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Research article

RISK FACTORS AND INTEGRATED ASSESSMENT OF HEALTH DISORDERS IN TEACHERS OF RURAL COMPREHENSIVE SCHOOLS

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Teaching is an occupation with high stress levels and extremely poor health indicators, which tend to decline as working records become longer.

The aim of this study was to investigate risk factors able to cause health issues in teachers of rural comprehensive schools and to determine the significance of clinical and laboratory indices as early indicators.

The work uses the results of hygienic, clinical and laboratory studies aimed at assessing health and working conditions of teachers employed at comprehensive schools in rural areas of the Republic of Bashkortostan.

*Sanitary and hygienic conditions in classrooms of rural comprehensive schools were assessed in conformity with the Guide R 2.2.2006-05. Medical check-ups resulted in 255 various somatic diseases diagnosed in 70 teachers, overall, 3.64 diseases per one examined teacher. Laboratory tests revealed elevated hemoglobin levels in 20.00 % of the examined female teachers and low ones in 8.57 %. Erythrocytosis was established in 64.29 % of the examined teachers. We also established some slight changes in hematocrit levels, which were elevated in 4.29 % and low in 8.57 % of the examined teachers. Accordingly, in case hemoglobin levels were low, erythrocyte indices MCV and MCH went down as well in 30.00–32.86 % of the female teachers. The number of workers with elevated glucose and cholesterol levels went up as their work records grew longer (the correlation coefficients were 0.94÷0.98). Examination of microflora found in the upper airway mucosa revealed clinically significant contamination, which was mostly represented by cocci bacteria, the most significant microorganisms being *Staphylococcus epidermidis*, *Staphylococcus spp* and β -haemolytic streptococci.*

Our integrated study has shown that working conditions at workplaces of teachers in rural comprehensive schools do not conform to safety standards as per work hardness and work intensity (intellectual, emotional and sensory loads). The study results confirm high importance of diagnostic methods as indicators of health issues in teachers employed at comprehensive schools. Preventive measures aimed at protecting teachers' health in rural areas should consider peculiarities of pathomorphosis that determines their health status.

Keywords: risk factors, health status, teachers, pedagogical activity, rural areas, hygienic assessment of working conditions, laboratory diagnostics, preventive activities.

Rural areas attract a lot of public attention in Russia [1, 2]. Studies accomplished over years by foreign and Russian experts give evidence of marked negative trends in health status of people who work and live in rural areas. Basic challenges most rural residents

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have to face are poorly available health care due to underdeveloped transport and road infrastructure and low population density as well as understaffing and reduced financing provided for rural healthcare organizations [3–7]. All the foregoing has its negative effects on health status of working age rural population. Teaching is an occupation with high stress levels and extremely poor health indicators, which tend to decline as working records become longer [8, 9]. According to social surveys, rural teachers tend to be middle-aged people and females account for approximately 90.0 % of them.

Previous hygienic studies have established that working conditions are harmful at teachers' workplaces, as per both work hardness and work intensity (intellectual, emotional, and sensory loads) [10–12]. Major harmful occupational factors related to pedagogical activity include intensive sensory loads on the acoustic and visual organs, considerable loads on the vocal apparatus of the larynx, high concentrations of epidemic contacts, high psychoemotional strain, and exposure to electromagnetic waves [13]. Recently, more articles have been published that concentrate on investigating effects of harmful occupational factors on teachers' health (more than 85 % of these teachers live in rural areas). These studies report multiple diseases of the musculoskeletal system (cervical and lumbar osteochondrosis, radiculitis), cardiovascular diseases (varicose veins of lower extremities), diseases of the vocal apparatus (acute and chronic pharyngitis, laryngitis, vocal nodules, and vocal cord paresis), diseases of the nervous system (neurosis and neurosis-like states), communicable diseases, allergic rhinitis, bronchial asthma, and other diseases [14].

Multiple studies accomplished in different RF regions report incidence among teachers of comprehensive schools, which is quite similar both in its structure and percentage of diseases in it. According to profound medical check-ups in the Ryazan region ($N = 263$), leading rank places in the incidence among

teachers belong to diseases of the circulatory system (22.3 %), endocrine diseases (15.2 %), diseases of the nervous system (13.3 %), and diseases of the blood and blood-forming organs (anemia) (11.5 %) [15]. A study that focused on health state of teachers from Ulyanovsk ($N = 52$) established several leading pathologies including diseases of the eye and adnexa, 68.0 %; cardiovascular diseases, 48.0 %; diseases of the musculoskeletal system, 44.0 % [16]. A regular medical check-up of teachers working in the Central Federal District ($N = 171$) established that the first diagnosed varicose veins of lower extremities accounted for 32.0 % among diseases of the circulatory system [17]. Periodical medical check-ups of teachers in Kazan ($N = 2090$) established a disease for the first time practically in each fourth worker. Outpatient examination and care was deemed necessary for 38.9 % of the examined teachers and 45.5 % of them needed regular medical check-ups. A trend was revealed for the number of diseases to grow with age and work records [18]. Diseases of the eye and adnexa take the first rank place among chronic non-communicable diseases in teachers of comprehensive schools in the Astrakhan region ($N = 120$), 18.3 %; they are followed by diseases of the circulatory system, 17.5 %; diseases of the nervous system, 14.2 %; diseases of the digestive system, 13.3 %; diseases of the respiratory system, 9.2 %; diseases of the musculoskeletal system and connective tissue, 1.00 % [19]. It seems quite relevant to consider diseases of the circulatory system, cardiovascular diseases, and diseases of the musculoskeletal and digestive system to be occupational for teachers given their high prevalence among them [14, 15].

At present, not enough attention is being paid to pre-nosologic diagnostics of health of working age population, including teachers of comprehensive schools. Homeostasis status can serve as an early marker of metabolic and structural-functional changes in the body internal environment [20]. Certain laboratory indicators were examined in teachers employed at comprehensive schools with diag-

nosed bronchial asthma and chronic obstructive pulmonary diseases. These indicators were stipulated by the Order of the RF Ministry of Labor No. 988n and the RF Ministry of Health No. 1420n issued on December 31, 2020¹ [21–23].

Therefore, an important relevant task for occupational medicine is to study effects produced by risk factors on health of teachers employed at comprehensive schools and body responses to them.

The aim of this study was to investigate risk factors able to cause health issues in teachers of rural comprehensive schools and to determine the significance of clinical and laboratory indices as early indicators of diseases.

Materials and methods. The work uses the results of hygienic, clinical and laboratory studies aimed at assessing health and working conditions of teachers employed at comprehensive schools in rural areas of the Republic of Bashkortostan. The studies were accomplished during a periodical medical check-up (PMC) in the clinic of the institute according to the Order of the RF Ministry of Labor No. 988n and the RF Ministry of Health No. 1420n issued on December 31, 2020¹.

The inclusion criteria were as follows: a typical school design that means a 10-year study period; a school was located in a rural area. The observation group was made of

70 teachers from different rural areas in Bashkortostan. All examined teachers were females; males were excluded from the analysis due to a very small number of them in the study sample. The average age of the examined teachers was 50.54 ± 1.29 years (21–30 years: 27.40 ± 0.39 years (7.14 %), $n = 5$ people; 31–40 years: 33.86 ± 0.28 years (10.00 %), $n = 7$ people; 41–50 years: 46.78 ± 0.34 years (25.71 %), $n = 18$ people; 51–60 years: 56.12 ± 0.34 years (44.29 %), $n = 31$ people; older than 60 years: 63.67 ± 0.39 years (12.86 %), $n = 9$ people).

Average work records as a teacher were 23.95 ± 1.43 years (0–10 years: $n = 15$; 11–20 years: $n = 10$; 21–30 years: $n = 19$; more than 30 years: $n = 26$). When describing some opportunistic pathogenic bacteria, we combined two groups of teachers with long work records into one since there were no differences between them.

Sanitary and hygienic conditions in classrooms of rural comprehensive schools were assessed in conformity with the Guide R.2.2.2006-05²

A time-study of teachers' working day was accomplished by analyzing how their work time was spent³. To do that, a methodical algorithm was used that included three stages:

1. Minute-by-minute records of time spent on performing typical teacher tasks;

¹ Ob utverzhdenii perechnya vrednykh i (ili) opasnykh proizvodstvennykh faktorov i rabot, pri vypolnenii kotorykh provodyatsya obyazatel'nye predvaritel'nye meditsinskie osmotry pri postuplenii na rabotu i periodicheskie meditsinskie osmotry: Prikaz Mintruda Rossii i Minzdrava Rossii ot 31 dekabrya 2020 goda № 988n/1420n [On Approval of the list of harmful and (or) hazardous) occupational factors and works, which require mandatory preliminary medical examinations prior to recruitment and periodical medical examinations: the Order by the RF Ministry of Labor No. 988n and the RF Ministry of Health No. 1420n issued on December 31, 2020]. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/573473071> (February 06, 2024) (in Russian).

² Guide R 2.2.2006-05. Guide on hygienic assessment of factors of working environment and work load. Criteria and classification of working conditions; approved by G.G. Onishchenko, the RF Chief Sanitary Inspector, on July 29, 2005, came into force on November 01, 2005. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/1200040973> (February 06, 2024) (in Russian).

³ O prodolzhitel'nosti rabochego vremeni (normakh chasov pedagogicheskoi raboty za stavku zarabotnoi platy) pedagogicheskikh rabotnikov i o poryadke opredeleniya uchebnoi nagruzki pedagogicheskikh rabotnikov, ogovarivaemoi v trudovom dogovore: Prikaz Minobrnauki RF ot 22.12.2014 № 1601 (red. ot 13.05.2019) [On duration of work time (the standard number of hours of pedagogical activity per wage rate) of teachers and on the procedure for determining teaching loads stipulated in labor contracts: the Order by the RF Ministry of Education and Science issued on December 22, 2014 No. 1601 (as of edited on May 13, 2019)]. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/420245392> (February 06, 2024) (in Russian).

2. Records of all tasks stating the beginning and the end of their fulfillment;

3. Analysis of collected data and making conclusions; analysis of specific tasks teachers have to tackle.

Statics of working postures was determined using the relevant estimation system: a teacher's working posture is a 'free posture, standing and being able to move around'⁴.

Occupational noise and vibration were measured with Oktava-101A, a precision noise meter and spectrum analyzer⁵.

Microclimate was estimated as per three mandatory parameters: air temperature, relative humidity, and air velocity. Measurements were performed by using a combined meter Testo 425. The actual measured microclimatic parameters were estimated in accordance with the Methodical guidelines MUK 4.3.2756-10⁶.

Natural and artificial lighting was examined with a valid lux meter Argus-07 in conformity with the GOST R 55710-13⁷.

The microbial component in the environment inside classrooms in comprehensive schools was analyzed in cold seasons (autumn and winter) and a warm season (summer). We used specific sanitary microbiology techniques including identification of the total microbial

number (TMN) and identification of sanitary-microbiological bacteria in indoor air, such as *Staphylococcus aureus* and *Streptococcus haemolyticus*. *Staphylococcus aureus* is a facultative bacterium found in the nasopharynx, pharynx and on skin; *Streptococcus haemolyticus* indicates likely indoor contamination with these bacteria.

Given growing prevalence of immune deficiency among population, development of chronic systemic and allergic diseases, mold fungi and yeast fungi were additionally identified in indoor air.

Blood corpuscles were examined with a hematologic analyzer Sysmex KX-21 [24]. We performed differential calculation of the white blood count together with calculating some integral characteristics of the body homeostatic systems: the allergization index (AI) and the leukocyte index of intoxication (LII) [25].

Biochemical screening included identification of glucose and cholesterol levels and was performed with a semi-automated analyzer Stat Fax and reagents provided by the Vector-Best company.

We analyzed a microbiological picture of the upper airway mucosa in all examined teachers using optimal selective, differen-

⁴ GOST R ISO 6385-2016. Ergonomics. Ergonomic principles in the design of work systems: National Standard of the Russian Federation, approved and enacted by the Federal Agency on Technical Regulation and Metrology on October 20, 2016 No. 1445-st. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/1200140609> (February 06, 2024) (in Russian).

⁵ MUK 4.3.3722-21. Kontrol' urovnya shuma na territorii zhiloi zastroiki, v zhilykh i obshchestvennykh zdaniyakh i pomeshcheniyakh: Metodicheskie ukazaniya, utv. Federal'noi sluzhboi po nadzoru v sfere zashchity prav potrebiteli i blagopoluchiya cheloveka 27 dekabrya 2021 g. [Control of noise level in residential areas, in residential and public buildings and premises: Methodical guidelines, approved by the Federal Service for Surveillance over Consumer Rights Protection and Human Wellbeing on December 27, 2021]. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/727896915> (February 07, 2024) (in Russian).

⁶ MUK 4.3.2756-10. Metodicheskie ukazaniya po izmereniyu i otsenke mikroklimata proizvodstvennykh pomeshchenii: Metodicheskie ukazaniya, utv. Rukovoditelem Federal'noi sluzhby po nadzoru v sfere zashchity prav potrebiteli i blagopoluchiya cheloveka, Glavnym gosudarstvennym sanitarnym vrachom RF G.G. Onishchenko 12.11.2010 [Methodical guidelines on measuring and assessing microclimate inside production facilities: Methodical guidelines, approved by G.G. Onishchenko, the Head of the Federal Service for Surveillance over Consumer Rights Protection and Human Wellbeing, the RF Chief Sanitary Inspector, on November 12, 2010]. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/1200085911> (February 08, 2024) (in Russian).

⁷ GOST R 55710-2013. Lighting of indoor work places. Norms and methods of measuring: National Standard of the Russian Federation, approved and enacted by the Federal Agency on Technical Regulation and Metrology on November 08, 2013 No. 1364-st. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/1200105707> (February 08, 2024) (in Russian).

tial-diagnostic and chromogenic nutrient media⁸.

Research data were analyzed in Statistika for Windows, applied software for statistical analysis; the analysis involved determining mean values, authenticity per Student's t-test (t) and the significance level (p). We used the correlation coefficient (r) and the non-parametric χ^2 test to determine whether health issues were correlated with longer work records.

Results and discussion. Sanitary-hygienic assessment of working conditions at workplaces of teachers in rural comprehensive schools involved analyzing work time, measuring noise levels, microclimate, and artificial lighting, and assessing indoor air quality inside classrooms.

The time-study of a teacher's workday allowed dividing it into several large functional blocks, each having a specific function: perceptive one related to watching a situation in a class; academic one related to explaining a new subject; control one related to evaluating students' performance; organizational one related to organizing effective students' work; communicative one related to an ability to communicate adequately either with a student or a class as a whole.

Fulfillment of all functional responsibilities requires keeping a standing working posture for up to 71–75 % of the total work time.

In addition to the standard teaching load, a teacher spends some time on getting ready for classes (3–4 hours), checking home tasks. Some time is also spent on classroom management, cultural events, work with parents, and control over students' behavior. In rural comprehensive schools, teachers often have additional tasks

associated with gardening and growing vegetables in school vegetable gardens.

Teachers in comprehensive schools are exposed to unstably elevated noise levels. Noise levels measured during classes did not exceed permissible levels as per the dBA scale and were equal to 55 dBA.

Each break involves intensive student movement and loud talks in corridors and other school premises thus making noise levels go up to 95 dBA. Therefore, the category of working conditions was estimated as harmful, hazard degree 1 (3.1), in the analyzed schools.

A teacher spends the most part of a workday inside a school building with certain microclimate parameters. We established that air temperature and relative humidity inside the analyzed schools conformed to safety standards only during a cold season (winter). Air temperatures tended to be too high and air was too dry inside classrooms in spring, autumn and summer. Air velocity did not exceed 0.1 m/sec during the whole school year.

We measured natural and artificial lighting inside classrooms. Natural lighting was authentically lower at the beginning of the school year (152.9 ± 33.5 lux) than at the end of it (620.4 ± 92.9 lux) ($p < 0.05$). The coefficient of natural light (CNL) was 3.1 % at the beginning of the school year and 4.1 % at the end of it; it means it was in conformity with safety standards.

We analyzed the microbiological component in indoor air in classrooms; as a result, we established that the total average bacterial levels were 360 CFU/m³ in autumn and winter. Sanitary significant bacteria were represented

⁸ MU 4.2.2039-05. Tekhnika sbora i transportirovaniya biomaterialov v mikrobiologicheskie laboratorii: Metodicheskie ukazaniya, utv. i vved. v deistvie Rukovoditelem Federal'noi sluzhby po nadzoru v sfere zashchity prav potrebitelei i blagopoluchiya cheloveka, Glavnym gosudarstvennym sanitarnym vrachom Rossiiskoi Federatsii G.G. Onishchenko 23 dekabrya 2005 g. [The Procedure for collecting and transporting biological materials into microbiological laboratories: Methodical guidelines, approved and enacted by G.G. Onishchenko, the Head of the Federal Service for Surveillance over Consumer Rights Protection and Human Wellbeing, the RF Chief Sanitary Inspector, on December 23, 2005]. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/1200044664> (February 10, 2024) (in Russian); MUK 4.3.3722-21. Kontrol' urovnya shuma na territorii zhiloi zastroiki, v zhilykh i obshchestvennykh zdaniyakh i pomeshcheniyakh: Metodicheskie ukazaniya, utv. Federal'noi sluzhboi po nadzoru v sfere zashchity prav potrebitelei i blagopoluchiya cheloveka 27 dekabrya 2021 g. [Control of noise level in residential areas, in residential and public buildings and premises: Methodical guidelines, approved by the Federal Service for Surveillance over Consumer Rights Protection and Human Wellbeing on December 27, 2021]. *KODEKS: electronic fund for legal and reference documentation*. Available at: <https://docs.cntd.ru/document/727896915> (February 07, 2024) (in Russian).

by *Staphylococcus aureus* at the level of 23.5 CFU/m³, *Streptococcus haemolyticus* at the level of 14.0 CFU/m³ and mold fungi at the level of 8.0 CFU/m³.

Microbiological tests performed in summer revealed the total bacteria contamination in indoor air being 369 CFU/m³; the analysis of isolated sanitary significant bacteria established a slight decrease in the level of *Staphylococcus aureus*, down to 22 CFU/m³, and mold fungi, down to 6 CFU/m³. In addition to that, non-fermenting gram-negative bacteria of *Pseudomonas* genus, *Ps. Aeruginosa*, were identified for the first time at the level of 2 CFU/m³, but at the same time no *Streptococcus haemolyticus* were identified in indoor air in summer.

The periodical medical check-up revealed that diseases of the circulatory system (DCS) and diseases of the musculoskeletal system (DMS) took the leading places in the incidence among the examined teachers. DCS included essential hypertension (70.0 % of the examined women), coronary heart disease (4.29 %), and acute disorders of the cerebral circulation (2.86 %). DMS were mostly represented by polyarthritis with damage to large joints; they were identified in 61.43 % of the examined teachers. Diseases of the nervous system included cerebrovascular diseases in 35.71 % of the teachers and disorders of the autonomic nervous system in 4.29 % of them. Diseases of the digestive system, including chronic gastritis, chronic pancreatitis, and stomach ulcer, were identified in 38.57 % of the examined women. A gynecological exam revealed various inflammatory diseases of the female breeding organs in 34.43 % of the examined women.

Such diseases of the respiratory system as bronchial asthma and chronic obstructive pulmonary disease were found in 11.43 % of the examined teachers. The medical check-up resulted in 255 various somatic diseases diagnosed in 70 teachers, overall, 3.64 diseases per one examined teacher.

Clinically significant bacterial contamination (10⁵ CFU/tampon) was identified in microflora found in the upper airway mucosa; mostly,

cocci and fungi were present (Table 1). Most samples of biomaterials collected from the upper airways contained β -haemolytic streptococcus, 35.71 %; *Staphylococcus epidermidis*, 18.57 %; *Staphylococcus aureus*, 8.57 %; yeast fungi from *Candida albicans* genus prevailed among yeast-like fungi, 25.71 %.

Table 1

Frequency of certain opportunistic pathogens in teachers employed at rural comprehensive schools

Isolated bacteria	Isolation frequency (%) N = 70
<i>Staphylococcus aureus</i>	8.57
<i>Staphylococcus epidermidis</i>	18.57
β -haemolytic streptococcus	35.71
<i>Enterococcus</i> spp.	28.13
<i>Candida albicans</i>	25.71

Some bacteria were isolated with different frequency in teachers with different work records. β -haemolytic streptococcus and *Staphylococcus epidermidis*, *Candida albicans* were identified 1.5-2.0 times more frequently in teachers with work records longer than 10 years (Table 2).

We established a functional correlation between all isolated bacteria and work records of the examined teachers: *Candida albicans*, $r > 0.56$; *Enterococcus* spp, $r < 0.80$.

A hematological study established that average indicators included in the complete blood count were within reference values in all examined teachers (hemoglobin was 132.77 \pm 1.50 g/l; erythrocytes, 4.86 \pm 0.05 \cdot 10¹²; hematocrit, 39.58 \pm 0.36 %; leukocytes, 6.46 \pm 0.22 \cdot 10⁹; platelets, 242.03 \pm 7.45 \cdot 10⁹). Average AI and LII values were above reference ones (AI was 2.20 \pm 0.19; LII, 5.17 \pm 0.46).

A comparative analysis of frequency of deviating hematological indicators revealed the following (Table 3).

Red blood indicators showed both elevated and low levels of hemoglobin, erythrocytes, and hematocrit. Elevated hemoglobin levels above 142 g/l were found in 20.00 % of the examined females; levels below 116 g/l, 8.57 %. Erythrocytosis was established in

Table 2

Frequency of certain opportunistic pathogens in teachers employed at rural comprehensive school with different work records (%)

Isolated bacteria	Isolation frequency (%)		
	Work records 0–10 years N = 15	Work records 11–20 years N = 10	Work records 21–30 years N = 45
Staphylococcus aureus	-	20.00	-
Staphylococcus epidermidis	13.33	20.00	21.43
β -haemolytic streptococcus	26.60	20.00	57.14
Enterococcus spp.	42.86	-	35.71
Candida albicans	-	10.00	28.88

Note: '-' means bacteria were not identified.

Table 3

Frequency of deviating hematological indicators from standards in teachers employed at rural comprehensive schools in Bashkortostan (%)

A trend in deviation of an indicator from age-specific standards	Observation group N = 70
Hemoglobin, g/l	20.00 \pm 4.82
Erythrocytes, $10^{12}/l$	8.57 \pm 3.37
Hematocrit, %	64.29 \pm 5.77
MCV	4.29 \pm 2.44
MCH	8.57 \pm 3.37
MCHC	30.00 \pm 5.52
Leukocytes, $10^9/l$	32.86 \pm 5.65
Segmented, %	2.86 \pm 2.01
Eosinophils, %	18.57 \pm 4.68
Lymphocytes, %	5.71 \pm 2.79
ESR, mm/h	24.29 \pm 5.16
Platelets, $10^9/l$	44.29 \pm 5.98
Allergization index	25.71 \pm 5.26
Leukocyte index of intoxication	11.43 \pm 3.83
Glucose	5.00 \pm 2.62
Cholesterol	78.57 \pm 4.94
	82.86 \pm 4.54
	11.43 \pm 3.83
	17.14 \pm 4.54

64.29 % of the teachers. Some slight changes were also detected in hematocrit levels, which were elevated in 4.29 % and low in 8.57 % of the examined teachers. Erythrocyte indices MCV and MCH went down in 30.00–32.86 % of the female teachers. Elevated eosinophil granulocyte count was found in 24.29 % of the participants. Calculated values of the leukocyte index of intoxication and allergization index were high in the examined teachers: an elevated leukocyte index of intoxication was diagnosed in

82.86 % and allergization index in 78.57 % of the examined teachers. Biochemical blood serum tests identified disrupted carbohydrate metabolism in the examined teachers working in rural comprehensive schools. Elevated glucose levels were established in 11.43 % of the examined teachers; elevated cholesterol levels, 17.14 %.

Table 4 provides frequency of deviating hematological and biochemical indicators in the examined teachers depending on their work records.

Table 4

Frequency of deviating hematological and biochemical indicators from standards in the examined teachers depending on their work records (%)

A trend of deviation in an indicator	The observation group			
	Work records, years			
	0–10 N= 15	11–20 N= 10	21–30 N= 19	Longer than 30 N= 26
Hemoglobin, g/l < 116 g/l (f)	26.67 ± 11.82	-	10.53 ± 7.23	-
> 142 g/l (f)	13.33 ± 9.09	30.00 ± 15.28	10.53 ± 7.23	23.08 ± 8.43 $\chi^2 = 7.68$ $p > 0.025$
Erythrocytes, $10^{12}/l$ > $4.7 \cdot 10^{12}/l$	60.00 ± 13.09	60.00 ± 16.33	68.42 ± 10.96	92.31 ± 5.33 $\chi^2 = 6.32$ $p > 0.05$
Hematocrit, % > 44 % (f)	-	-	5.26 ± 5.26	7.69 ± 5.33 $\chi^2 = 1.21$ $p > 0.9$
< 36 %	20.00 ± 10.69	-	15.79 ± 8.59	-
MCV < 80 fL	33.33 ± 12.60	20.00 ± 13.33	36.84 ± 11.37	26.92 ± 8.87
MCH < 27 pg	46.67 ± 13.33	20.00 ± 13.33	42.11 ± 11.64	23.08 ± 8.43
Leukocytes, $10^9/l$ > $8.8 \cdot 10^9/l$	6.67 ± 6.67	40.00 ± 16.33	15.79 ± 8.59	7.69 ± 5.33
Segmented, % > 70 %		10.00 ± 10.00	5.26 ± 5.26	3.85 ± 3.85
Eosinophils, % > 5 %	33.33 ± 12.60	20.00 ± 13.33	10.53 ± 7.23	23.08 ± 8.43 $\chi^2 = 0.51$ $p > 0.9$
Lymphocytes, % > 40 %	13.33 ± 9.09	20.00 ± 13.33	52.63 ± 11.77	50.00 ± 10.00
Platelets, $10^9/l$ > $320 \cdot 10^9/l$	20.00 ± 10.69	20.00 ± 13.33	10.53 ± 7.23	3.85 ± 3.85
< $160 \cdot 10^9/l$	6.67 ± 6.67	-	-	7.69 ± 5.33
Allergization index > 1.2 cu	73.33 ± 11.82	90.00 ± 10.00	78.95 ± 9.61	76.92 ± 8.43 $\chi^2 = 1.32$ $p > 0.9$
Leukocyte index of in- toxication > 2.1 CU	80.00 ± 10.69	100.00 ± 0.00	73.68 ± 10.38	84.62 ± 7.22 $\chi^2 = 0.14$ $p > 0.95$
Glucose > 6.1	-	20.00 ± 13.33	15.79 ± 8.59	15.38 ± 7.22 $\chi^2 = 2.56$ $p > 0.9$
Cholesterol > 5.2	33.33 ± 12.60	30.00 ± 15.28	15.79 ± 8.59	3.85 ± 3.85

Note: ‘-’ means no deviations identified.

Teachers with longer work records tended to have elevated hemoglobin levels as their prevalence grew from 13.33 % during the first years of work and up to 23.08 % in teachers with work records 30 years and longer. Erythrocytosis was elevated in teachers from all work records-specific groups. Hematocrit levels grew in teachers with work records 30 years and longer. The non-parametric χ^2 was applied for red blood indicators. Authenticity was established for hemoglobin $\chi^2 = 7.68$ ($p < 0.0025$), erythrocytes $\chi^2 = 6.32$ ($p < 0.05$), and hematocrit $\chi^2 = 1.21$ ($p < 0.9$). A correlation between

work records and red blood indicators reached 0.80–0.94; however, we did not establish any correlation between them and age. Accordingly, in case hemoglobin levels were low, hypochromia markers, namely, erythrocyte indices MCV and MCH went down as well.

Elevated eosinophil granulocyte count was diagnosed in 33.33 % of the teachers at the beginning of their pedagogical activity; there was a slight increase in it down to 23.08 % in teachers with long work records $\chi^2 = 0.51$ ($p > 0.9$). As work records began longer, frequency of elevated leukocyte in-

dexes tended to grow. The allergization index was elevated in 73.33 % of teachers with work records between 0 and 10 years and in 76.92 % of teachers with work records longer than 30 years ($\chi^2 = 1.32, p < 0.9$). Similarly, elevated values of the leukocyte index of intoxication were established in 80.00 % women with their prevalence growing up to 84.62 % among teachers with longer work records ($\chi^2 = 0.14, p > 0.95$).

The shares of workers with elevated glucose and cholesterol levels grew as work records became longer; they were 15.79 % and 30.00 % and their correlation varied between 0.94 and 0.98. Authenticity was identified for glucose ($\chi^2 = 2.56, p < 0.9$).

The hygienic study established that working conditions of rural teachers were harmful, degree I (3.1), as per work hardness and harmful, degree I-II (3.1–3.2.), as per work intensity. These findings of hygienic studies performed at workplaces of teachers from rural comprehensive schools are in line with data reported in other studies [10, 11].

Our investigation of DCS risk factors established that teachers older than 40 years tended to have unstable blood pressure and coronary heart disease. About 60 % of the teachers complained that daily stressor loads, especially during preparations to the finals (between April and June), led to cardiovascular exacerbations. Elevated cholesterol levels also indicate a higher risk of atherogenic processes in the body and result in higher prevalence of cardiovascular diseases.

The teachers also complained of back and leg pains, which they deemed to be associated with long-term strain of the skeletal muscle.

Medical records of more than a half of the examined teachers had frequent (more than 3–4 times a year) inflammatory diseases of the upper airways (laryngitis, tracheitis, quinsy, etc.). The teachers stated that they usually had to go through them ‘on foot’ since it was impossible to abandon a workplace.

Our findings confirm the results reported by other experts who mention elevated prevalence of chronic non-communicable diseases in this occupational group [11, 26, 27].

As work records grew longer, the examined teachers tended to have elevated levels of hemoglobin, erythrocytes, and hematocrit. This might be associated with overstrain of the body functions due to hypoxia and mobilization of compensatory mechanisms. We established such changes in morphological properties of red blood as anisocytosis, poikilocytosis, and polychromasia in the examined teachers.

Teachers have to spend most their work time at their workplaces in classrooms with air in them contaminated with a multitude of microorganisms. Microflora found in the upper airway mucosa turned out to contain the same bacteria strains as indoor air inside classrooms. We should assume that diseases of the respiratory system (bronchial asthma and COPD) developed in the examined teachers under exposure to various bacteria strains and their combinations. Also, teachers are exposed to (allergenic) dusts in their work due to the necessity to read a lot of books and look through a lot of archive documents. Isolated bacteria, elevated values of the allergization index and the leukocyte index of intoxication, elevated eosinophil levels indicate weaker resistance, occurring sensitization and allergization of the body. This is consistent with previous studies that focus on the similar homeostasis indicators in workers employed in non-production spheres [21].

Conclusion. The accomplished sanitary-hygienic studies have established that working conditions at workplaces of teachers employed at rural comprehensive schools are harmful, hazard degree I–II (3.1–3.2).

Major risk factors include:

- elevated microbial contamination inside classrooms where teachers have to spend a considerable part of their work time;
- necessity to maintain a ‘standing’ working posture for 80 % of the total work time;
- occupational stresses;
- poorly available health care due to underdeveloped transport and road infrastructure and low population density;
- understaffing and reduced financing provided for rural healthcare organizations.

Realization of health risks is confirmed by medical statistical data and profound examinations of teachers' health status. Thus, diseases of the respiratory system have been established in 11.4 % of the examined teachers. The accomplished medical check-up resulted in 255 various somatic diseases diagnosed in 70 teachers, overall, 3.64 diseases per one examined teacher.

High prevalence of chronic pathologies has been established among teachers working in rural comprehensive schools according to PMC data. Diseases of the circulatory system (71.43 %) and musculoskeletal system (61.43 %) turned out to be the most significant ones. Hematological tests have revealed elevated levels of hemoglobin (20.00 %), erythrocytes (64.29 %), and hematocrit (4.29 %) in the examined teachers; they also have established structural and functional changes in red blood such as changes in erythrocyte form and volume, as well as laboratory signs of ongoing

body sensitization (eosinophilia and elevated allergization index values).

Our microbiological investigations have identified clinically significant concentrations of β -haemolytic streptococcus (35.71 %), *Staphylococcus epidermidis* (18.57 %), and *Staphylococcus aureus* (8.57 %), which can reduce the body resistance and induce drastic inhibition of its compensatory-adaptive abilities.

It seems extremely relevant to develop integrated plans on how to improve health of teachers working in rural comprehensive schools. Preventive measures aimed at protecting teachers' health in rural areas should consider peculiarities of pathomorphosis that determines their health status.

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