



Hygienic Assessment of Working Conditions and Occupational Health Risks Among Railway Transport Workers in the Fergana Valley

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Abstract

This study aimed to evaluate working conditions and occupational health risks among railway transport workers in the Fergana Valley. A comprehensive hygienic assessment of the working environment was conducted based on data obtained from 6,018 employees of railway transport enterprises. Hygienic measurements of microclimate, noise, airborne pollutants, and workplace factors were performed using standardized methods. Medical examination records, occupational morbidity statistics, temporary disability indicators, and questionnaire data collected between 2020 and 2024 were analyzed. The results demonstrated that workers were exposed to multiple harmful occupational factors, including excessive noise, elevated temperatures, airborne dust, diesel fuel vapors, and psycho-emotional stress. Musculoskeletal disorders, cardiovascular diseases, respiratory diseases, and sensorineural hearing impairment represented the most prevalent health conditions. Occupational disease rates increased with work experience and duration of exposure. Implementation of comprehensive preventive measures was associated with improved working conditions and substantial economic benefits.

Keywords: *occupational health, railway transport workers, hygienic assessment, working conditions, occupational diseases, noise exposure*

INTRODUCTION

Railway transport plays a crucial role in the economic development of modern societies by ensuring continuous movement of passengers and goods across extensive geographical territories. The efficiency and safety of railway transportation largely depend on the health status, professional performance, and working capacity of railway employees. Therefore, preservation of occupational health among railway workers represents an important public health, social, and economic priority.

Workers employed in railway transport enterprises are exposed to a wide range of occupational hazards during their professional activities. The working environment is characterized by complex interactions of physical, chemical, ergonomic, and psycho-emotional factors that may adversely affect health and working capacity. Long-term exposure to unfavorable occupational conditions contributes to increased prevalence of occupational diseases, temporary disability, reduced productivity, and deterioration of quality of life among employees.



Among the most significant occupational hazards in railway transport are excessive noise, vibration, unfavorable microclimatic conditions, industrial dust, exhaust gases, chemical contaminants, insufficient workplace ergonomics, and elevated psycho-emotional stress. Continuous exposure to these factors may result in functional disturbances of various organs and systems, leading to chronic diseases and reduced occupational performance. Numerous studies have demonstrated that occupational exposure to noise and vibration significantly increases the risk of hearing disorders, cardiovascular dysfunction, sleep disturbances, and neuropsychological disorders.

The Fergana Valley is one of the most densely populated and economically active regions of Uzbekistan, where railway transport serves as a major component of industrial and commercial infrastructure. Railway enterprises operating within the region employ a substantial workforce involved in locomotive operation, maintenance services, technical support, cargo transportation, dispatching activities, and administrative functions. Occupational activities performed under varying environmental and technological conditions may contribute to different levels of occupational risk among employees.

In recent years, increasing attention has been directed toward occupational risk assessment and implementation of preventive measures aimed at improving workplace conditions. Modern occupational hygiene emphasizes comprehensive evaluation of workplace factors and development of evidence-based interventions to reduce harmful exposures. Identification of occupational hazards and assessment of their health effects constitute essential components of preventive healthcare and occupational safety management systems.

Several international studies have demonstrated strong associations between unfavorable working conditions and increased prevalence of musculoskeletal disorders, cardiovascular diseases, respiratory illnesses, hearing impairment, and psychological stress among transport workers. Occupational health surveillance programs indicate that prolonged exposure to harmful workplace factors contributes not only to disease occurrence but also to reduced work efficiency and increased economic losses resulting from temporary disability and medical expenditures.

The growing importance of occupational health protection has stimulated development of national and international regulations aimed at improving workplace safety standards. Hygienic assessment of working conditions allows objective evaluation of occupational hazards and provides scientific evidence for implementation of preventive interventions. Effective preventive programs may contribute to reduction of occupational morbidity, improvement of employee well-being, enhancement of productivity, and optimization of economic outcomes for enterprises.

Despite significant progress in occupational health management, comprehensive data regarding working conditions and occupational risks among railway transport workers in the Fergana Valley remain limited. Existing information indicates that many employees continue to experience exposure to harmful workplace factors capable of negatively affecting health and professional performance. Consequently, systematic evaluation of occupational conditions remains necessary for development of targeted preventive measures and improvement of occupational health protection systems.



The present study aimed to perform a comprehensive hygienic assessment of working conditions and occupational health risks among railway transport workers in the Fergana Valley, evaluate the prevalence of occupationally related health disorders, and determine the effectiveness of preventive measures designed to improve workplace safety and employee health outcomes.

MATERIALS AND METHODS

A comprehensive hygienic and epidemiological study was conducted among railway transport workers employed in enterprises operating within the Fergana Valley. The investigation was carried out between 2020 and 2024 and included assessment of occupational hazards, evaluation of workplace conditions, analysis of workers' health status, and determination of occupational risk factors affecting employee well-being and work capacity.

The study population consisted of 6,018 railway transport employees engaged in various occupational activities including locomotive operation, rolling stock maintenance, track maintenance, dispatching services, engineering support, technical supervision, and administrative functions. Workers representing different age groups, professional categories, and lengths of employment were included in the analysis. The study population comprised both male and female employees who had undergone mandatory periodic medical examinations according to national occupational health regulations.

Assessment of workplace conditions was performed using standardized hygienic research methods approved by national sanitary and occupational health authorities. A total of 1,840 hygienic measurements were conducted at different workplaces and production sites. Measurements included evaluation of microclimatic parameters, workplace noise levels, vibration exposure, illumination characteristics, concentrations of airborne dust, chemical contaminants, and other environmental factors potentially affecting worker health.

Microclimatic assessment included measurement of air temperature, relative humidity, and air movement velocity in accordance with established occupational hygiene standards. Noise exposure levels were determined using certified sound-level measuring equipment. Particular attention was directed toward workplaces characterized by prolonged exposure to locomotive engines, repair machinery, technical equipment, and transport-related operations. Vibration measurements were conducted in occupational settings where workers were exposed to mechanical oscillations generated during railway transportation and maintenance activities.

Chemical and environmental monitoring included determination of airborne dust concentrations, diesel fuel combustion products, exhaust gases, lubricating materials, and other industrial pollutants present in workplace environments. Laboratory analyses were performed using validated analytical techniques to ensure reliability and accuracy of environmental measurements.

Medical data were obtained from periodic health examinations, occupational health records, temporary disability reports, and enterprise medical service documentation. Information regarding morbidity patterns, prevalence of chronic diseases, temporary disability indicators, and occupationally related health disorders was systematically

collected and analyzed. Special attention was given to diseases of the cardiovascular system, respiratory system, musculoskeletal system, auditory organs, and nervous system because these conditions are commonly associated with occupational exposures in railway transport environments.

In addition to environmental and medical assessments, a structured questionnaire survey was conducted among employees to evaluate subjective perceptions of workplace conditions, occupational stress, fatigue, sleep quality, job satisfaction, and awareness of occupational health risks. The questionnaire also collected information regarding lifestyle factors, smoking status, physical activity, work experience, and adherence to occupational safety requirements.

Occupational risk assessment was performed through comparative analysis of workplace exposure levels and health outcomes. Employees were stratified according to occupational category, duration of employment, and degree of exposure to harmful workplace factors. This approach enabled identification of high-risk occupational groups and evaluation of associations between occupational exposures and adverse health outcomes.

The effectiveness of preventive interventions implemented during the study period was also evaluated. Preventive measures included improvement of workplace ventilation systems, modernization of technical equipment, implementation of noise-reduction technologies, optimization of work-rest schedules, strengthening of occupational health monitoring, and enhancement of worker health education programs. Economic effectiveness of preventive measures was assessed through analysis of reductions in temporary disability rates, occupational morbidity indicators, and productivity losses. Statistical analysis was performed using standard epidemiological and biostatistical methods. Quantitative variables were expressed as mean values and standard deviations, while qualitative variables were presented as frequencies and percentages. Comparative analyses were conducted to determine relationships between occupational exposures and health outcomes. Statistical significance was established at a confidence level corresponding to $p < 0.05$.

The study was conducted in accordance with ethical principles governing occupational health research. Confidentiality of participant information was maintained throughout all stages of data collection and analysis. All data were processed and presented in aggregated form without disclosure of personal identifiers.

RESULTS

The hygienic assessment of working conditions demonstrated that railway transport workers in the Fergana Valley were exposed to a complex combination of occupational hazards capable of adversely affecting health status and work capacity. Analysis of environmental measurements revealed that several workplace factors exceeded recommended hygienic standards, particularly in occupations associated with locomotive operation, repair and maintenance activities, and technical servicing of railway equipment.

Microclimatic assessment demonstrated considerable variation in workplace environmental conditions depending on occupational category and production area. Elevated air temperatures were frequently observed in repair workshops and

locomotive maintenance facilities, particularly during the summer period. In several workplaces, air temperature values exceeded recommended hygienic standards by 2–5°C. Relative humidity and air circulation parameters were also found to be suboptimal in certain enclosed production areas. Prolonged exposure to unfavorable microclimatic conditions contributed to increased worker fatigue, reduced concentration, and decreased occupational performance.

Noise exposure represented one of the most significant occupational hazards identified during the investigation. Hygienic measurements revealed that noise levels exceeded permissible limits in a substantial proportion of workplaces associated with locomotive operation, rail maintenance machinery, and repair equipment. Average workplace noise levels ranged from 78 to 96 dBA, with the highest values recorded among locomotive crews and maintenance personnel. Continuous exposure to elevated noise levels was associated with increased prevalence of hearing impairment, sleep disturbances, irritability, and reduced work efficiency.

Table 1. Distribution of harmful occupational factors identified among railway transport workers

Occupational factor	Number of affected workplaces	Percentage (%)
Excessive noise	412	22.4
Unfavorable microclimate	367	19.9
Airborne dust	321	17.4
Chemical contaminants	278	15.1
Vibration exposure	246	13.4
Inadequate illumination	216	11.8
Total	1840	100.0

Air quality assessment demonstrated the presence of occupational exposure to airborne dust and chemical contaminants. Elevated concentrations of particulate matter were detected in repair workshops, track maintenance areas, and locations involving mechanical processing of materials. Diesel fuel combustion products, exhaust gases, lubricants, and industrial aerosols were identified among the principal chemical contaminants affecting workplace environments. Workers exposed to these factors reported higher frequencies of respiratory complaints including chronic cough, throat irritation, and episodic breathing discomfort.

Analysis of medical examination data demonstrated substantial prevalence of chronic diseases among railway transport employees. Diseases of the musculoskeletal system represented the most common category of health disorders identified during the study period. Long-term physical workloads, repetitive occupational movements, and ergonomic strain contributed significantly to development of these conditions. Musculoskeletal disorders accounted for approximately 35% of all recorded chronic diseases among workers.

Cardiovascular diseases represented the second most common category of health disorders. Arterial hypertension, ischemic heart disease, and chronic circulatory disturbances were frequently observed among employees exposed to prolonged

occupational stress and unfavorable workplace conditions. Cardiovascular pathology accounted for approximately 22% of diagnosed chronic diseases.

Respiratory diseases constituted an important component of occupational morbidity. Chronic bronchitis, recurrent respiratory infections, and functional respiratory disturbances were observed more frequently among workers exposed to dust and airborne pollutants. Respiratory diseases represented approximately 18% of recorded morbidity cases.

Table 2. Structure of major health disorders among railway transport workers

Disease category	Number of cases	Percentage (%)
Musculoskeletal diseases	856	35.0
Cardiovascular diseases	538	22.0
Respiratory diseases	440	18.0
Nervous system disorders	318	13.0
Hearing impairment	269	11.0
Other diseases	123	5.0

One of the most significant findings of the investigation was the high prevalence of auditory disorders among employees exposed to prolonged occupational noise. Medical examinations revealed that 42.2% of workers employed in high-noise environments demonstrated varying degrees of sensorineural hearing impairment. The prevalence of hearing loss increased progressively with duration of employment and cumulative occupational exposure.

Questionnaire results indicated that occupational fatigue and psycho-emotional stress were widespread among railway transport personnel. More than half of respondents reported regular experiences of fatigue at the end of work shifts. Sleep disturbances, decreased concentration, irritability, and emotional exhaustion were particularly common among employees involved in shift work and safety-critical operations.

Analysis of occupational experience demonstrated a clear association between duration of employment and prevalence of chronic health disorders. Employees with more than 15 years of occupational exposure exhibited significantly higher rates of cardiovascular diseases, hearing impairment, and musculoskeletal disorders compared with workers having shorter employment histories.

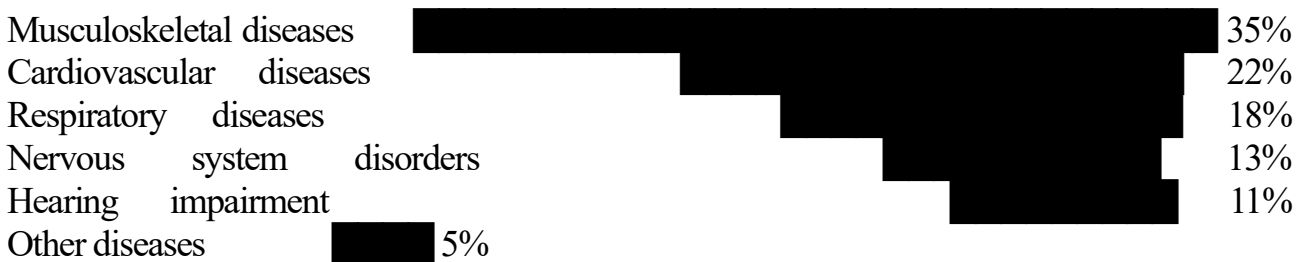
The evaluation of temporary disability indicators revealed substantial economic consequences associated with occupational morbidity. Increased rates of sick leave and reduced work productivity were observed among workers affected by chronic occupationally related health disorders. The cumulative burden of temporary disability represented a significant challenge for both employees and employers.

Implementation of preventive measures during the study period produced measurable improvements in occupational health indicators. Modernization of workplace equipment, enhancement of ventilation systems, introduction of noise-reduction technologies, and strengthening of occupational health surveillance contributed to reduction of harmful exposures. Improvements in workplace conditions were associated with decreases in temporary disability rates and enhanced employee well-being.

Economic assessment demonstrated that implementation of the preventive program generated an estimated economic benefit of approximately 974 million Uzbek soums through reduction of productivity losses, decreased medical expenditures, and lower temporary disability rates. These findings indicate that investments in occupational health protection may provide substantial long-term economic advantages for railway transport enterprises.

Overall, the results demonstrate that railway transport workers in the Fergana Valley remain exposed to multiple occupational hazards contributing to increased risks of chronic disease, functional impairment, and reduced work capacity. The findings further indicate that comprehensive preventive interventions can significantly improve workplace conditions, reduce occupational risks, and enhance both health and economic outcomes.

Figure 1. Prevalence of major health disorders among railway transport workers (%)



DISCUSSION

The results of the present study demonstrate that railway transport workers in the Fergana Valley are exposed to a complex combination of occupational hazards capable of significantly influencing their health status, professional performance, and quality of life. The investigation confirmed that harmful workplace factors remain widespread despite ongoing modernization of railway infrastructure and implementation of occupational safety measures. The findings indicate that occupational hygiene continues to play a crucial role in the prevention of work-related diseases and preservation of employee health within railway transport enterprises.

One of the most important findings of the study was the high prevalence of exposure to excessive workplace noise. Noise remains one of the most common occupational hazards in railway transport systems worldwide. International studies have consistently demonstrated that prolonged exposure to elevated noise levels contributes not only to hearing impairment but also to cardiovascular dysfunction, sleep disorders, psychological stress, and decreased work performance. The present study revealed that noise levels exceeded recommended hygienic standards in several occupational settings, particularly among locomotive operators and maintenance personnel. The identification of sensorineural hearing impairment among 42.2% of exposed workers confirms the substantial occupational significance of this hazard.

The observed relationship between duration of employment and prevalence of hearing impairment supports findings reported in previous occupational health investigations. Long-term cumulative exposure appears to play a decisive role in development of

chronic auditory dysfunction. Similar trends have been documented among railway workers in Europe, Asia, and North America, where hearing disorders remain one of the most frequently recognized occupational health problems in transport industries. These observations emphasize the necessity of strengthening hearing conservation programs and implementation of effective engineering controls aimed at reducing occupational noise exposure.

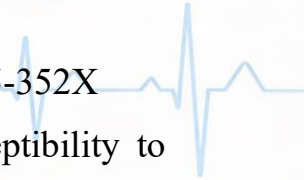
The results additionally demonstrated a high prevalence of musculoskeletal disorders among railway employees. Musculoskeletal diseases accounted for the largest proportion of chronic health conditions identified during the study. This finding may be explained by prolonged static postures, repetitive occupational movements, manual handling activities, and ergonomic deficiencies present in many work environments. Railway maintenance personnel and technical workers frequently perform physically demanding tasks requiring substantial biomechanical effort, thereby increasing the risk of chronic musculoskeletal pathology.

International occupational health literature consistently identifies musculoskeletal disorders as one of the leading causes of temporary disability and reduced productivity among industrial workers. The findings of the present study correspond closely with global observations indicating that inadequate workplace ergonomics contribute significantly to development of chronic pain syndromes, joint disorders, and functional limitations. Consequently, improvement of workplace design and implementation of ergonomic interventions should represent priority components of occupational health management programs.

Cardiovascular diseases constituted the second most prevalent category of health disorders observed among railway workers. Several occupational factors may contribute to increased cardiovascular risk within this population. Chronic psycho-emotional stress, irregular work schedules, shift work, insufficient physical activity, and exposure to environmental hazards may collectively influence cardiovascular health. Previous studies have demonstrated that transport workers frequently experience elevated levels of occupational stress resulting from high responsibility, operational demands, and continuous attention requirements.

The findings of the present study suggest that cardiovascular disease prevention should receive increased attention within occupational health programs. Early identification of cardiovascular risk factors, regular medical surveillance, promotion of healthy lifestyles, and implementation of workplace wellness initiatives may contribute substantially to reducing disease burden among railway personnel. Preventive interventions targeting hypertension, obesity, smoking, and physical inactivity could provide significant health benefits and improve long-term occupational outcomes.

Respiratory diseases represented another important component of occupational morbidity identified during the investigation. Exposure to industrial dust, diesel exhaust emissions, chemical contaminants, and airborne particles likely contributed to increased prevalence of respiratory complaints and chronic respiratory disorders. Numerous international studies have demonstrated associations between occupational exposure to airborne pollutants and development of chronic respiratory diseases among transport workers. Long-term inhalation of particulate matter may result in chronic



airway inflammation, reduced pulmonary function, and increased susceptibility to respiratory infections.

The questionnaire survey additionally revealed widespread occupational fatigue and psycho-emotional stress among workers. These findings are particularly important because psychological well-being has become an increasingly recognized component of occupational health. Modern occupational environments require continuous concentration, rapid decision-making, and high levels of responsibility. Such demands may contribute to chronic stress, emotional exhaustion, sleep disturbances, and reduced mental performance. The observed prevalence of fatigue among employees suggests that optimization of work-rest schedules and implementation of psychosocial support programs may be beneficial.

An important aspect of the present investigation involves evaluation of preventive measures implemented during the study period. The findings demonstrated measurable improvements in workplace conditions following modernization of equipment, enhancement of ventilation systems, and introduction of occupational health interventions. These results support the effectiveness of preventive approaches based on occupational hygiene principles. Reduction of harmful exposures was associated with improvements in employee health indicators and decreased temporary disability rates.

The economic analysis further demonstrated the practical value of occupational health interventions. The estimated economic benefit of approximately 974 million Uzbek soums indicates that investments in workplace safety and health protection may yield substantial financial returns. Reduced absenteeism, improved productivity, lower healthcare expenditures, and enhanced employee performance collectively contribute to economic sustainability of occupational health programs. These findings are consistent with international evidence demonstrating that preventive occupational health measures frequently generate economic benefits exceeding implementation costs.

The study highlights the importance of integrated occupational risk management within railway transport enterprises. Effective prevention requires cooperation among occupational hygienists, physicians, engineers, enterprise administrators, and employees. Comprehensive occupational health programs should include regular environmental monitoring, medical surveillance, risk assessment, worker education, and continuous improvement of workplace conditions. Such multidisciplinary approaches are essential for achieving sustainable improvements in employee health and workplace safety.

Several limitations should be acknowledged. Although the study involved a large population of railway workers and extensive hygienic measurements, the investigation was conducted within a specific geographic region and may not fully represent conditions present in all railway enterprises. Furthermore, some health indicators were obtained through questionnaire surveys and may be influenced by subjective reporting. Nevertheless, the large sample size, comprehensive environmental assessment, and detailed medical analysis strengthen the reliability of the findings and provide valuable information for future occupational health planning.

Overall, the results confirm that occupational hazards remain significant determinants of health outcomes among railway transport workers. At the same time, the study demonstrates that scientifically based preventive measures can substantially reduce occupational risks, improve employee well-being, and generate meaningful economic benefits. These findings support continued development and implementation of evidence-based occupational health strategies within the railway transport sector.

CONCLUSION

The present study demonstrated that railway transport workers in the Fergana Valley are exposed to multiple occupational hazards, including excessive noise, unfavorable microclimatic conditions, airborne dust, chemical contaminants, vibration, and psycho-emotional stress. Long-term exposure to these factors contributes significantly to the development of occupationally related health disorders and negatively affects working capacity, quality of life, and overall health status of employees.

The findings revealed that musculoskeletal diseases, cardiovascular disorders, respiratory diseases, nervous system disturbances, and sensorineural hearing impairment represent the most prevalent health problems among railway workers. The prevalence of chronic diseases increased with duration of employment and intensity of occupational exposure, indicating the cumulative impact of harmful workplace factors on employee health.

Implementation of comprehensive preventive measures, including modernization of technical equipment, improvement of workplace ventilation systems, reduction of occupational noise exposure, strengthening of medical surveillance, and enhancement of occupational health education, was associated with measurable improvements in workplace conditions and employee health indicators. These interventions contributed to reduced temporary disability rates and improved occupational safety outcomes.

The economic assessment confirmed that occupational health interventions provide substantial financial benefits in addition to health improvements. The estimated economic effect achieved through preventive measures demonstrates the practical value of investing in occupational hygiene and worker protection programs. Reduced productivity losses, lower medical expenditures, and decreased absenteeism contribute significantly to organizational efficiency and economic sustainability.

The results emphasize the necessity of continuous occupational health monitoring, systematic risk assessment, and implementation of evidence-based preventive strategies within railway transport enterprises. Strengthening occupational hygiene services and expanding preventive programs may contribute to reduction of occupational morbidity, preservation of employee health, enhancement of workplace safety, and improvement of long-term economic performance.

Future research should focus on longitudinal assessment of occupational exposures, evaluation of emerging workplace hazards, and development of innovative preventive technologies aimed at further improving occupational health protection among railway transport workers.

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