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Assessment of the Impact of Industrial Harm on the Mucous and Solid Tissues of the Oral Cavity

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Abstract: Occupational pathology of the oral cavity is one of the pressing problems of modern dentistry and occupational medicine, due to the steady increase in the number of workers exposed to adverse production factors. According to the World Health Organization, more than 2.8 billion people worldwide work in conditions of exposure to various occupational hazards, and oral diseases of occupational etiology account for up to 15-20% of all occupational diseases in the structure of the total morbidity of the working population.

Keywords: occupational hazards, oral cavity, periodontal tissues, oral mucosa, production factors, dental health of workers, occupational hygiene, occupational pathology, enamel erosion, occupational dentistry.

Introduction. Industrial enterprises of chemical, metallurgical, machine-building, mining, and other sectors of the national economy are characterized by the presence of a wide range of potentially hazardous production factors capable of directly or indirectly affecting oral tissues. The intensification of industrial production, the introduction of new technological processes and chemical substances create additional risks for the health of workers and require constant monitoring of their impact on the state of organs and tissues of the dentoalveolar system. The anatomical and physiological characteristics of the oral cavity make its tissues particularly vulnerable to various industrial hazards. The mucous membrane of the oral cavity, characterized by high permeability, rich vascularization, and intensive innervation, serves as a primary barrier to the entry of toxic substances into the body. Dental hard tissues, despite their high mineralization, are also susceptible to aggressive chemical compounds that can disrupt their structural integrity and functional properties.

The modern classification of industrial hazards includes chemical, physical, biological, and psychophysiological factors of the production environment. Chemical factors are represented by inorganic and organic compounds, acids, alkalis, heavy metal salts, organic solvents, and other toxic substances. Physical factors include ionizing and non-ionizing radiation, vibration, noise, extreme temperatures, and working area air pollution.

The pathogenetic mechanisms of industrial harmful substances' effects on oral tissues are characterized by diversity and depend on the nature of the acting factor, its concentration, exposure duration, and the individual sensitivity of the organism. Direct toxic effects manifest as chemical burns of the mucous membrane, erosive-ulcerative lesions, and disruption of keratinization and epithelial regeneration processes. Indirect effects are implemented through systemic effects, including impaired microcirculation, immunosuppression, endocrine dysfunctions, and metabolic disorders.

Acid erosion of teeth is one of the most characteristic manifestations of the professional impact of inorganic and organic acids on the hard tissues of teeth. Workers in chemical production facilities, battery plants, and galvanic workshops are exposed to sulfuric, hydrochloric, nitric, acetic, and other acid vapors, leading to the demineralization of enamel and dentin, the development of increased tooth sensitivity, and the formation of characteristic hard tissue defects.

The effect of alkaline compounds is characterized by the development of alkaline necrosis of the oral mucosa, disruption of saliva formation processes, and a change in the pH of the oral fluid. Workers in industries involving the use of caustic soda, ammonia, calcium hydroxide, and other alkaline

substances constitute a high risk group for the development of chemical burns of the oral cavity and their long-term consequences.

Heavy metal salts have a complex effect on oral tissues, manifesting as a metallic taste, mucosal hyperpigmentation, gingivitis, stomatitis, and characteristic changes in the gingival margin. Lead, mercury, and cadmium intoxications have specific clinical manifestations in the oral cavity, making dental examination an important component in the diagnosis of occupational poisoning.

Organic solvents widely used in the paint and varnish, chemical, and pharmaceutical industries are capable of causing degenerative changes in the oral mucosa, dysfunction of the salivary glands, and the development of xerostomia. Chronic exposure to benzene, toluene, xylene, and other aromatic hydrocarbons is associated with an increased risk of developing precancerous oral diseases.

Industrial dust of various origins has mechanical and chemical effects on oral tissues. Silicate dust, formed when working with quartz-containing materials, can cause chronic stomatitis, hyperkeratosis of the mucous membrane, and increased erosion of teeth. Asbestos dust is associated with the development of malignant neoplasms in the oral cavity, which requires special attention to preventive measures for workers in the relevant industries.

The physical factors of the production environment also have a significant impact on the condition of the oral cavity. Ionizing radiation causes radiation mucositis, xerostomia, disruption of wound healing processes, and increased risk of malignant tumors. Nuclear industry workers, radiologists, and other professional groups exposed to ionizing radiation require regular dental monitoring and preventive measures. Vibration disease developing in workers using a vibration instrument is accompanied by a disruption of microcirculation in the oral tissues, which can lead to the development of periodontitis, delayed wound healing, and a decrease in local resistance to infection. Noise exposure is associated with an increased risk of developing bruxism and associated dentofacial system disorders.

The temperature factors of the industrial environment have a significant impact on the condition of oral tissues. Working in high-temperature conditions contributes to the development of xerostomy, disruption of the electrolyte balance of oral fluid, and an increased risk of dental caries. Exposure to low temperatures can lead to impaired blood circulation in the oral tissues and the development of cold injuries.

Biological factors of the production environment, including various microorganisms, fungi, viruses, and their products, pose a particular danger to workers in agriculture, the food industry, medical institutions, and biotechnological industries. Occupational infections of the oral cavity can have specific clinical manifestations and require a differentiated approach to diagnosis and treatment.

Psychophysiological factors of the labor process, including nervous-emotional tension, monotony of work, unfavorable ergonomic conditions, have an indirect influence on the condition of the oral cavity through neuro-humoral regulatory mechanisms. Chronic stress contributes to the development of bruxism, aphthous stomatitis, scarlet fever, and other diseases of the oral cavity with unclear etiology.

The diagnosis of occupational diseases of the oral cavity is a complex interdisciplinary task requiring close cooperation between dentists, occupational pathologists, occupational hygienists, and other specialists. Establishing a cause-and-effect relationship between the influence of a production factor and the development of pathological changes in the oral cavity is based on a comprehensive assessment of professional history, clinical examination results, workplace hygienic characteristics data, and the results of additional research methods.

Modern diagnostic methods include spectral analysis of oral tissues to determine the content of toxic substances, cytological and histological studies to assess the nature of pathological changes, immunological tests to identify disorders of local and general immunity. Molecular-biological methods allow for the identification of genetic polymorphisms associated with increased sensitivity to the effects of industrial hazards.

The prevention of occupational oral pathology is based on the principles of primary, secondary, and tertiary prevention. Primary prevention includes the hygienic regulation of harmful substances in the air of the work area, improvement of technological processes, use of collective and individual protective equipment, conducting preliminary and periodic medical examinations.

Secondary prevention is aimed at early detection of the initial signs of occupational pathology, implementation of therapeutic and preventive measures, and prevention of disease progression. The development of professional oral hygiene programs, including the use of special means to protect the mucous membrane and hard tissues of teeth from the effects of industrial hazards, is of particular importance. The oral cavity, being the initial part of the digestive tract and respiratory tract, is in direct contact with aggressive substances present in the production environment. This makes the tissues of the oral cavity particularly vulnerable to the development of occupational pathology. Occupational diseases of the oral cavity represent a pressing medical and social problem of our time, caused by the widespread prevalence of harmful production factors and their negative impact on the dental health of the working population. Modern industrial production is characterized by the widespread use of various chemical substances, physical influences, and technological processes that can negatively impact workers' health. A special place in the structure of occupational diseases is occupied by lesions of the oral cavity tissues, which often become the first manifestations of the impact of harmful production factors on the human body.

According to the International Labor Organization (ILO), more than 2.3 million cases of occupational diseases are registered annually worldwide, with a significant portion affecting the oral organs [1]. The problem is becoming particularly relevant due to the intensive development of the chemical, metallurgical, and mining industries, where workers are exposed to aggressive chemical substances, industrial dust, high temperatures, and other unfavorable factors of the production environment. Statistical data indicate that the prevalence of dental diseases among workers in harmful industries is 2.5-3 times higher than similar indicators in the general population [2]. The oral cavity, being the "entrance gate" of the body, is the first to be exposed to industrial aerosols, acid and alkali vapors, metal and mineral dust, which leads to the development of specific pathological changes in periodontal tissues, mucous membrane, and hard tissues. The most characteristic manifestations of occupational exposure are acidic enamel necrosis, occupational periodontitis, mucosal leukoplakia, and chronic recurrent aphthous stomatitis. [3].

The socio-economic significance of the problem is determined not only by high morbidity rates but also by a significant decline in the quality of life of workers, premature loss of work capacity, significant economic losses associated with temporary disability, and the need for expensive treatment. According to WHO experts, the economic damage from occupational diseases of the oral cavity is 0.8-1.2% of the gross domestic product of developed countries [4]. Modern challenges and new risks are associated with the introduction of nanotechnologies, the use of new synthetic materials, and the development of biotechnologies. Metal nanoparticles, carbon nanotubes, and quantum dots possess unique physicochemical properties, and the mechanisms of their biological effects on oral tissues remain insufficiently studied. Preliminary studies show that nanoparticles are capable of penetrating the oral mucosa and accumulating in periodontal tissues, causing oxidative stress and inflammatory reactions[5].

The socio-economic significance of the problem is determined not only by high morbidity rates but also by a significant impact on the quality of life of workers, their work capacity, and social functioning. According to the WHO, the economic damage from occupational diseases of the oral cavity is 0.8-1.2% of the gross domestic product of developed countries, which in absolute terms is estimated at billions of dollars annually[6].

Analysis of temporary disability shows that workers with occupational diseases of the oral cavity lose an average of 18.3 working days per year compared to 4.7 days in the control group. Premature loss of work capacity due to severe forms of occupational pathology of the oral cavity occurs in 12.4% of patients under 50 years of age, which leads to significant social and economic losses[7]. Tertiary

prevention involves the medical and social rehabilitation of workers with established occupational diseases of the oral cavity, rational employment, and dispensary observation. Developing individual rehabilitation programs, taking into account the nature and severity of occupational pathology, is an important component of comprehensive medical care for this category of patients.

The socio-economic significance of the problem of occupational oral pathology is determined not only by direct costs for the treatment and rehabilitation of injured workers, but also by indirect losses associated with temporary and permanent loss of work capacity, decreased labor productivity, and reduced quality of life of patients. The economic effectiveness of preventive measures significantly exceeds the costs of treating developed occupational diseases.

Modern industrial development trends, including the automation of production processes, the introduction of nanotechnologies, and the use of new chemical compounds, pose new challenges for the prevention of occupational pathology in the oral cavity. Nanoclusters and nanoparticles possess unique physicochemical properties, the mechanisms of their biological action on oral tissue require further study. International experience in the prevention of occupational pathology indicates the need to develop unified approaches to assessing occupational risks, standardize diagnostic and treatment methods, and create a system for monitoring the health status of the working population. Harmonizing national standards with international requirements contributes to improving the effectiveness of preventive measures.

Personalized medicine opens up new opportunities for predicting the individual risk of developing occupational oral pathology based on genetic testing, assessing metabolic status, and other biomarkers. Developing algorithms for an individual approach to prevention and treatment, taking into account the patient's genetic predisposition and phenotypic characteristics, is a promising area for the development of occupational pathology.

Telemedical technologies and remote monitoring systems open up new opportunities for real-time monitoring of workers' health, early detection of pathological changes, and timely implementation of corrective measures. The integration of production environment monitoring systems with medical information systems allows for the creation of a comprehensive professional risk management system.

The cost of treating occupational diseases of the oral cavity is 3.2-4.8 times higher than the cost of treating similar diseases of non-professional etiology due to the greater severity of lesions, the need for specialized treatment methods, the duration of therapy, and the high frequency of relapses[8]. The disadvantages of the existing system for the prevention and diagnosis of occupational diseases of the oral cavity include: the lack of unified diagnostic criteria for various forms of occupational pathology, insufficient training of dentists on occupational pathology issues, incomplete coverage of workers with preventive examinations (73.2% versus the recommended 100%), late diagnosis of diseases (68.4% of cases, diagnosis is established in the late stages) [9]. International experience in combating occupational diseases of the oral cavity demonstrates the effectiveness of comprehensive prevention programs. In Germany, the implementation of the national program "Gesunde Zähne am Arbeitsplatz" has led to a 34% decrease in the frequency of occupational lesions of the oral cavity over 10 years. In Japan, the use of a system for early detection of occupational pathology using biomarkers has reduced the incidence of severe forms of the disease by 42%[10]. Scientific and technological progress opens up new possibilities for diagnosing, treating, and preventing occupational diseases of the oral cavity. The development of molecular diagnostics, proteomics, and metabolomics allows for the identification of early markers of industrial harmful effects before the development of clinically pronounced pathologies. Using artificial intelligence and machine learning in data analysis opens up prospects for creating personalized prevention programs[11].

Demographic trends increase the relevance of the problem: the aging of the working population, the increase in the duration of labor activity, and the growth of the number of women employed in hazardous industries. By 2030, it is projected that the number of workers over 50 years old in hazardous working conditions will increase to 38.7%, which will require a review of approaches to the medical provision of this category of workers. Thus, the impact of harmful production factors on the

condition of oral tissues is a multifaceted problem requiring a comprehensive interdisciplinary approach, uniting the efforts of specialists in the fields of dentistry, occupational pathology, occupational hygiene, and healthcare organization. Developing effective strategies for the prevention, early diagnosis, and treatment of occupational diseases of the oral cavity is a priority task of modern occupational medicine and has important socio-economic significance for societies[12].

Modern trends in industrial development, the introduction of new technologies and materials, and changes in the nature of production processes require a reassessment of approaches to assessing occupational risk to dental health and the development of effective preventive measures. The insufficient study of the mechanisms of action of new chemical compounds, nanoparticles, and electromagnetic fields on oral tissues necessitates in-depth research in this area. The production environment is characterized by the presence of a complex of physical, chemical, biological, and psychosocial factors that, under certain conditions, can adversely affect the working person's body. The oral cavity, having high sensitivity to external influences and being the initial part of the digestive tract, is the first to be exposed to industrial hazards coming through inhalation[13].

The main groups of production factors that negatively affect oral tissues include: chemical substances (acids, alkalis, heavy metal salts, organic solvents), physical factors (industrial dust, high and low temperatures, ionizing radiation), biological agents (pathogenic microorganisms, fungi, viruses), and ergonomic factors (improper organization of the workplace, monotony of work). The pathogenetic mechanisms of oral cavity occupational pathology development are diverse and include direct toxic effects on tissues, disruption of local defense mechanisms, changes in microbiocenosis, development of allergic reactions, and systemic metabolic disorders. The features of the anatomical structure and physiological functions of the oral cavity (rich vascularization, high permeability of the mucous membrane, constant humidity) create prerequisites for the rapid development of pathological processes[14].

The clinical manifestations of the impact of industrial hazards on the oral cavity are characterized by a wide range of pathological changes: from functional disorders of saliva secretion to severe destructive processes in the tissues of the periodontium and jawbone. The most common forms of occupational pathology are occupational dental erosion upon exposure to acid aerosols, fluorosis upon excessive fluoride intake, and pneumoconioses of the maxillofacial region upon inhalation of silicon-containing dust. Diagnosing occupational diseases of the oral cavity presents certain difficulties related to the need to differentiate them from general somatic pathology, the polymorphism of clinical manifestations, and the long latent period of disease development. This requires a comprehensive approach using modern research methods, including molecular-genetic and biochemical impact markers [15].

The prevention of occupational diseases of the oral cavity should be comprehensive and include technical, sanitary-hygienic, medical-biological, and organizational measures. Developing effective personal protective equipment, optimizing work and rest schedules, and conducting regular preventive examinations and medical checkups for employees are of particular importance.

Conclusions: The problem of the impact of harmful production factors on the condition of oral tissues remains relevant in modern occupational medicine. Early detection and timely treatment of occupational lesions of the oral cavity, as well as effective prevention, significantly reduce the risk of developing serious complications and preserve the work capacity of workers. Successfully solving this problem requires a comprehensive approach, including improving technological processes, strict adherence to sanitary and hygienic standards, regular medical monitoring of workers, and increasing their awareness of potential occupational hazards. Further development of preventive dentistry in production conditions, the introduction of new methods for early diagnosis and effective treatment of occupational lesions of the oral cavity remain important tasks of modern occupational medicine.

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