed in the port work environment. Brazilian maritime port, RS, Brazil, 2014

Professional occupations observed	Locations observed N = 87	Activities observed	N	%
Shore handling	Pier (n = 66)	Hopper operation (hopper for receiving grain load)	42	48
		Mason	5	5.7
		Operation of weighing scale	4	4.5
		Ship berthing and unberthing	3	3.4
		container loading and unloading	3	3.4
		Unloading of barge or lighter (transport of merchandise for boat not moored in the wharf)	3	3.4
		Backhoe loader operation	2	2.2
		Crane Operation	2	2.2
		Paver (repair activity at the pier using mallets and mason's blades)	2	2.2
	Car yard (n = 4)	Mooring and unmooring of cargo	3	3,4
		Operator of vehicles on cargo lift platforms	1	1.1
	Mechanical workshop (n = 3)	Carpentry	2	2.2
		Welding	1	1.1
Gate of entry (n = 4)	Monitoring trucks with cargo in ports	3	3.4	
	Assistance in loading and unloading of goods	1	1.1	
Stevedoring	Ship deck (n = 2)	Winch operations and signaling	2	2.2
	Barge or lighter (n = 2)	Loading of barge or lighter	2	2.2
	Ship's hold (n = 3)	Cleaning and operation of backhoe excavator	3	3,4
Cargo checking	Ship access ramp (n = 3)	Cargo counting and checking	3	4.4

The observation periods totaled 167 hours and 10 minutes, and 87 observations were made. Of these, 77 (88.5%) concerned shore handling operations, seven (8.04%) concerned stevedoring and three (3.4%) cargo checking. Hopper operation (42; 48.2%) was the most frequently observed activity, since the handling of bulk cargo is an important segment of port activities, and mason work (five, 5.7%) and weighing scale operation (four, 4.5%) were respectively the second and third most frequently observed activities.

The observations occurred during the different work shifts (morning and afternoon), and involved workers who performed different activities and occupations in the work places. Examples: workers in shore handling who worked at the pier, workers in carpentry, etc.

### Sources of physical, chemical and biological occupational hazards

All the observations identified exposure to the sources of physical, chemical and biological hazards capable of causing respiratory disorders, as shown below (Table 2).

Table 2 - Identification of sources of physical, chemical and biological occupational hazards observed in the port work environment. Brazilian maritime naval port, RS, Brazil

Sources of Occupational Hazards	N = 87 observations N (%)
Physical	
Cold	67 (77)
Wind	63 (72.4)
Humidity	41 (47.1)
Non-ionizing radiation	22 (25.2)
Heat	8 (9.2)
Rain	4 (4.6)
Mist	2 (2.3)
Chemical	
Dust produced in cargo handling	80 (91.9)
Gases	20 (23)
Biological	
Pigeon stool	19 (21.8)

The transport of cargoes (fertilizers, seeds and grains) was one of the most frequent activities observed. Urea (NH<sub>3</sub>) was found to be the most widely handled fertilizer in the port: of the 87 observations related to the handling of fertilizers, 19 (21.8%) concerned urea. Potassium rock and diammonium phosphate were described in six (6.8%) observations each. Granulated ammonium sulphate was described in four observations (4.6%) and monoammonium phosphate and potassium chloride, in three (3.4%). Of the cereals transported, wheat and corn bran were described in five (5.7%) observations, for each cereal, and soybean in two (2.3%) observations.

The presence of liquid or solid particles suspended in the atmosphere was also remarkable. The main sources of toxic substances were motor vehicles and dust resuspension. There was an association between air pollutant emissions from motor vehicles, the movement of cargoes and the presence of chemical dust, as well as wind, humidity, non-ionizing radiation and heat.

### Occupations and sites of work-exposure to hazards

Sixty-six (75.8%) workers observed performed their activities at the pier. Except for the workers who performed indoor activities (mechanical workshop), all of them were exposed to physical hazard

associated to the weather conditions. Dust resulting from cargo handling was the source of chemical hazards observed in the port. Biological hazards were predominant at the pier (66; 75.8%), due to the large concentration of pigeons attracted by the grains in the soil.

It should also be stressed, among the data observed, that the three types of hazards investigated were visualized in all workplaces, as shown in Table 3 below.

Table 3 – Workplace and exposure to physical, chemical and biological hazards according to the professional occupations observed. Brazilian maritime port, RS, Brazil, 2014

Occupations observed	Workplace	N = 87 N (%)	Main sources of hazards		
			Chemical	Physical	Biological
Shore handling (87.4%)	Pier	66 (75.8)	Cargo handling.	Rain, wind, humidity and non-ionizing radiation.	Pigeon stool.
	Car yard	4 (4.5)	Cargo handling.	Rain, wind, humidity and non-ionizing radiation.	Pigeon stool.
	Mechanical workshop	3 (3.4)	Inhalation substances present in paints, varnishes and solvents.	-----	----
	Entrance gate	3 (3.4)	Cargo handling.	Rain, wind, humidity and non-ionizing radiation.	Pigeon stool.
Stevedoring (9,1%)	Deck	3 (3.4)	Cargo handling.	Rain, wind, humidity and non-ionizing radiation.	Pigeon stool.
	Hold	3 (3.4)	Cargo handling.	Rain, wind, humidity and non-ionizing radiation.	Pigeon stool.
	Barge or lighter	2 (2.2)	Cargo handling.	Rain, wind, humidity and non-ionizing radiation.	Pigeon stool.
Cargo checking (3.4%)	Ramp for access to vessels	3 (3.4)	Cargo handling.	Rain, wind, humidity and non-ionizing radiation.	Pigeon stool.

## ● DISCUSSION

Most workers were men over 50 years of age who have been working in the port facility for more than 15 years. It is known that the onset of some occupational diseases requires latency and a long period of exposure. It also depends on the health status of the worker.

The work environment in port facilities presents several sources of health hazards<sup>(4)</sup>, which means that most TPA perform their activities in an environment exposed to physical, chemical and biological hazards.

The study found that the weather conditions can create conditions that favor a higher concentration of particulate matter in the atmosphere, and higher temperatures contribute to increase the concentration of air pollutants. Particulate material is formed by extremely small particles in the air that when inhaled may affect the cardiovascular and respiratory system<sup>(15-16)</sup>.

The chemical hazards were observed in cargo handling fertilizers and motor vehicles, associated with weather conditions. Fertilizers are organic and inorganic substances, consisting of three main compounds: Potassium (K), Phosphorus (P) and Nitrogen (N)-NPK. According to the International Fertilizer Industry Association (IFA) and the United Nations Environment Program (UNEP)<sup>(17)</sup>, Ammonia (NH<sub>4</sub>) is the source of approximately 99% of the nitrogen supplies. However, these supplies must be converted into other substances, such as urea (NH<sub>3</sub>), in some applications. This substance was handled in most port operations observed.

In the health-sickness process, we stress the importance of exposure to dust during the handling of cargo such as urea. This substance does not pose risks to health when stored and transported, but in contact with the respiratory system it may cause throat irritation, burning pain and inflammation. This hazard is associated with the loading and unloading of fertilizer in bulk.

According to the observations made, during the loading of urea into the vessels, part of the cargo is dropped on the floor, and in hot and humid days, there is volatilization of ammonia. When disposed, ammonia reacts with sulfur compounds in the atmosphere. At high concentrations it increases the concentration of nitrite in blood, with oxidation of hemoglobin, impairing oxygen transport by the blood, and interfering with oxygen delivery to the tissues<sup>(19-20)</sup>.

It is also of responsibility of occupational health nurses the identification of occupational risk factors that can, directly or indirectly, harm the workers' health. Exposure to chemical hazards as a result of fertilizer handling, as well as from air pollution emissions from motor vehicles, trucks and machines was detected in the observation of the activities performed by workers at the pier.

Depending on the concentration and daily amount of exposure of workers, carbon monoxide can cause conjunctivitis, headache, and dyspnea, and depending on the time length even loss of visual acuity<sup>(20)</sup>. A study identified symptoms such as chronic bronchitis, emphysema and obstructive diseases<sup>(21)</sup>. Some studies also showed that daily and continuous exposure to carbon monoxide and hydrogen sulfide can cause chronic obstructive pulmonary disease (DPOC) and death<sup>(22)</sup>.

Other important respiratory disorders are associated with welding activities performed by workers in the mechanical workshop at the pier, where elimination of stainless steel may cause acute lung injury<sup>(23)</sup> and chronic damage such as pneumoconiosis. The latter concern a group of occupational diseases associated to inhalation of small particles. Only particles less than 10µm in diameter penetrate the lungs upon inhalation, because they cannot be easily eliminated by the body defense mechanisms, resulting in an inflammatory process. The pneumoconiosis may be aggravated during exposure to environmental pollution and may over time cause fibrosis and emphysema or chronic airflow limitation and, especially, dyspnea on exertion<sup>(24)</sup>.

Other chemical substances, such as chlorine (Cl) and gases derived from nitrogen and sulfur (present in the atmosphere due to the chemical process that occurs during volatilization of ammonia), at high concentrations and after a long time of exposure, can cause disorders in the upper respiratory tract<sup>(25)</sup>. Over time, cumulatively, urea (NH<sub>3</sub>) can also affect the workers' health conditions, and thus, maintenance and/or adaptation to the environment is necessary to ensure the balance of the functional structure and for health preservation<sup>(26)</sup>.

The source of biological hazard observed was the predominance of pigeons in the external environment of the port. These animals can transmit cryptococcosis, which is a respiratory disorder resulting from inhalation of dust containing dry feces, which may cause asymptomatic lung infection, reaching the Central Nervous System (SNC) and spreading to other organs<sup>(27)</sup>. So the challenges faced by the health actions to protect workers, according to the Institute of Medicine (IOM), the challenges faced by health professionals regarding the measures targeted to the protection of workers derive, among others, from individual factors such as beliefs and risk perception; from environmental factors, including the availability of Personal Protective Equipment (EPI) as well as organizational factors such as training programs. The coordination of these factors is a major component for promoting safety<sup>(28)</sup>.

We emphasize the importance of health actions targeted to workers in the port environment, with the identification of the exposure to hazards in actions targeted to health promotion and prevention of occupational disorders<sup>(29)</sup>.

The characteristics of port activities that involve high employee turnover, and the fact that no observations were made during the night and in the weekends, prevented us from collecting more information. Also, we were unable to observe the activities of workers of all port occupations, which was one limitation of the present study.

## ● CONCLUSION

Environmental exposure and sources of hazards were observed in the activities performed by temporary port workers. These sources of hazards can cause major respiratory disorders. Port workers are frequently exposed to sources of occupational hazards, and they are less or more vulnerable to these hazards depending on their activities and workplace.

The workers most exposed to occupational hazards were those who performed shore handling activities, most of them at the pier, an environment that exposes these individuals to different sources of hazards, such as ionizing radiation, wind, humidity, pigeons and dust produced by fertilizers.

Occupational health nurses must carry out health interventions to encourage the use of Personal Protective Equipment to prevent or minimize occupational exposure, and develop educational actions to promote health care and prevent respiratory diseases. Therefore, a socio-environmental approach is needed to improve the quality of work and the well-being of temporary port workers.

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