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OCCUPATIONAL STRESS CAUSED BY SHIFT WORK AS A RISK FACTOR FOR WORKERS' HEALTH DISORDERS

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We examined risk for occupational stress evolvement caused by shift work in various occupational groups basing on the analysis of up-to-date domestic and foreign works. The article contains brief description of specific shift work forms in different countries and its probable contribution into poorer work quality. We detected bilateral correlation between sleep disturbance and work; this correlation is associated with psychosocial risks (including work style, high demands and low level of control, workday length and shift work as well as imbalance between labor efforts and payments). We showed that desynchronizing when a person has shift work schedule, especially with shift rotation, exerts negative stress influence on physical and mental health, causing high risks for obstructive sleep apnea, cardiovascular diseases, metabolic syndrome, pancreatic diabetes, functional disorders of nervous system state and mental health, and even evolvement of certain malignant neoplasms. There is a brief analysis of the data on higher risks of these health disorders for workers from various occupational groups, including law enforcement agencies, doctors and nurses, railroad workers etc. We noted the correlation between increase in pathologic changes probability and length of shift work with shift rotations. The obtained data prove that shift work, especially with shift rotations, is dangerous for health and longevity. We need to improve legal regulation in order to reduce potential danger of shift work for workers' health.

Key words: occupational stress, shift work, desynchronizing, sleep apnea, health risk.

According to WHO program aimed at mental health preservation for 2013-2020 there is a number of risk factors, including low social and economic status, alcohol abuse and stress, which are characteristic both for mental disorders and the whole non-infectious diseases category. As per 2012 data mental and neurologic disorders, and disorders caused by toxicomania, amount to 13% of total global diseases burden, including depression; its share is equal to 4.3% and it is considered to be one of the most significant reasons for disability all over the world (11% of all years spent in disability state on the global level). According to forecasts, aggregated economic loss caused by mental disorders will amount to 16.3 billion dollars in 2011-2030 period [35].

World labor organization (WLO) also pays close attention to occupational stress as one of the reasons for disorders related to hazardous physical

and emotional reactions [47]. Stress can lead to memory loss, stomach ulcer evolvement, bowels inflammatory diseases, musculoskeletal system disorders, hypertension, and, consequently, to cardiovascular diseases evolvement. There may also be its negative influence on immune state, which, in its turn, can lead to higher oncologic risks. All these disorders cause most diseases, as well as high levels of disability and mortality. The US National Institute of Occupational Health notes that 26-40% workers complain on having stress-factors at their workplace [27, 38]. In Europe stress occupies the 2nd place among health disorders reasons; 50-60% of all lost workdays are related to occupational stress; and a number of people suffering from work stressors grows annually [37, 38, 44]. Shift work can be considered one of such stress factors.

Shift work peculiarities. Shift work is work organized in 2, 3 or 4 shifts when each workers'

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group has to work within fixed work hours according to shift schedule [15]. There are several systems of shift work defined as per certain basic characteristics: constant or varying; continuous (all seven days in a week) or discontinuous (break for Sunday or a weekend); with or without night shifts. Other factors which can probably exert some influence on workers' health include shift cycle length, shift length, a number of workers/teams working in shifts, time when work starts and finishes, shift speed and direction (clockwise or counterclockwise), days-off number and position, and shifts regularity / non-regularity [33]. Widespread forms of shift work organization at enterprises in the RF are weekly shift rotation in a shift schedule with two days-off at the end of the week (slow rotation) or fast rotation (in 3-4 days) of shifts in a cycle.

Total night work in any shift is the most significant factor which is to be taken into account when we consider biological functions disorder. According to various assessments, about 15-20% of all working population work in shifts including night work; although authentic and comparable statistic data on the issue are unavailable in most countries. As per WLO assessment, in Canada 25% of all working population constantly work on multi-shift schedule; the figure amounts to 10% in Sweden; 10 million people work in shift in Japan, and about 22 million, in the USA where average occurrence of shift work including night shifts amounts to 14.8% (16.7% for men and 12.4% for women). Shift work is most widely spread among medical workers, transport staff, communication, leisure and hotel personnel (more than 30%), among service workers, in mining industries and processing industries (20-30%). Shift work occurs more frequently in young workers' work schedules and reduces for elder workers; its share exceeds 20% in the youngest age groups, but it decreases to 10% in age group older than 55 [33]. Occupation and employment branches assessment for 2.1 million people was carried out in Canada; it revealed that 17% respondents had night shifts, 5% had regular evening work schedule, 2% regularly worked in night shifts, and 10% had mixed (rotated) shift schedule. Night shifts were most widely spread among operators in oil-drilling and pulp and paper industries (>65%); they also prevailed for catering workers, receptionists and bar tenders in hotels and motels; police officers; caretakers. 37% of women and 29% of men working in hospitals had night shifts [30].

Desynchronizing and shift work. As we know, desynchronizing is characterized with high

probability of various pre-pathologic and pathologic disorders involvement. It is proved that biological rhythms desynchronization causes socially significant diseases of nervous, cardiovascular, reproductive and endocrine system. Shift work (especially in night shifts) breaks natural rhythm of body biological functions; workers suffer from strain and overstrain. Nervous and mental strain caused by shift work makes for neurotic disorders, cardiovascular system and digestive system diseases [15]. First of all, it is true for certain workers' groups in such spheres as health care, public security, catering, mining industry, and construction, which run a specific risk of sleep disturbance due to occupational stress [7]. 10% out of 15% of American shift workers mentioned symptoms proving sleep disturbance caused by shift work. Analysis of the US National poll "Sleep in America" data obtained in 2008 after 1000 workers had been questioned showed that as a result of shift work 21% of them ran 3 times higher risks of accidents caused by somnolence during driving (95% CI=1.27-6.0), and the risk grew 4 times if they suffered from sleep disturbance caused by shift work (95% CI=1.15-16.48). These conditions also result in aggravation of cardiovascular and other chronic diseases [45]. There is a particular term for significantly higher risk of specific sleep disturbance when working in shifts which can be met scientific works written in English: Shift Work Sleep Disorder (SWSD). Workers suffering from SWSD run higher risks of injuries; wrong decisions caused by lower vigilance; lower labor productivity; stronger alcohol and tobacco smoking dependence; higher proneness to conflicts in a family. If a person suffers from SWSD he or she usually has chronic fatigue, mood disturbances, non-specific gastrointestinal, cardiovascular and endocrine disorders with such concomitant diseases as diabetes, respiratory diseases, neurologic disorders etc. Depending on nature of chronic sleep disorder, risk for acute myocardial infarction grows 1.27-1.45 times.

Shift work as risk factor in various economic branches. There was domestic research carried out at 8 industrial enterprises in Rostov region comprising 1091 male workers distributed as per work schedule (standard and shift work schedules). The research revealed that arterial hypertension occurrence among shift workers was significantly higher than among workers who had standard work schedule (34.4 against 27.4% correspondingly; $p < 0.01$). The researchers detected authentic discrepancies in abdominal obesity occurrence (69.2 against 19.3%) and carbohydrate metabolism disorders (19.0

against 10.6%). It proved cause-and-effect relation between work schedule and arterial hypertension evolvement combined with metabolic disorders [2].

There were also some studies dedicated to peculiarities of blood rheological properties in young people working at night and to determining the correlation between them and cardiovascular diseases prevalence. The research focus group consisted of 592 people (312 male and 280 female) aged from 21-22 to 35 (control group included 1480 people); 50% worked at night for more than 5 years. It was detected that young people prone to arterial hypertension, and being under chronic stress caused by changes in work and leisure rhythms, had significant changes in hemorheological parameters, such as higher blood viscosity, higher aggregating and lower erythrocyte deformability, and it made cardiovascular disorders evolve and grow progressively worse. If a person is prone to hypotension, it takes longer period of night work for similar homorheological changes to develop. Degree of manifestation for homorheological disorders was directly proportional to the length of night work period [4]. When conducting similar research comprising 120 people, scientists detected microcirculatory processes disorders which correlated with the rate of blood pressure increase ($r=0.97$) and grew worse as night work period increased resulting in tissue hypoxia evolvement. Significant degree of tissue damage and depletion of body compensatory mechanisms in people with more than 5 years of night work suffering from primary hypertension is confirmed by the level of porphyrins and age pigment endogenous fluorescence. As night work period increases, intracardiac hemodynamics deteriorates and heart remodeling processes evolve. When night work period exceeds 5 years, a number of people with neurovisceral imbalance signs grows and level of stress hormones and renin goes up. Young people suffering from primary hypertension and having to work at night had higher pro-oxidant potential and lower antioxidant protection; such disorders correlated with microcirculatory disorders parameters (r from 0.88 to 0.96) [1]. When studying correlation between primary hypertension and work schedule of locomotive teams workers at Russian Railways, researchers detected that absolute majority of engine drivers (94.5%) worked with night shifts in their schedule, including 47% having double rotation (day - night), 25.8% having triple rotation (day - evening - night). Non-regular rotation of work shifts occurred in the schedule of 55.7% locomotive teams workers. It was found that primary hypertension was much more frequently diagnosed in people who had to work in night shifts ($OR=3.14$, 95% $CI:1.55-6.57$), and it was

statistically assessed as a diseases associated with work ($RR=1.53$, 95% $CI:1.18-1.99$; etiological fraction was 34.67%). So, chronic stress occurring in people working in night shifts should be treated as a state associated with work [6]. There was research dedicated to assessing occurrence frequency for various types of myocardium remodeling in male workers employed at Russian railways and having to work in night shifts (conductors and personnel on duty at railway stations) and in male workers having only day shifts in their work schedule; it showed that additional activation of renin-angiotensin-aldosterone system in relation to chronic stress in workers providing railway traffic safety and biological rhythms desynchronizing occurring due to frequent night shifts may result in more frequent evolvement of heart left ventricle hypertrophy [17]. Analysis of working conditions and health carried out on shipboard personnel revealed the biggest number of cardiovascular diseases, arterial hypertension, stomach and duodenum ulcer in comparison with people from other occupational groups (flight personnel, manual labor workers, medical workers, engineers and technicians etc.). People from this occupational group were influenced by a complex of hazardous factors in 97% cases; shift work schedule was one of this factors and it enables us to assume there is a correlation between it and higher risks of above-mentioned diseases [14].

In the course of complex functional state dynamics research which was accomplished in winter on oil-and gas industry workers in Zapolyarye during 5-night work shifts each lasting 12 hours it was detected that endurance ($p=0.030$) and time of workload bearing capacity started to decrease from the 9th-10th day of a shift. When a field shift work schedule was used and personnel had to work in night shifts, fatigue in brain cortical structures started to evolve on the 14th-15th day from the beginning of shift period; this fatigue preceded weariness on physiological level. It proved decrease in body reserves and functional state of central nervous system starting from the 19th day of a shift period [16]. Studying precision and time characteristics of sensorimotor reactions and basic nervous processes balance during a night shift which was accomplished on workers employed by "Biochim" PLC showed that precision characteristics of sensorimotor relations decline during a night shift and a number of mistakes grows both in accomplishing visual sensorimotor reactions and in accomplishing them under time deficiency. It proves lower excitation and inhibitory processes evolvement in functional structures of central nervous system during a night shift [12].

In spite of significant dissimilarities in the data collected on unfavorable impact exerted by shift work schedule on health of people from various occupational groups we consider the research dedicated to this factor contribution into health risk for law enforcement workers and public healthcare workers to be the most interesting.

Law enforcement structures. Most research works dealing with probable unfavorable impact exerted by shift work on personnel of law enforcement structures (police officers) focus on quality and precision of work done and a decrease in number of mistakes. A questionnaire comprising 4,471 police officers was conducted in the USA; it included screening obstructive sleep apnea syndrome and determining a set of accompanying symptoms such as insomnia, restless legs syndrome, shift work sleep disorder (SWSD), narcolepsy, and catalepsy. The questionnaire revealed that 38.4% police workers had sleep disorders when they had to work in shifts and it was a risk factor both for poorer work quality and for involvement and exacerbation of various diseases [40]. As per data of cardiometabolic stress research carried out on police officers working in shifts scientists detected more frequent occurrence of such traditional risk factors for cardiovascular diseases as smoking, high levels of obesity, arterial hypertension and lipid metabolic disorders, in comparison with workers from other occupational groups in the USA [31].

As per data of transverse and prospective cohort study conducted on 4,957 police officers in the USA at least 40.4% of them had sleep disorders. 33.6% out of the whole cohort suffered from obstructive sleep apnea syndrome, 6.5%, from insomnia, moderate or even grave, and 5.4% related this insomnia to shift work. Screening of correlation between obstructive sleep apnea syndrome or sleep disorders and physical or mental health showed higher risks of diabetes, depression and cardiovascular diseases [41]. There was also a research dedicated to probable impact exerted by shift work on mental and physical health of police officers in the USA. It consisted of two parts: daily health assessment conducted on 464 officers and retrospect cohort research of mortality over 1950-2005 (100,000 man-years of research). It was determined that 26% police officers having night shifts suffered from apnea syndrome and the authors related it to sleep deficiency [46]. It was noted that when police officers suffering from post traumatic stress disorder had to work 10% more in night shifts, suicide ideas occurrence for them in-

creased by 13% (RR=1.13; 95% CI=1.00–1.22). Relative risk of all death causes amounted to 1.2 (95%CI=1.14-1.26), relative risk of death caused by cardiovascular diseases was equal to 1.1 (95%CI=1.02-1.19), and it was a bit higher for atherosclerotic diseases amounting to 1.20 (95%CI=1.14-1.26). Mortality caused by all malignant neoplasms was also a bit increased (RR=1.32; 95%CI=1.19-1.46), and it was to a greater extent characteristic for police officers who started their police career at the age <25 and who had a long period of service. The research revealed a very interesting correlation between mortality and shift work; mortality after night shifts was at least 2 times higher (6.6%) than after day shifts (3.4%). Then, the questionnaire conducted on 365 police workers (aged 27-66) in the state of New York helped to detect that work in evening and night shifts had negative stress influence on physical and mental health ($p<0.05$) regardless of the age, sex, occupational activity peculiarities and ethnic peculiarities [23].

Comparative research of the impact exerted by shift work on police officers in the USA and in Turkey showed that different shift peculiarities (in Turkey a shift lasts for 12 hours and then there comes 24-hour break) are an additional stressor exerting negative influence on health [20]. The analysis of shift work impact on stress involvement in 538 Turkey National police staff (407 regular police officers and 131 police supervisors) showed that shift work becomes one of stressors after 6 months. 55.8% police staff had non-regular shift work schedule; rotated shift work took the first place among stress reasons (35.5%) [34]. Similar data were obtained after analyzing stress factors in work of police officers in India [43]. The research conducted on 105 police constables in Kenya revealed a gender factor contribution into a degree of occupational stress (at physical and mental level) [39].

All the data available in the domestic literature contain very little information on the impact exerted by shift work on health and working capacity of the RF law enforcement workers. There was research of metabolic syndrome occurrence conducted on traffic officers from State Traffic Safety Inspection in Nizhniy Novgorod who worked in 12-hours day and night shifts. The research results revealed that $53 \pm 5.41\%$ traffic officers suffered from metabolic syndrome that was higher than average statistic level (20-40%) [cited as per 10]. $76.5 \pm 4.59\%$ traffic policemen suffered from high blood pressure, and $63.5 \pm 5.22\%$ of them suffered

from abdominal obesity. Parameters of metabolic syndrome occurrence among traffic policemen standardized as per age showed that this pathology increased as the work period grew. 26.7 cases per 100 workers were detected in the group with work period being equal to 0-4 years, 54.1 cases in the group with work period of 5-9 years, and 52.5 cases for workers who worked for more than 10 years. Relative risk of this pathology involvement in groups with longer periods of service in comparison with the first group (0-4 years of service) amounts to 2.02 and 1.97 standard units and it proves considerable probability of metabolic syndrome being occupationally caused in this group of workers. Duodenum ulcer prevalence among traffic policemen in Tatarstan working at road posts (lettered platoons) was equal to 49.3% while the figure for their colleagues from linear platoons (whose working places were fixed at stationary posts) and from command staff was significantly lower and amounted to 5.0 and 2.3% correspondingly. Therefore, we can conclude that even the data obtained from this small number of domestic research dedicated to negative impact exerted by shift work on law enforcement workers coincide with the results obtained by foreign researchers and expand them to a certain extent.

Public healthcare workers. The biggest number of works dealing with determining probable negative impact exerted by shift work on worker's health contains data on public healthcare personnel, first of all, doctors and nurses. An increase in number of occupational injuries and accidents caused by acute and chronic sleep deficiency was detected. Chronic sleep deficiency led to increased risk of such cardiovascular diseases as hypertension, stroke and heart diseases, as well as metabolic disorders such as obesity and diabetes [25]. Having analyzed the impact exerted by shift work on temporary disability parameters as per data of 1207 visits to doctors, researchers detected a positive correlation between evening shifts and longer sick leaves for female medical workers [36].

There was a research work conducted in Moscow and Moscow region (543 workers from public offices management; 158 medical workers; 403 engineers and technicians employed at an experimental civil engineering enterprise) and in Voronezh (299 people). The research showed that work in night shifts and work according to moving schedule correlated with higher health risks. Doctors who had to work in night shifts assessed their sleep as not having any regenerating properties 1.5 times more frequently; 65% had signs of chronobi-

ological disorders and higher triglycerides, dextrose and plasma hydrocortisone values while somatotrophic hormone level was 1.2 times lower. It was shown that chronic insomnia and sleep deprivation could be considered not only one of chronic stress signs but also an independent factor causing potential negative stress impact on workers' health [13].

Nurses working according to 12-hour shifts schedules were questioned in the USA during 4 weeks with the use of specialized Caroline questionnaire on somnolence assessment. Questioning revealed a considerable impact on working capacity each third shift caused by desynchronizing related to work in night shifts [26]. A study covering assessment of impact exerted by shift work with 11-hour intervals between shifts was conducted in Norway twice with a year break (2009 and 2010) and comprised 1,224 nurses. Correlation between shift work and SWSD, excessive somnolence, pathologic fatigability, anxiety, and depression, was assessed via regression analysis taking sex, age and number of shifts into account. One year shift work according to such schedule caused SWSD syndrome involvement (RR=1.01, 95% CI:1.00-1.01) and pathologic fatigability (RR=1.01, 95% CI:1.00-1.01). A decrease in number of such shifts leads to lower pathologic fatigability risk (RR=0.67, 95% CI:0.45-0.99) [24].

A correlation between stress and a doctor's specialization and his or her working conditions was detected. Surgeons are exposed to the greatest negative influence exerted by stress factors; this influence on general practitioners is lower. Shift work schedule accounts for 31.1% of stress reasons for surgeons; as for general practitioners, the figure is 23.0%. 48.5% medical workers reported having cardiovascular diseases caused by stress they had been through; 37.2% told the same about nervous system diseases; 34.1%, about gastrointestinal tract diseases; 17.6%, musculoskeletal system diseases; 7.5%, skin diseases; alcoholism was mentioned by 3% respondents [3].

Cohort research conducted on 54,724 nurses in the USA was dedicated to assessment of cardiovascular risk factors related to work in night shifts, taking age, at which such work occurred, into account (age groups 20-25, 26-35, 36-45, older than 46). If a respondent had to work in night shifts it led to obesity becoming more probable (body mass index ≥ 30 kg/m²; RR=1.37, 95% CI 1.31-1.43); greater caffeine consumption (≥ 131 mgr/day; RR=1.16, 95% CI 1.12-1.22) and total calorie consumption (≥ 1715 kcal/day;.

RR=1.09, 95% CI 1.04-1.13); smoking (RR=1.30, 95% CI 1.19-1.42); and reduction in sleep length (≤ 7 hours of sleep a day; RR=1.19, 95% CI 1.15-1.24). And we should note that if workers who had to work in night shifts were younger than 25 they ran lower risk in comparison with older age groups [42]. As scientists examined a possible correlation between diabetes risk and work in night shifts for nurses in Denmark, they analyzed work in night shifts, day shifts, evening shifts or rotated shifts. Only 837 out of 19,873 nurses (4.4%) suffered from diabetes after 15 years of work. A statistically authentic increase in diabetes risk was detected for nurses working in night shifts (RR=1.58; CI 1.25 - 1.99) or evening shifts (RR=1.29; CI: 1.04 - 1.59) (as per total model including body mass index assessment) [29]. As per data obtained by one of Russian researchers, relative risk of diabetes for medical workers depended on work period with night shifts and it increased 1.05 times if work period was equal to 1-2 years; 1.2 times, if it was equal to 3-9 years; 1.4 times, with work period equal to 10-19 years; and if work period was 20 years or more, it increased 1.58 times [18].

Research conducted on 110 medical workers in Khanty-Mansiysk with work period longer than 5 years included 54 workers of city emergency station working in shifts (10 or more night shifts in a month) and 56 workers of ambulatory service working only in day time. Liquid chromatography technique was applied and it allowed detecting authentically higher concentration of stress hormones (hydrocortisone and adrenaline) in blood of doctors and medical assistants in exit emergency teams in comparison with doctors and nurses working in out-patient departments [9]. Health assessment made for 725 nurses and midwives in Poland (354 had night shifts and 371 worked only in daytime) showed that chronic back pains, hypertension and thyroid gland diseases were the most widely spread diseases among them. Prevalence of thyroid gland diseases among them was higher than among female population in Poland in general (21.2% against 10%), and relative risk of this diseases increased as a period of night shift work grew longer. Besides, if women had to work in night shifts 8 or more times a month they ran authentically higher foot edema risk (RR = 8.55; 95% CI: 1.02-71.80) [21]. As per research data obtained in Taiwan there was authentically higher occurrence of urogenital system pathology, defective pregnancy and birth difficulties for

medical nurses than for other female staff working in hospitals [32].

6,077 doctors were questioned in 2002-2003 in Bashkortostan; questioning results combined with the data on occupational morbidity in public healthcare in Bashkortostan over 2000-2003 revealed that prevalence of psychophysical symptoms related to occupational fatigue syndrome

in doctors in the cohort as a whole varied from 9% to 48%. It reached even 63% among district general practitioners and pediatricians; but it was even higher among surgeons reaching 85%. Though the authors didn't relate higher risk of occupational fatigue syndrome for surgeons to work in shifts, such work undoubtedly is an additional factor causing evolvement of such syndrome. As researchers examined health, occupational fatigue syndrome evolvement, changes in vegetative innervation, psychopathologic and cognitive disorders in surgeons working in in-patient hospitals, resuscitators, and district general practitioners (age 30-55, work period ≥ 5 years), they detected clinical syndromes of vegetative dystonia in 86.7% of them; (14.8% had signs of prevailing vagotonia, and 85.1%, sympathicotonia); occupational fatigue syndrome occurred in 81.1% cases. Such a great manifestation of occupational fatigue syndrome in surgeons and resuscitators in comparison with general practitioners and physical training therapists can also be related to shift work in their schedule [11]. Questionnaires conducted in Taiwan in 2006-2007 and comprising 677 medical nurses revealed negative influence exerted on mental health by shift work [22]. Mental health assessment conducted in Brazil comprising 432 medical workers in two hospitals (doctors and nurses) allowed detecting that medical workers ran higher risk of minimal mental disorders evolvement if they worked in night shifts (OR=2.14; 95%CI:1.09-4.23) [19]. Research dedicated to negative impact exerted by shift rotation in comparison with constant work in night shifts carried out on workers in a hospital in the USA (with the use of Stanford somnolence scale and assessment of melatonin concentration in saliva) during 25-hour-period of sleep deprivation revealed specific concentration disorders in workers who had rotated shifts in comparison to night workers [28]. Psychological examination carried out on medical students who combined studies with shift work detected influence exerted by night work on increased irritability after a shift. And here men were 57.5% more stress-resistant than women; medical assistants in exit emergency teams were more irritable after work shifts

(87.4%), the second place belonged to nurses (85.7%) and then the 3rd place was occupied with personnel on duty at chemists' (81.6%) [8].

Conclusion. The above-given analysis of works conducted in various countries gives stronger evidence proving that shift rotating is potentially dangerous for health and longevity. It also proves the necessity to develop legal regulation of shift work in order to preserve health of workers from various occupational groups.

There are tasks that require further research; such tasks include developing practical recommendations for people working in shifts, defining contribution made by length and intensity of work rotation in night shift and shift schedules taking individual peculiarities of workers (i.e. chronotype) into account, as well as issue of potential carcinogenic risk caused by shift work which has been widely examined over the last few years.

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