

HEALTH RISK MANAGEMENT IN OCCUPATIONAL MEDICINE

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PROFESSIONAL RISK OF DEVELOPING DISEASES OF THE PERIPHERAL NERVOUS SYSTEM IN TRACTOR DRIVERS – MACHINE OPERATORS OF AGRICULTURAL PRODUCTION

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Based on the results of the hygienic assessment of working conditions in the domestic agricultural machinery of old and new models when performing the main types of seasonal agricultural work during the annual production cycle and analysis of accumulated occupational diseases' nosology structure in agricultural workers of the Saratov region over the period from 2004 to 2014, the estimation of professional risk diseases of the peripheral nervous system in tractor drivers – machine operators of agricultural production is given. Professional risk assessment carried out under the procedure set forth in P2.2.1766-03 has shown that the category of a priori risk to their health during an annual production cycle ranged from high to very high (unbearable). It was revealed that the most important factors shaping the harmful working conditions when working on agricultural machinery that can act as a trigger in the formation of vertebral diseases of the peripheral nervous system, are general and local vibration, adverse micro-climatic conditions, long uncomfortable static working posture and physical stress. The risk of diseases in the peripheral uneven system in machine operators of agriculture was attributed to the high risk category with an index of professional diseases (IPD) equal to 05 %.

Key words: tractor drivers – machine operators of agricultural production, harmful factors of production environment and labor process, professional diseases of the peripheral nervous system.

The back pain epidemic continues to grow year by year; in fact, 34 to 82% of the population of developed and developing countries suffer from repeated pains in the back. The peak incidence occurs in the age of from 30 to 60 years. The WHO reports that the amount of money spent on the treatment of dorsalgia is three times higher than on the treatment of cancer patients [12]. In Russia, it is the most common cause of job-related disability: 20-80% of cases among the socially active population, and 20.4% - among the disabled persons suffering from the degenerative diseases of the osteo-articular system [6, 7].

According to the epidemiological findings, the syndrome of back pains is common among

working-age population. What is more, because of the limited access to specialized healthcare services resulting from the remoteness of some villages from medical organizations, low mobility of village residents, unwillingness or impossibility to take a break from work, as well as lack of targeted detectability of peripheral nervous system disorders during mandatory medical examinations, the physical numbers of morbidity of agricultural workers are 1.7 times higher as compared to the data on hospital or clinic visits [11].

The musculoskeletal system disorders have a complex pluricausal nature determined by various factors: biomechanical, involution, hereditary, developmental abnormalities, hormonal, vascular

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(hypoxic), autoimmune, and adverse environmental conditions that trigger the occurrence and exacerbation of the back pain syndrome [8].

In occupational medicine, much attention is paid to the hygienic assessment of the impact of workplace factors and working process on pathogenesis and the clinical manifestation of this common pathology.

Today researchers believe [2, 3, 9] that the following risk factors may induce job-related peripheral nervous system disorders:

- Physical stress (hard labor): lifting and moving items of weight or cumulative load to the spine, performing monotonous repeated tasks while working with the torso bent forward or backward, using a fixed or awkward body position;
- Whole-body and local vibration especially when combined with physical stress;
- Poor working conditions and workplace microclimate (high humidity, convected or radiant heat, temperature fluctuations);
- Elevated noise level;
- Chronic stress;
- Indoor air quality problems (chemical pollution);
- Chronic stress;

Vertebrogenic disorders of the peripheral nervous system, mainly reflex and compression syndromes at cervical and lumbosacral levels associated with the functional overload are among the most common job-related disorders in Russia today (up to 54% of cases of detected job-related pathology in some of the industries) affecting mostly men aged under 45 [1].

Agricultural tractor operators (agricultural machine operators) are the most qualified professional group in the farming sector. Their working conditions are determined mainly by the technical characteristics and the state of the used machinery; today 60-75% of the machinery is outdated and worn out [4]. When using the agricultural machines, the operators are exposed to most of the above mentioned hazardous job-related factors which could trigger vertebrogenic disorders of the peripheral nervous system [1].

The aim of this research is to assess the job-related risks inducing peripheral nervous system disorders among agricultural tractor operators based on an integrated description of the working conditions, level and structure of occupational morbidity.

Materials and methods. The working conditions during the operation of the agricultural machines most commonly used in Saratov region today: old-style models (DT-75, DT-75N, DT-75S,

K-700, K-701A, VT-100 Volgar, MTZ-80) and recent models (Belorus 1523), as well as combine harvesters: old-style models (SK-5M Niva, SK-5ME-1 Niva-Effekt», RSM-10 Don-1200 and RSM-10 Don-1500) and recent models (RSM-101 VECTOR and RSM-142 CROS).

Assessment of the working conditions was performed with the help of the methods and equipment most commonly used in labor hygiene. Classification of the working environment and working process was conducted in accordance with Regulation 2.2.2006-05 “Guidance to hygienic assessment of occupational hazards. Criteria and classifications of the working conditions”. Health risk assessment was performed with the use of the method described in Regulation R 2.2.1766-03 “Guidance to the assessment of occupational health risks. Organizational and methodological framework, principles and criteria of the assessment”. The parameters of workplace climate, noise level, whole-body and local vibration, workplace air quality – pollution caused by aerosols mainly fibrogenic of action and chemicals, hardness of work and physical stress when performing the main seasonal field works throughout the annual production cycle were performed and analyzed.

The factor and structural analysis of the occupational diseases affecting agricultural operators was performed based on the data collected by the occupational disease clinic Federal Budgetary Research Institution “Saratov Research Institute of Agricultural Hygiene” under the Federal Service for Supervision over the Protection of Human Rights and Wellbeing, and the statistical materials provided by the Directorate of Rospotrebnadzor in Saratov region on form №389-1/y-01 Occupational Disease (Poisoning) Registry for 2004-2014.

Data analysis was performed with the use of Microsoft Office-2007 (MS Excel-07) and Statistica 10.0 software.

Results and discussion.

The analysis of the research findings has indicated that the biggest hazardous job-related factors posing threat to the health and well-being of agricultural operators include elevated noise and vibration levels, workplace air dustiness, poor microclimate in the machine cabins depending on the type of works, model, and length of service of the agricultural machine.

A working engine, traversing gear, propulsion system, and exhaust system are the main sources of noise in tractors. The research findings indicate an elevated maximum permissible level (MPL) of noise at the workplace in cabins of all models and

makes of the tractors under review. The frequency analysis of the levels of the sound pressure has shown that it was wide-range noise with the elevated MPL by 1-18dBA in the cabins of old-style models during all types of field works. The highest noise level (up to $98 \pm 2,4$ dBA) was registered in the cabins of chain-track tractors DT-75 and DT-75S during grain planting. The lowest noise level was registered inside the cabin of "Belorus" 1523 tractor during hauling operations.

The analysis of the noise level inside the combine harvester cabins has shown that only inside RSM-142 CROS and RSM -101 Vector, the noise is close to the permissible level. Inside outdated machines SK-5 Niva, Don-1200, Don-1500), the most popular combine harvesters today, the maximum permissible noise level is exceeded by 5-dBA. The noise level inside the cabin of combine harvester CK-5M Niva during grain harvesting was registered at under $88 \pm 3,3$ dBA. The frequency analysis of the levels of sound pressure showed that it was broadband noise with elevated MPL at both high and low frequencies.

Whole-body vibration in the cabins of agricultural machines varies in terms of strength and transmits through the seat – with the maximum vertical intensity. Local vibration transmits through the operator controls on the hands and legs.

Whole-body vibration in the cabins of agricultural machines is a broadband process with the range of 1-250 Hz, exceeded MPL to 6 dB. In the tractor cabins, increased whole-body vibration was registered at the center frequency of 4-16 Hz, in the combine harvesters – at 4-31.5 Hz. The maximum MPL increase of whole-body vibration (up to 5 dB) was registered on the levers of chain-track tractor DT-75S during grain planting and on the steering wheel of tractors K-700 and K-701A during plowing.

The comparison of vibroacoustic parameters indicated that increased levels were proportional to longer service life. For example, the levels of noise and whole-body vibration in the cabins of the machines with over 10 years in service life were by 2-6 dBA and 2-5 dB higher (respectively) as compared to the average service life of 5-10 years.

In the cabins of new combine harvesters RCM-101 VECTOR and RCM-142 ACROS, the level noise and the levels of whole-body and local vibrations does not exceed MPL. However within 5 years in service, the sound level in RCM-101 VECTOR increases by 5 dBA.

Agricultural field operations cause dust production. The amount of dust varies due to the differences in the field operations, effectiveness of air

purifiers, weather, speed and driving direction of the machine. The main source of dust during agricultural field operations is the undercarriage and the trailing or mounted agricultural implements.

Through gaps in the floor, doors and windows as well as through the air-supply ventilator, dust gets inside the cabin, stays in the air and sets on the operator's clothing, cabin floor and other working surfaces resulting in permanent dustiness of the workplace.

The findings indicate that 76-94% of the dust is soil residues, and the rest is plant residues (seeds, pollen, plant dust particles). The composition of the dust generated in the cabin of a grain harvester is mixed (68-83% organic particles, 32-17% – mineral particles). The concentration of free silica in the dust detected in the cabins of tractors and grain combine harvesters did not exceed 10%.

The highest concentration of dust in the tractor cabins was registered during harrowing (32.1 ± 2.4 mg/mI) and grain planting (34.2 ± 2.8 mg/mI). During grain harvesting, the highest concentration of dust was registered inside the combines of old makes SK-5M1 and SK-5 equipped with low-quality air purifiers (33.3 ± 3.1 mg/mI). In the cabins of combine grain harvesters of newer makes RSM-101 VECTOR and RSM-142 ACROS equipped with air conditioners, the level of dust was lower than MPL (0.14 ± 0.8 mg/mI).

The air in the cabins of agricultural machines of older makes, the air was filled not only with dust, but also with exhaust gases (carbon oxides, nitrogen oxides, acrolein) at the concentration below MPL.

The parameters of the microclimate inside the cabins of the tractor makes under review (temperature, humidity, air velocity, and thermal load) have expressed seasonal variations and are significantly determined by the presence and quality of the air cleaning equipment, cabin sealing and heat insulation. The major sources of heat inside a tractor cabin include solar irradiation (70-80%), working engine, and heated surfaces.

During the warm season, the air temperature inside the cabin of older makes equipped with low quality ventilation devices significantly exceeds the permissible level. To lower the temperature, the operators work with open windows and doors which results in increased dustiness. In the cabin of a chain-track tractor of older makes DT-75, DT-75N, VT-100, the maximum air temperature during the grain planting operations can reach $+39^\circ\text{C}$ while the outdoor temperature is $+26.4 \pm 0.89^\circ\text{C}$.

In the cabins of grain combine harvesters of the older makes SK-5M Niva and RSM-10 Don 1500 with 5-10 years of service, when the microclimate managing devices are turned off, the air temperature can exceed the outdoor temperature by 10 °C. The temperature of the working surfaces inside the cabin can reach +45°C which causes discomfort. The relative air humidity fluctuates in the range 45-90% and depends on the type of microclimate managing devices. The air quality inside the cabins of the grain combines harvesters RSM-101 VECTOR and RSM-142 ACROS with the working air conditioner meets the hygienic standards.

During the cold season, the air inside the tractor cabins is cooler as compared to the outside temperature (below +14°C). The lowest air temperature is registered inside the tractor DT-75 during snow ridging.

Throughout their work day, the agricultural operators have to maintain an awkward working position for extended periods (up to 80% of the shift) coupled with limited general body mobility. In the machines of older makes, an awkward working position is coupled with periodic body tilting and static physical load due to the biomechanically unsound workplace and undue exertion applied to the driving controls. The cabins of the machines of newer makes (RSM-101 VECTOR and RSM-142 ACROS) meet the ergonomic requirements; the operating controls are within the sensor-motor zones which provides for a comfortable working position. However the operators still have to maintain a static working posture for extended periods of time which creates level 2 harsh working conditions (class 3.2).

The analysis of labor intensity has shown that the work carried out by machine operators requires

intensified attention, vision, and hearing due to the need of accurate driving (especially during grain planting and harvesting) and perception of differentiated signals against the noisy background.

Operators typically experience nervous and emotional tension due to tight deadlines of field operations, unsafe or unhealthful working conditions, technical breakdowns, and, quite frequently, unpredictable weather conditions. At the same time, the length of a working shift during emergency field operations (planting, harvesting) can total 12 hours or more.

Based on research findings, we performed a general hygienic assessment of working conditions during agricultural field operations; as a result, we classified the working conditions in terms of the machines under review as hazardous (classes 3.3-3.4) depending on the type of works, type and make of the machine, and length in service (see Table 1).

Now it can be seen that the operators driving older agricultural machines are exposed to a wide range of hazardous job-related factors (physical stress, high level of whole-body vibration, unfavorable microclimate) which can trigger vertebro-genic disorders of the peripheral nervous system as compared to the operators driving newer tractors and grain combine harvesters; the latter mainly face the risk of the musculoskeletal disorders due to the physical stress caused by work in an awkward static posture.

Assessment of the occupational risk performed in correspondence with the method described in R 2.2.1766-03, has shown that the a priori occupational risk to the operators' health changed throughout the annual production cycle from high to very high (impermissible).

A Hygienic Assessment of Operator Working Conditions during Seasonal Agricultural Field Operations

Factor	Classification of workplace conditions					
	Pre-planting plowing	Grain planting	Grain harvesting	Plowing		Snow ridging
				Summer	Fall	
Microclimate	3.1– 3.2	3.1–3.4	2*-3.4	2*-3.4	2	2-3.2
Aerosols of mainly fibrogenic action	3.1– 3.3	3.1– 3.3	2*– 3.3	3.1– 3.3	3.1	–
Gas contamination	2	2	2	2	2	2
Noise	3.1– 3.3	3.1–3.3	2*- 3.2	3.1–3.2	3.2	3.2
Whole-body vibration	3.1	3.1	2* - 3.1	2– 3.1	2– 3.2	3.1
Local vibration	3.1–3.2	3.1–3.2	2* - 3.1	2*-3.2	2*-3.2	3.1
Hardness of work	3.2	3.2	3.2	3.2	3.2	3.2
Intensity of work	3.2	3.2	3.2	3.2	3.2	3.2
Total grade	3.4	3.4	3.3-3.4	3.3-3.4	3.3	3.3

Note: * – in the cabins of newer Russian machines with less than 3 years in service.

Analysis of the job-related morbidity of agricultural operators in Saratov region for 2004-2014 revealed 415 patients suffering from 662 occupational disorders (OD). Despite a twofold reduction in the number of agricultural operators (from 13086 to 6031 people) over the period under review, the level of occupational morbidity in this professional group remains elevated as compared to general morbidity (1,52–5,85 per 10000 agricultural workers in the RF) totals from 25.2 to 56.7 per 10000 operators in different years under review.

The average age of agricultural operators with the initial OD diagnosis totals $49,1 \pm 0,3$ years; at the same time, in 73.4% of cases OD were detected among the operators who had been exposed to hazardous job-related factors for 10-30 years (average length of service $23,3 \pm 0,4$ years).

In the nosological range of cumulative occupational disorders, the first place is taken by the peripheral nervous system diseases (39.5%), namely, lumbosacral radiculopathy, the second – by the respiratory diseases (19.4%), chronic obstructive pulmonary disease, chronic dust non-obstructive bronchitis, bronchial asthma, the third – by the vibration disease (18.3%), the fourth – by sensorineural hearing loss (15.6%). In the last 7 years, the number of patients with the initial combined OD has been continuously growing: only 55.2% of agricultural operators was diagnosed one OD, 39.4% - with 2 disorders, 11.9% - with 3 OD. However, in 76.4% of cases with combined occupational disorders, radiculopathy of lumbosacral level was recorded as the primary diagnosis (Figure 1).

It is noteworthy that the factors contributing to the development of harmful working conditions



Figure 1. Morbidity of job-related peripheral nervous system disorders

during the operation of agricultural machines can cause various peripheral nervous system disorders at the lumbosacral level only in the operators with many years of professional experience. Our observations indicate that the onset of lumbosacral radiculopathy in this group of workers, as a rule, includes functional pain syndromes that occur after at least 10 years of professional experience. This data corresponds with the results obtained by other researchers who are convinced that in some professions with the working conditions similar to those involving the operation of agricultural machines in terms of sanitary and hygienic characteristics, occupational vertebrogenic pathology at the lumbosacral level occurs, on average, after 10-15 years of professional experience [2].

With the account for the class of risk, severity and index of occupational disorders which are, in accordance with R 2.2.1766-03 an integral part of the assessment of occupational health risks, the peripheral nervous system disorders affecting agricultural operators were referred to high risk group with 05% index of occupational diseases.

Consequently, the results of the conducted study indicate that despite a renovation of the technical park, the working conditions of agricultural tractor operators are still harmful and bear the risk of development of job-related peripheral nervous system disorders, namely mainly reflex and compression syndromes at cervical and lumbosacral levels related to the functional stress. This needs to be taken into account when developing prevention programs aimed to reduce the rate of job-related pathologies in this group of agricultural workers.

The results of the conducted studies served as a base for the development of priority hygienic and preventative activities aimed to reduce the risk of operators' health disorders.

Considering that it is impossible to completely remove the hazardous factors affecting the operators due to the fact that 70-75% of the agricultural machine park is older worn-out machines, the hygienic and sanitary-and-technical activities are becoming very important. The activities include renovation the machines, timely general repairs and thorough overhaul, regulation of the hygienic factors of the working environment, hygienic and physiological rationalization of the technological processes as well as work/rest schedule, differentiated scientifically grounded professional selection of the job candidates with the account for individual characteristics, vital statistics, and the presence of adverse health conditions.

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