

Review

## ANALYSIS OF OCCUPATIONAL RISK FACTORS CAUSING DISEASES OF THE CIRCULATORY SYSTEM IN MEDICAL WORKERS: LITERATURE REVIEW

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*The review focuses on analysis of domestic and foreign literature sources concentrating on influence exerted by occupational factors and factors related to labor process on prevalence of diseases of the circulatory system (CSD) among medical workers. At present, specific features typical for occupational activities performed by medical workers are proven to be among major causes of high CSD prevalence among them. Experts have established most common occupational factors and labor-related factors that are able to induce and stimulate development of cardiovascular pathology. Labor intensity associated with neuro-emotional loads, high responsibility, round-the-clock working regime and night shifts (hazard category 3.2–3.3) is established to have a leading role among adverse labor-related factors for medical workers. Other significant contributions are made by adverse chemicals and biological agents, noise and ultrasound, laser exposure and ionizing radiation. Some authors showed that CSD prevalence was considerably higher among medical workers than among people employed in other industries. The highest CSD prevalence was detected among medical workers with the most adverse working conditions (hazard category 3.2–3.3). A high degree of occupational conditionality for CSD is typical for surgeons, therapists, and phthiatricians. Emergency doctors run the highest risk of CSD (RR = 3.1; EF = 67.7 %). Assessment cardiovascular risks according to the SCORE system revealed that approximately 15 % medical workers older than 40 ran moderate cardiovascular risks; medical workers older than 50, high (20.0–22.0 %) or extremely high (10.0–12.5 %) total risks of death due to CSD.*

**Key words:** occupational and work-related risks; diseases of the circulatory system; medical workers.

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Diseases of the circulatory system (CSDs) hold the leading place as per prevalence and severity of complications in the structure of overall morbidity and are among major causes of disability and untimely deaths of employable population [1, 2]. The most common reasons for the epidemic of cardiovascular pathology are factors related to life style such as smoking, alcohol intake, irrational and unhealthy diets, hypercholesterolemia, hypertriglyceridemia, overweight, and hypodynamia [3, 4]. Social and hygienic studies indicate that CSDs are registered in 37–41 % people and at present there is unprecedented growth in CSDs among population. In Bashkortostan CSDs prevalence grew from 31,372.3 cases in 2013

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to 32,253.4 cases in 2017 per 100 thousand adults. They usually take the 3<sup>rd</sup>–5<sup>th</sup> place in the structure of overall morbidity (9.8–14.5 %) and the 1<sup>st</sup>–3<sup>rd</sup> place in the mortality structure (49.9 %) [5–7].

Public healthcare is an activity where workers are exposed to a set of adverse occupational factors including labor hardness and intensity, biological, chemical, and physical factors; they all make for a risk of occupational and work-related diseases, CSDs included. Working conditions and labor process that are typical for various categories and occupational groups in public healthcare are undoubtedly very significant when it comes down to health protection. A lot of medical workers are exposed to hazardous factors, notably, intense nervous and emotional strain, uncomfortable microclimate, adverse chemicals, biological agents, noise, ultrasound, laser exposure, ionizing radiation, and insufficient lighting at a workplace [8–11]. Medical workers are often simultaneously exposed to several adverse occupational factors, from 4 to 7, at their workplaces [12–16]. Occupational activities performed by medical workers involve substantial intellectual loads, elevated requirements to capacity of operative and long-term memory as well as attention; some specialists (doctors and paramedics in emergency aid teams, surgeons) often have to work under extreme conditions in case of an emergency and it requires developing a set of preventive activities aimed at preserving their health and maintaining necessary occupational skills [2, 17–23]<sup>1</sup>. CSDs prevalence among medical workers is different in various occupational groups (from 39.6 to 55.8 cases per 100 patients); however, they occupy the first rank place in the overall morbidity (25.0–27.6 %) for doctors of practically all specialties and the second or third rank place for nurses and paramedics [24]. Bearing in mind that medical workers are exposed to a lot of variable adverse occupational factors at their workplaces

and CSDs prevalence is high among them, a lot of studies have concentrated on assessment of working conditions with a focus being on risk factors of cardiovascular diseases and substantiating suggestions on how to prevent them [7–9, 11–16, 25–31]. Examination of working conditions and workers' health is accomplished according to valid regulatory documents. An evidence base for occupational risk assessment is results obtained in research works concentrating on hygienic assessment of working conditions and occupational activities as adverse factors that can cause damage to health of medical workers with various specialties employed at various healthcare organizations [1, 2, 17–27, 32–41]<sup>1,2</sup>.

Hypodynamia, long-term static loads, local overstrain of some muscles, exposure to physical, chemical, and biological factors, psychoemotional stress, work in shifts and at night are a priori occupational risk factors that determine labor hardness and intensity. Another substantial health risk factor is decreasing labor motivation that has been detected recently [42, 43].

Labor intensity is the most substantial adverse occupational factor for all groups of medical workers; it occurs due to nervous and emotional loads, time deficiency, high responsibility for ultimate results (of treatment), and unpredictability of outcomes in urgent and emergency situations. Round-the-clock work and night shifts result in desynchronosis and chronic lack of sleep that contribute significantly to risks of cardiovascular diseases, make for developing hypertension, obesity, excessive consumption of caffeine, smoking, developing diabetes mellitus, and authentic increase in concentrations of hydrocortisone, adrenalin, and glucose in blood. It is well known that intense working regime induces stress in 31.1 % cases among surgeons and 23.2 % cases among therapists. As a result, 48.5 % of medical workers who have to work in shifts suffer from various diseases of the

<sup>1</sup> Cardiology. The national guide. In: E.V. Shlyakhto ed. Moscow, GEOTAR–Media, 2015, 800 p.

<sup>2</sup> Adverse chemicals: a reference book. In: V.A. Filov ed. Leningrad, Khimiya, 1988, 512 p. (in Russian).

circulatory system. Practically all doctors (92.2 %) and 75.0–81.8 % nurses and paramedics complain about high nervous and emotional strain they have to face at their workplaces [14, 15, 20, 21, 23, 29, 44, 45].

Working conditions assessed as per labor intensity are classified as belonging to 3.1 hazard category (hazardous, the first degree) for therapeutic doctors and nurses and 3.2–3.3 hazard category (hazardous, the 2<sup>nd</sup> or 3<sup>rd</sup> degree) for surgeons and emergency aid teams [28–31].

Russian researchers showed in some previous works that signs of emotional burnout syndrome with various intensities were detected in 40–80 % doctors in the country [44, 45]. Permanent chronic psychoemotional stress and physical fatigue lead to occurring occupational burnout syndrome (OBS); 45.7 % surgeons, 39.7 % workers of emergency aid teams and 19.21 % therapists are already at the exhaustion stage in it [10]. Age of medical workers who already suffer from OBS is 45–50 years. Psychoemotional factors that influence OBS development also include job satisfaction, interpersonal and occupational relations at work and at home, salary, quality of life, and somatic wellbeing. Psychosocial state of a doctor or a nurse is vital for safety and quality of their occupational activities. It was established that average “total occupational stress” was by more than 7 times higher for a doctor with any specialty than, for example, for a worker employed at an oil processing enterprise. Major signs that indicate occurring OBS are physical fatigue (36.6–42.4 % of doctors, 54.6–61.7 % of nurses and paramedics), elevated blood pressure, low spirits, and asthenia. Morbidity is equal to 11,142.7 ‰ among people with already formed OBS and is by 1.8 times higher than among medical workers who do not suffer from it yet (617.2 ‰) with CSDs accounting for 21.8 % in it. A peak in CSDs occurrence is detected among workers aged 30–49 and with their working experience varying from 10 to 20 years; specific weight of CSDs reaches 37.0–50.8 % among such workers. Correlation analysis revealed a strong di-

rect functional correlation ( $r = 0.87$ ,  $p < 0.01$ ) between morbidity levels and stages in OBS development [5, 10, 23, 38, 41–45].

Medical workers' labor is hard due to necessity to lift and move patients, forced working postures, and long-term static loads that result in physical fatigue, circulatory disorders, elevated blood pressure, and occurring asthenia [7, 8, 15, 16, 21, 25, 37]. Physical fatigue is mentioned by 36.6–42.4 % of doctors and 54.6–61.7 % of nurses and paramedics. Regular physical overloads are among factors that cause developing arterial hypertension. Short-term physical overload can induce atherogenic dyslipidemia and activate coagulation factors; it is also a factor that makes for developing Da-Costa's syndrome which involves breathlessness and heart disorders (elevated blood pressure and heart rate and chest pains). Long-term static load that occurs when a worker has to work standing makes for developing chronic venous insufficiency in the lower extremities.

Working conditions were assessed per labor hardness for various occupational groups of medical workers (lifting and moving heavy weights, working in a forced posture, and static loads); the assessment revealed that working conditions belonged to different categories, starting from category 2, permissible working conditions (therapeutic medical workers), to hazard category 3.2, hazardous working conditions with the 2<sup>nd</sup> hazard degree (surgeons, doctors and paramedics in emergency aid teams).

Medical workers are also exposed to chemical, biological, and physical occupational factors. Exposure to chemicals basically occurs due to dealing with medications, anesthetics, aseptic drugs and disinfectants. Medical workers widely use analgesics, hormones, antibiotics, vitamins, nootropic drugs and cardioprotectors at their workplaces; concentrations of such drugs can reach maximum permissible levels at some workplaces. Chronic exposure to certain compounds leads to elevated heart rhythm and minute blood volume and, as a result, influences athero-

genic restructuring of vessels and the myocardium producing effects that correspond to their properties [2, 14–16, 22, 27, 32, 33, 36, 37]. Working conditions assessed as per the chemical factor belonged to hazard category 3.1 for some occupational groups of medical workers (nurses, paramedics, anesthetists, resuscitators, and surgeons).

Nurses and doctors employed at anti-tuberculosis medical organizations, infectiologists, otolaryngologists, and doctors working at out-patient and in-patient clinics are constantly exposed to biological factors of bacterial, viral, and fungi nature at their workplaces [15, 17, 21, 23, 25, 26, 31, 36]. Surgeons and diagnosticians have direct contacts with biological materials (patients' tissues, blood, urine, sputum, etc.). Working conditions assessed as per the biological factor corresponded to hazard category 3.2–3.3.

Diagnosticians and physiotherapists (X-ray specialists, radiologists, specialists who perform US, MRI or CT) are exposed to electromagnetic fields with different frequencies. Chronic exposure to electromagnetic fields with high frequencies produces atherogenic and cardiotoxic effects and can result in developing syndromes that involve sinus bradycardia, arterial hypertension (AH), diencephalic crisis, and angiospastic reactions; all this disrupts coronary and cerebral circulation. Exposure to ultrasound results in developing peripheral vegetative-sensory disorders, makes for developing angiodystonic syndrome and autonomic sensory neuropathy [3, 9, 11, 27, 37].

Complex studies with focus on health of medical workers in various regions in the country and our own long-term research revealed that CSDs prevalence and their specific weight in the structure of overall morbidity were higher among medical workers than among workers employed in various industries. Profound medical examinations accomplished in various public healthcare organizations showed that on average 48.3 cases of cardiovascular diseases were detected per 100 examined doctors and 37.4 cases per

100 examined nurses and paramedics [18, 24]. Their specific weight varies from 32.8 to 48.8 % in overall morbidity [24]. These rates are substantially higher than among workers employed at various industrial enterprises as well as among population in general. For examples, from 18 to 20 cases of cardiovascular diseases were detected at periodical medical examinations per 100 examined workers in different city districts, municipal districts and urban settlements and this was 23.9 % in overall morbidity [22]. CSDs were diagnosed in 28 % of workers employed at oil processing and petrochemical enterprises; in 26.0 % of workers employed at chromium compounds production; and in 34.6 % of workers employed at a poultry farm [2, 22, 26, 36, 41].

We compared CSDs prevalence among doctors, nurses and paramedics with various specialties and among total employable population in Bashkortostan in 2018 [41], the latter rate taken as background level; the comparison revealed that this pathology was much more frequent among medical workers.

From 7.2 to 37.8 new cases of cardiovascular diseases occurred per 100 medical workers against the background rate (attributive risk).

At present the leading role in health disorders among workers belongs to diseases that do not have any specific etiology and are caused by multiple exposures to low levels of various adverse factors; this combined exposure is an independent risk factor in itself. In most cases they are poly-etiological somatic diseases such as hypertension, ischemic heart disease, ulcer, etc. These diseases are usually called work-related. A work-related disease is the most significant indicator showing that working conditions are unsatisfactory; a number of such diseases tends to grow as working experience under adverse or hazardous working conditions becomes longer and is also higher than among workers who are not exposed to such factors at their workplaces [1–3, 5, 12, 18, 20, 24]<sup>1</sup>. Work relatedness of circulatory diseases in medical workers is

caused by adverse occupational factors that can potentially induce and support developing cardiovascular pathology.

CSDs are to a great extent work-related among surgeons, therapists, and phthisiatricians as well as among doctors from emergency aid teams (RR = 2.3–3.1; EF = 56.5–67.7 %). Emergency aid doctors run the highest risks of developing CSDs (RR = 3.1; EF = 67.7 %). Diagnosticians working in in-patient hospitals run an average risk of work-related CSDs and work relatedness is also average (RR = 1.6–1.8; EF = 33.3–44.4 %).

Some researchers [18, 24] note that CSDs account for 48.3 % cases in morbidity among doctors and 37.4 % cases among nurses and paramedics. In this case attributive risk amounts to 30.3 cases per 100 people for doctors and to 19.4 cases for nurses and paramedics; relative risks reach 2.6 for doctors and 2.0 for nurses and paramedics. Accordingly, etiological fraction of occupational risk factors amounts to 50.0–61.0 % and it means that work relatedness is high. These summarized rates allow estimating occupational activities performed by medical workers as those with high risks of developing cardiovascular pathology.

Risks of cardiovascular diseases were assessed as per SCORE system among medical workers employed at an emergency aid station, workers dealing with hemodialysis, phthisiatricians, infectiologists, resuscitators, dentists, and therapists in in-patient hospitals. The assessment revealed that most workers younger than 40 were exposed to moderate risks of such diseases and only 12.0–15.0 % among them were exposed to high relative risks of cardiovascular diseases. Workers who were older than 50 were exposed to high (20.0–22.0 %) or very high (10.0–12.5 %) total risks of death due to CSDs [5, 8, 11, 22, 32, 37, 39].

Some studies revealed early, including pre-clinical ones, signs of cardiovascular disorders. Myocardial hypertrophy was detected in 18.0 % of examined workers through electrocardiography (ECG) and echocardiography (Echo CG). Duplex ultrasound of ves-

sels and main arteries in the brain revealed atherosclerotic stenotic signs in 8.0 % and non-stenotic ones in 12.2 % of examined workers; changes in brachiocephalic artery, in 5.0 % [2, 4, 5, 7, 34]. Persistent elevated blood pressure was determined in 16.8 % of workers both at day and at night through daily monitoring over blood pressure. Heart rhythm disorders and conductivity disorders were detected in 13.6 % of examined workers through daily ECG monitoring. ST segment was depressed under physical loads in 1.0 % of examined workers.

Analytical review of Russian and foreign research works has revealed that at present working conditions and occupational activities performed by medical workers involve exposure to adverse occupational factors that can potentially induce and support developing cardiovascular disorders. A set of occupational factors (labor hardness and intensity, chemical, biological, and chemical factors) was established for various occupational groups of medical workers based on hygienic studies that involved assessment of working conditions. Working conditions for medical workers with certain occupations belonged to 3.1–3.3 hazard category (they were hazardous, the 1<sup>st</sup>–3<sup>rd</sup> hazard degrees). Labor intensity is the leading adverse factor practically for all occupations (3.2–3.3). The most hazardous working conditions existed at workplaces of surgeons and all workers in emergency aid teams (3.2–3.3). We showed that CSDs prevalence was by 2.0 times higher among medical workers than among population in general (48.8 % and 23.9 % accordingly) or among workers employed in other industries. It was also proven that the highest CSDs prevalence and their high (up to 67.7 %) work relatedness were detected for medical workers with the most hazardous working conditions at their workplaces (surgeons and workers employed at an emergency aid station) [7]. Work relatedness of developing CSDs was average for medical workers from other occupational groups. Having assessed occupational risks of cardiovascular

disorders for medical workers, we determined several stages in CSDs occurrence: the initial one when working experience didn't exceed 5 years; a stage of strained adaptation; and a clinical stage in pathology development. These stages are to be taken into account when periodical medical examination are held since it helps perform early diagnostics and

determine "risk groups" as regards developing CSDs and implementing prevention and rehabilitation programs.

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