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РОССИЙСКИЙ ВЕСТНИК ГИГИЕНЫ

НАУЧНЫЙ МЕДИЦИНСКИЙ ЖУРНАЛ ВОРОНЕЖСКОГО ГОСУДАРСТВЕННОГО МЕДИЦИНСКОГО УНИВЕРСИТЕТА ИМ. Н. Н. БУРДЕНКО И РОССИЙСКОГО НАЦИОНАЛЬНОГО ИССЛЕДОВАТЕЛЬСКОГО МЕДИЦИНСКОГО УНИВЕРСИТЕТА ИМ. Н. И. ПИРОГОВА

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ASSESSING QUALITY OF DRINKING WATER SUPPLY IN DIFFERENT REGIONS OF THE RUSSIAN FEDERATION

Sazonova OV, Tupikova DS ✉, Ryazanova TK, Gavryushin MYu, Frolova OV, Trubetskaya SR

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The main task of any country associated with sanitary and epidemiological welfare of population is to obtain drinking water of good quality. In the majority of regions of the Russian Federation, quality of water taken from water sources and water supply systems is still unsatisfactory. As far as the extent of human impact on the environment goes, the Samara region is an ecologically unfavorable part of the Volga region. With the accession of the Republic of Crimea to the Russian Federation, the problem of water supply here has been intensified and the question of whether the drinking water corresponds to Sanitary Rules and Regulations 2.1.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 arose. The purpose of the study is to analyze quality of drinking water supply in the regions of the Russian Federation. Drinking water samples taken from the centralized domestic water supply system in the Samara urban district and Republic of Crimea were analyzed using 20 sanitary and chemical parameters. Quality of drinking water doesn't correspond to the requirements for oil products in all samples; the average value of this parameter exceeded the maximum permissible limit by 0.18 mg/dm^3 in the Samara urban district and by 0.04 mg/dm^3 in the Republic of Crimea, all the other parameters were within normal limits. However, during the comparative analysis quality of drinking water in the Republic of Crimea was insignificantly better than in the Samara urban district. Quality of drinking water is determined with the source of drinking water supply (surface and underground). Thus, to make the prepared drinking water normal, a respective water treating is necessary. Bad condition of water supply pipes can also produce a negative impact on quality of water obtained by a consumer.

Keywords: drinking water, centralized water supply, municipal hygiene

Author contribution: Sazonova OV — academic advising; Tupikova DS, Gavryushin MYu — study initiation, data collection, processing of results; Ryazanova TK, Frolova OV — design, data collection; Trubetskaya SR — analysis of sources, preparation and correction of the article.

Compliance with ethical standards: the study was approved by the Ethics Committee of the Samara State University of the Ministry of Health of the Russian Federation (protocol No. 184 as of December 21, 2021). No voluntary informed consent for every participant (authorized representative) was required.

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К ОЦЕНКЕ КАЧЕСТВА ПИТЬЕВОГО ВОДОСНАБЖЕНИЯ РАЗЛИЧНЫХ РЕГИОНОВ РОССИЙСКОЙ ФЕДЕРАЦИИ

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Качество питьевого водоснабжения является главной задачей государства по санитарно-эпидемиологическому благополучию населения. Качество воды из источников водоснабжения и в водопроводных сетях в большинстве регионов России продолжает оставаться неудовлетворительным. По степени антропогенного воздействия на окружающую среду Самарская область является одним из экологически неблагополучных районов Поволжья. После присоединения Республики Крым к территории Российской Федерации проблема водоснабжения на этой территории усилилась, а также встал вопрос о соответствии питьевой воды нормам СанПиНа 2.1.3685–21 и СанПиНа 2.1.3684–21. Цель исследования состоит в анализе качества питьевого водоснабжения регионов Российской Федерации. Были проанализированы пробы питьевого водоснабжения из централизованной хозяйственно-питьевой сети в г. о. Самара и Республике Крым по 20 санитарно-химическим показателям. Качество питьевой воды не соответствует требованиям по нефтепродуктам во всех пробах, среднее значение этого показателя в г. о. Самара превышало уровень ПДК на 0,18 мг/дм^3, а в Республике Крым на 0,04 мг/ дм^3, все остальные показатели находились в пределах нормы, но при сравнительном анализе качество питьевой воды в Республике Крым было незначительно лучше, чем в г. о. Самара. Качество питьевой воды определяется источником питьевого водоснабжения (поверхностным и подземным). Следовательно, для достижения нормативного состава приготовленной питьевой воды необходима соответствующая водоподготовка. На качество воды у потребителя отрицательное влияние может оказывать и неблагоприятное состояние труб распределительной сети.

Ключевые слова: питьевая вода, централизованное водоснабжение, коммунальная гигиена

Вклад авторов: О. В. Сазонова — научное руководство; Д. С. Тупикова, М. Ю. Гаврюшин — инициатор исследования, сбор материала, обработка результатов; Т. К. Рязанова, О. В. Фролова — дизайн, сбор материала; С. Р. Трубецкая — анализ источников, подготовка и правка статьи.

Соблюдение этических стандартов: исследование одобрено этическим комитетом ФГБОУ ВО СамГМУ Минздрава России (протокол № 184 от 21 декабря 2021 г.). Добровольное информированное согласие для каждого участника (его законного представителя) не требовалось.

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The key purpose of any community is to create a favorable living environment so that people could live a long healthy life, and the country could ensure development of human potential. One of the most important constituents of the favorable living environment is sanitary and epidemiological well-being of people as a basis of national security. Nevertheless, the issue of environmental pollution and protection in the Russian Federation is still timely and relevant in the beginning of the

third millennium. Provision of population with drinking water of good quality is one of the main tasks of epidemiological welfare and prevention of population morbidity by the country [1, 2].

In accordance with sanitary and epidemiological requirements, drinking water should have epidemiological and radiological safety, harmless chemical composition and good organoleptic properties [3, 4]. According to some authors, quality of water that comes from water supply sources and networks in the majority of regions in the Russian Federation is still bad [5–7].

In 2014, the Russian Federation gained new territories due to accession of the Crimean Peninsula, which is of an important strategic and economic value. Owing to natural and geographical peculiarities, the peninsula had the shortest water supply as compared with other regions of Russia and the USSR. In the 60s of the last century, the North Crimean Canal was built to provide drylands of Crimea with water. Dnipro water from the Kakhovka reservoir was taken to the peninsula through the Canal that had poorly coped with the task for several decades. Following accession of Crimea to Russia, Ukraine blocked the Canal, and the question of fresh water became critically acute. In the present time, hydrotechnical constructions have been built. They took water from the Belogorsk and Taygan water reservoirs to the North Crimean Canal. Three water intake areas were also created in Nizhny Gorsk and Dzhankoi Districts.

According to the Agricultural Research Institute of Crimea, over 50% water sources in Crimea do not correspond to Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 [8].

The Samara region belongs to heavily industrial, densely-populated and urbanized regions of Russia. By the extent of human impact on the environment, the Samara region is one of environmentally unfriendly regions of the Volga River basin. Motor vehicles have been playing the leading role in the creation of ecological and hygienic situation in the Samara region over the last years, as exhaust gases from these vehicles account for 60–80% of all toxic atmospheric emissions here.

The Volga River and its tributaries, that account for more than 38.5% of the total intake from all water sources in the Russian Federation, experience a great anthropogenic impact. The Samara urban area has prerequisites for a tense ecological and hygienic environmental situation. It dictates the need for constant surveillance over sanitary and hygienic condition of environmental objects, including the centralized domestic water supply system [9–11].

The sanitary and hygienic well-being of drinking water can produce both favorable and unfavorable effects on people's health. Composition of drinking water influences the total health risk. Thus, drinking water quality should be monitored on a constant basis.

MATERIALS AND METHODS

Quality of drinking water from the centralized domestic water supply system in the Samara urban area and Republic of Crimea (hereinafter referred to as the RC) was analyzed.

The samples were taken in summer 2021. The studies were conducted using 20 sanitary and chemical parameters in accordance with Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21. The studies were conducted using sanitary and chemical parameters based on health and hygiene rules and standards. Water samples were drawn in summer 2020–2021. The primary data were collected and stored using Microsoft Excel 2013 (*Microsoft*, USA).

STUDY RESULTS

As shown in table, drinking water corresponds to the requirements of Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 by many sanitary and chemical parameters.

The content of oil products was higher than MPL in all tested samples from the Samara urban area and Republic of Crimea. This can be an indicator of non-qualitative water supply.

Table. Quality of drinking water supply in the Samara urban area and Republic of Crimea

Ser. No.	Identifiable value	Units of measurement	MPL (maximum permissible limit)	Outcomes	
				Samara urban district	Republic of Crimea
1	Odour	points	no more than 2	0	0
2	Turbidity	mg/l	1.5	0.55 ± 0.06	0.93 ± 0.17
3	Color	degrees	20	15.6 ± 3.4	11.9 ± 2.4
4	pH value	pH units	20	7.42 ± 0.2	7.8 ± 0.2
5	Total hardness	° of hardness	7.0	8.2 ± 0.7	6.7 ± 0.2
6	Dry residue	mg/dm^3	1000	695 ± 32	530 ± 48
7	Permanganate index (PI)	mg/dm^3	5.0	3.48 ± 0.46	0.76 ± 0.15
8	Oil products	mg/l	0,1	0.28 ± 0.08	0.14 ± 0.07
9	Sulphates	mg/dm^3	500	116 ± 5	137 ± 15
10	Chlorides	mg/dm^3	350	75 ± 4	94 ± 2
11	Ammonia and ammonium ions	mg/dm^3	1.5	0.23 ± 0.07	< 0.1
12	Nitrites	mg/dm^3	3.0	0.014 ± 0.005	0.010 ± 0.005
13	Nitrates	mg/dm^3	45	6.2 ± 0.7	5.1 ± 0.8
14	Cadmium	mg/dm^3	0.001	< 0.001	< 0.001
15	Lead	mg/dm^3	0.01	< 0.001	< 0.001
16	Zinc	mg/dm^3	5.0	0.005 ± 0.005	< 0.010
17	Copper	mg/dm^3	1.0	0.0069 ± 0.0007	0.022 ± 0.006
18	Arsenic	mg/dm^3	0.01	0.008 ± 0.0004	< 0.002
19	Iron (in aggregate)	mg/dm^3	0.3	0.26 ± 0.06	0.29 ± 0.07
20	Anionic surfactants	mg/dm^3	0.5	0.006 ± 0.001	< 0.015

In the Samara urban area, the average value of that parameter exceeded the MPL by 0.18 mg/dm^3. It should be noted that according to the studies conducted at the department of food hygiene with a course of hygiene for children and adolescents and by Pharmatsia Research and Educational Center of the Samara State Medical University of the Ministry of Health of the Russian Federation, the content of oil products in drinking water from the centralized water supply system in the Samara urban area tends to increase.

Exceeding the maximum permissible limit of carbon compounds in surface water and groundwater is a consequence of industrial development and non-compliance with ecological standards of manufacture. Dangerous compounds seep through the soil into groundwater and contaminate the natural sources of drinking water. Water is also contaminated with oil products from transport activity and when artesian and oil-bearing layers are mixed. Consumption of water with high content of oil products increases the risk of cancer of internal organs, diseases of digestive and endocrine systems and oral cavity.

Within the Samara urban area, hardness values of groundwater samples exceeded the maximum permissible limits. Color, dry residue, permanganate index (PI), sulphates, chlorides and copper content were within normal hygienic limits. PI of drinking water in the Samara urban area was 4.5 times higher than that in the RC, whereas the average values of drinking water color and dry residue found in Samara were 1.5 times higher than the respective average values for the analyzed samples in the RC. It is worth noting that in the Samara urban district the values of dry residue were higher than normal limits (1000 mg/dm^3) in areas where drinking water is mixed with groundwater, i. e., Kuibyshevskyi district (1690.70 mg/dm^3) and Ozerny village (1435.20 mg/dm^3).

Water permanganate index is an indicative that the water contains dissolved readily oxidizable organic substances. Water color is an indirect parameter showing the presence of dissolved organic matter, in particular, humic and fulvic acids. This can also be indicative of technogenic-related contamination.

Dry residue characterizes the content of organic and inorganic matter in water. High values of dry residue influence the organoleptic indicators of water, in particular, taste. In separate areas of the Samara urban district, high values of mineralization by the dry residue are due to the values of groundwater supply sources, the Samara River impact and possible non-effective functioning of decontamination stations.

In its turn, content of sulphates and chlorides in the analyzed samples of drinking water in the RC exceeded by 1.2 times the respective values in the Samara urban area. Content of copper was 3 times lower in drinking water of the Samara urban area as compared with that of the RC.

Copper produces a negative effect on water-supply and sanitary engineering devices, as its higher water content is dangerous for human health. Professionals believe that copper is the third hazard class substance with its maximum permissible limit being 1.0 mg/l.

Nitrogenous compounds present in drinking water as nitrates, nitrites and ammonia, are indicative of contamination of water sources with sewage. No exceeded values were found in all analyzed samples by all the parameters of nitrogenous compounds.

DISCUSSION OF RESULTS

In the analyzed samples, drinking water corresponded to the requirements of Sanitary Rules and Regulations 1.2.3685–21 and Sanitary Rules and Regulations 2.1.3684–21 by many sanitary and chemical parameters. During the comparative analysis of sanitary and chemical parameters of drinking water in the Samara urban area and Republic of Crimea, higher concentrations of sulphates (mean difference of 21.5 mg/dm^3), chlorides (mean difference of 19 mg/dm^3) and copper (mean difference of 0.015 mg/dm^3) were found in water samples from the Republic of Crimea and higher values of dry residue (mean difference of 165.02 mg/dm^3), color (mean difference of 3.66 mg/dm^3) and permanganate index (mean difference of 2.72 mg/dm^3) were detected in samples of drinking water from the Samara urban area. The obtained results can demonstrate natural composition differences in the sources of central water supply, water treating and condition of water supply pipes [2, 8]. Based on the conducted analysis it was shown that quality of the analyzed samples of drinking water in the Samara urban area and Republic of Crimea does not correspond to hygienic requirements as far as oil product content goes.

Quality of drinking water is determined with a source of drinking water supply (surface and underground). Thus, respective water treatment is necessary to obtain normal composition of prepared drinking water [10, 11]. Bad condition of water supply pipes also produced an unfavorable effect on quality of water obtained by the consumer. In this case, the consumer can improve quality of drinking water by following a number of recommendations [5, 7, 10].

CONCLUSIONS

Nonconformance to hygienic requirements was reported during the conducted study estimating quality of drinking water supply in different regions of the Russian Federation. The obtained results are a testimony to the insignificant effect of cleaning with pumping and filtering units regarding organic substances which are resistant to oxidation.

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BIOLOGICAL CONTAMINATION OF WATER IN RUSSIAN WATER BODIES AND ITS EPIDEMIOLOGICAL SIGNIFICANCE

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Drinking water, household water, and recreational water can be the vehicle of infections and invasions transmitted by fecal-oral route. In this paper we studied the impact of the quality of water in water bodies on the incidence of enteric infections and invasions in the population of the Russian Federation based on the State reports "On the State of Sanitary and Epidemiological Well-Being of the Population of the Russian Federation" issued by the Federal Center of Rospotrebnadzor in 2011–2020. Based on microbiological parameters, the quality of water from the centralized sources of water supply in the Russian Federation corresponds to microbiological parameters of water in waterworks before entering the distributive pipelines (3.5 and 2.9% off-nominal tests, respectively, *Rxy* = 0.98). Giardia cysts were found in 0.06% of the assessed water samples collected from the centralized sources of water supply. This parameter correlates with the percentage of off-nominal microbiological water tests (*Rxy* = 0.84). The values of biological water contamination tend to decrease. The incidence of acute enteric infections and giardiasis shows a negative trend and correlates with the indicators of biological water contamination obtained for water from the centralized sources of water supply and grade II reservoirs. The findings, that support the literature data on the impact of biological water contamination on the incidence of enteric infections and invasions in the population, highlight the relevance of maintaining the sanitary and hygienic condition, as well as providing thorough sanitary and hygienic control of water bodies.

Keywords: water sources, drinking water, microbiological parameters, morbidity, acute enteric infections, giardiasis

Author contribution: Evtodienko AM — data acquisition and processing; Evtodienko AM, Zdolnik TD — manuscript writing; Zdolnik TD — manuscript editing and approval.

Compliance with ethical standards: the informed consent was submitted by all study participants. The study was conducted in accordance with the principles of biomedical ethics.

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БИОЛОГИЧЕСКАЯ КОНТАМИНАЦИЯ ВОДЫ ВОДНЫХ ОБЪЕКТОВ РОССИИ И ЕЕ ЭПИДЕМИОЛОГИЧЕСКОЕ ЗНАЧЕНИЕ

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Вода питьевого, хозяйственно-бытового и рекреационного водопользования может служить фактором передачи инфекций и инвазий с фекально-оральным механизмом передачи. В работе изучено влияние качества воды водных объектов на заболеваемость населения Российской Федерации кишечными инфекциями и инвазиями по материалам Государственных докладов «О состоянии санитарно-эпидемиологического благополучия населения в Российской Федерации» федерального центра Роспотребнадзора России за 2011–2020 гг. Качество воды централизованного водоснабжения в Российской Федерации по микробиологическим показателям соответствует микробиологическому состоянию воды на водопроводных сооружениях перед подачей в разводящую сеть (3,5 и 2,9% нестандартных проб соответственно, *Rxy* = 0,98). Цисты лямблий обнаруживались в 0,06% исследованных проб воды централизованного водоснабжения. Показатель коррелирует с долей нестандартных проб воды по микробиологическим показателям (*Rxy* = 0,84). Показатели биологической контаминации воды всех исследованных водных объектов имеют тенденцию к снижению. Заболеваемость острыми кишечными инфекциями и лямблиозом характеризуется отрицательным трендом, коррелирует с показателями биологического загрязнения воды централизованного водоснабжения и водоемов II категории. Результаты исследования, подтверждающие данные литературы о влиянии биологического загрязнения воды на заболеваемость населения кишечными инфекциями и инвазиями, свидетельствуют об актуальности соблюдения санитарно-гигиенических нормативов и тщательного санитарно-эпидемиологического надзора за водными объектами.

Ключевые слова: источники водоснабжения, питьевая вода, микробиологические показатели, заболеваемость населения, острые кишечные инфекции, лямблиоз

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Соблюдение этических стандартов: добровольное информированное согласие было получено для каждого участника. Проведенное исследование соответствует требованиям биомедицинской этики.

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High quality organization of water supply to the population is essential for prevention of multiple disorders, including the communicable diseases [1]. Numerous epidemiological data from both past (late 19 — early 20 century) and modern periods show the relationship between the incidence of infections and invasions transmitted by fecal-oral route and the state of water supply [2–5].

In Russia, public water supplies are a branched network of the water intake, water treatment, and water distribution facilities, some of which need repair and renovation.

According to SanPiN 2.1.3684–21 "Sanitary and Epidemiological Requirements for the Maintenance of Urban and Rural Settlements, Water Facilities, Drinking Water and Drinking Water Supply, Atmospheric Air, Soils, Living Quarters, Operation of Industrial, Public Premises, Organization and Conduct of Sanitary and Anti-Epidemic (preventive) Measures", water from the water-supply sources can be used for drinking and domestic use in case of compliance with the requirements for drinking water. In case of non-compliance with the hygienic

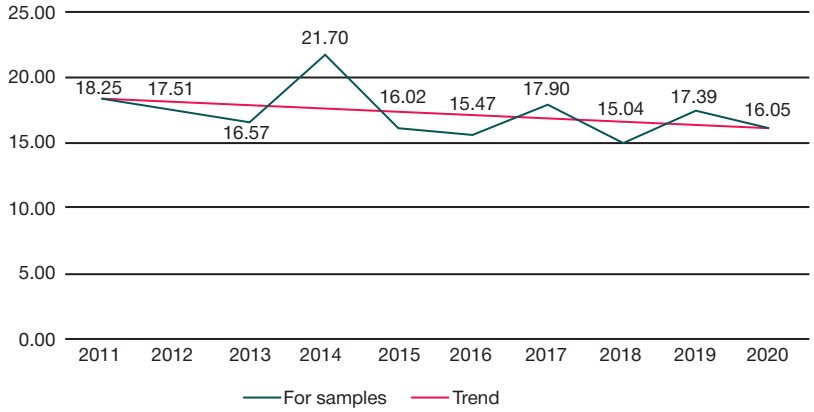

Fig. 1. Proportion of water samples from class I reservoirs that do not meet the standards by microbiological criteria in 2011-2020 (%).

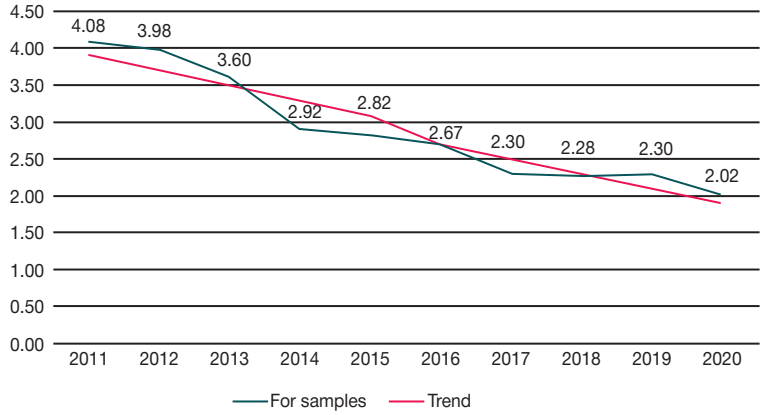

Fig. 2. Proportion of water samples from water works prior to their supply through the distribution network that do not meet the hygienic standards by microbiological criteria in 2011-2020 (%).

standards of the quality of water from the water-supply sources used as public sources of drinking water supply, water treatment should be used to ensure the quality and safety of water in the distribution network in accordance with the hygienic standards [6].

The study was aimed to assess the impact of the quality of water from water bodies on morbidity in the population of the Russian Federation based on the analysis of the relationship between the microbiological and parasitological parameters of water quality and the incidence of enteric infections and invasions in the population.

The research tasks included:

- assessing microbiological parameters of the quality of water from the sources of domestic water supply (grade I reservoirs);
- assessing microbiological parameters of the quality of water in waterworks before entering the distributive pipelines;
- assessing microbiological and parasitological parameters of the quality of water from water-supply sources;
- assessing microbiological parameters of the quality of recreational water (grade II reservoirs);
- assessing the incidence of acute enteric infections and invasions (giardiasis) in the population.

METHODS

The study involved the use of data from the State reports "On the State of Sanitary and Epidemiological Well-Being of the Population of the Russian Federation" issued by the Federal Center of Rospotrebnadzor in 2011–2020. Statistical processing of the data was performed using Microsoft Excel.

RESULTS

According to the study, in 2011–2020, the average share of off-nominal tests (based on the microbiological parameters of water samples collected from grade I reservoirs) was 17.19%, and showed a moderate downward trend (Rav.gr. = –1.28%) (Fig. 1).

The percentage of off-nominal tests for water samples collected from waterworks before entering the distributive pipelines was 2.90%, and showed a pronounced downward trend (Rav.gr. = –7.02%) (Fig. 2).

The reported decline in the share of off-nominal microbiological tests of water samples collected from waterworks before entering the distributive pipelines compared to that of water from the surface water-supply sources may be interpreted as evidence of the relatively high quality water treatment in the majority of waterworks in Russia.

The percentage of positive tests of water samples collected from the centralized sources of water supply was 3.50%; a pronounced deceleration of the growth rate was observed (Rav.gr. = –5.97%) (Fig. 3). This value is marginally higher than the percentage of positive tests of water samples collected from waterworks before entering the distributive pipelines, which indicates no significant effect of the state of water distribution pipelines on the parameters of the drinking water microbiological quality.

Parameters of the microbial composition of water from the centralized sources of water supply correlate with the

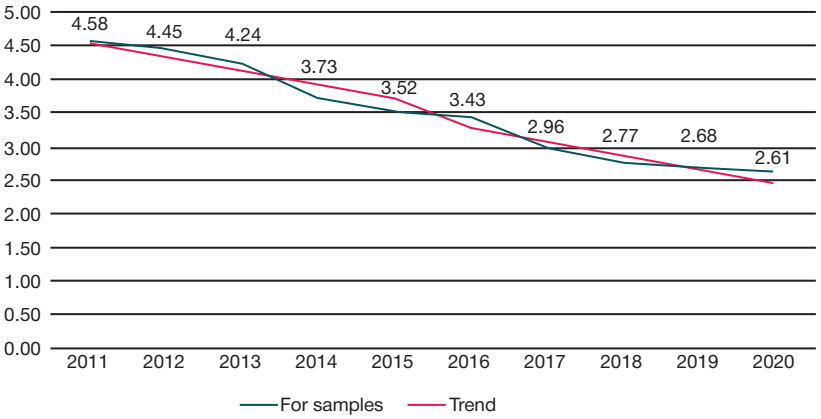

Fig. 3. Proportion of water samples from the centralized water supply system that do not meet the hygienic standards by microbiological criteria in 2011-2020 (%).

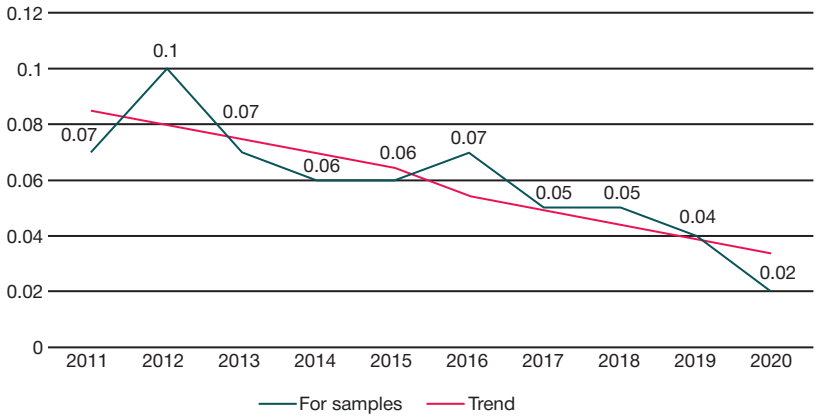

Fig. 4. Proportion of water samples from the centralized water supply system that do not meet the hygienic standards by presence of lamblia cysts in 2011-2020 (%).

microbiological quality of water in waterworks before entering the distributive pipelines (R_{xy} = 0.98).

Analysis of the dynamic changes in microbiological quality of water over the past 10 years indicates a slight decline in the share of off-nominal tests of water samples collected from grade I reservoirs during the studied period. Furthermore, a significant decrease in the number of positive tests of water samples collected before entering the distributive pipelines and from the distributive pipelines during the same time period is observed. This may be interpreted as evidence of the improvement in the quality of waterworks performance in Russia over the past few years.

According to literature, chlorination and ultraviolet light that are used to disinfect water in waterworks have a harmful effect on the bacterial flora, however, these do not provide sufficiently effective Giardia cyst inactivation [7, 8]. Considering this fact, it was interesting to analyze the data from the State reports on the content of this protozoan species in drinking water.

According to the study, the average share of off-nominal tests of water samples collected from the centralized sources of water supply (based on the presence of Giardia cysts) was 0.06%; a moderate downward trend was observed (Rav. gr. = –8.63%) (Fig. 4).

Despite the above literature data on the insufficient effect of standard water disinfection methods on Giardia cysts, our study revealed a strong correlation between the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply and the number of samples containing Giardia cysts (R_{xy} = 0.84).

The average share of off-nominal tests (based on the microbiological parameters of water samples collected from grade II reservoirs) was 22.76%, and showed a moderate downward trend (Rav.gr. = –2.25%) (Fig. 5). This indicator corresponds in some ways to the results for water from grade I reservoirs.

The average incidence of acute enteric infections (AEI) in Russia over the studied 10 years is 521.1 per 100,000 population, and shows a moderate downward trend (Rav.gr. = –2.77%) (Fig. 6).

The incidence of acute enteric infections correlates with the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply (R_{xy} = 0.49) and water samples collected from grade II reservoirs (R_{xy} = 0.56), which is in line with the literature data on the epidemiological role of water [5].

Information about the incidence of certain enteric infections and its trends is provided in Table. Analysis of this information has revealed a positive correlation between the incidence of such bacterial infections, as dysentery (R_{xy} = 0.96) and salmonellosis (R_{xy} = 0.94), hepatitis A virus (R_{xy} = 0.61) and the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply. No correlations between the percentage of off-nominal microbiological tests of water samples collected from the centralized sources of water supply and the incidence of viral enteric infections (except hepatitis A virus) have been revealed, possibly due to the fact that disinfectants used for water treatment mostly affect bacterial flora. This provision is also in line with literature data [5].

The average incidence of giardiasis in the Russian Federation over 10 years is 34.7 per 100,000 population; a pronounced downward trend is observed (Rav.gr. = –10.40%).

There is a strong correlation between the incidence of giardiasis and the percentage of off-nominal tests of water

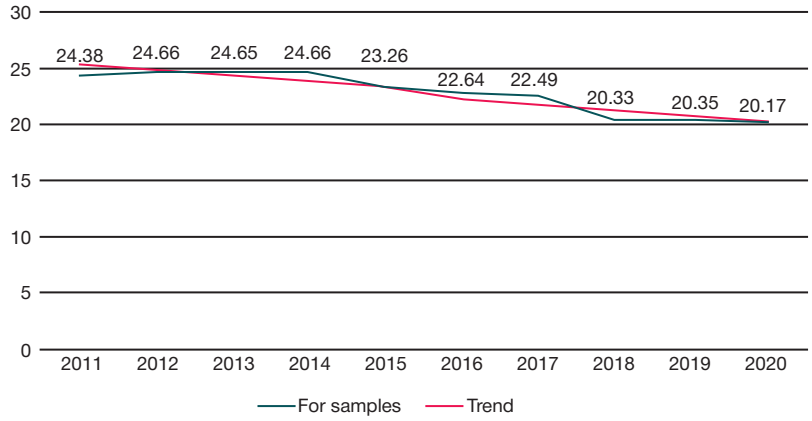

Fig. 5. Proportion of water samples from class II reservoirs that do not meet the hygienic standards by microbiological criteria in 2011-2020 (%).

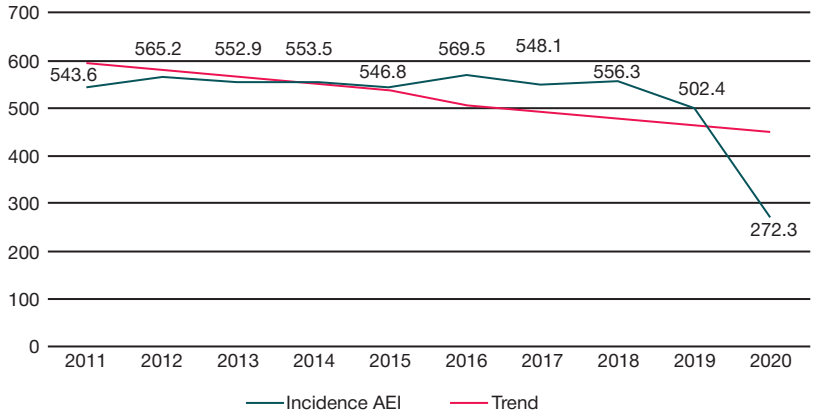

Fig. 6. The incidence of acute intestinal infections in the Russian Federation in 2011-2020 (%)

Table. Characteristics of the incidence of certain types of intestinal infections

Acute intestinal infections	Average incidence	Average growth rate
Dysentery	6.6	–10.96
Salmonellosis	27	–6.76
Viral hepatitis A	4.5	–7.02
Enterovirus infection	7.82	4.87
Norovirus infection	16.2	17.48
Rotavirus infection	72.2	–1.77

samples collected from the centralized sources of water supply based on microbiological (R_{xy} = 0.98) and parasitological (R_{xy} = 0.87) parameters.

DISCUSSION

The results obtained based on the averaged data from the large territory of the Russian Federation make it impossible to draw reliable conclusions. However, it is possible to formulate the basic provisions that arise from the findings:

- based on microbiological parameters, the quality of water from the centralized sources of water supply in the Russian Federation is generally consistent with the quality of water in waterworks before entering the distributive pipelines; this may be interpreted as evidence of the rather good state of the distributive pipelines having no sufficient effect on the quality of water supplied to the population;
- the observed correlation between the percentage of off-nominal tests of water samples collected from the centralized sources of water supply (based on the presence of Giardia cysts) with the percentage of water samples non-compliant with the hygienic standards based on microbiological parameters may be interpreted as evidence of the sufficient effect of water treatment on pathogenic protozoa in most of Russia;
- the findings confirm the literature data on the impact of biological water contamination on the incidence of enteric infections (especially bacterial) and invasions in the population.

CONCLUSION

The main provisions of the study make it possible to conclude that maintaining the sanitary and hygienic condition, as well as providing thorough sanitary and hygienic control of water bodies is relevant.

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THE COVID-19 PANDEMIC IN DIFFERENT COUNTRIES: RUSSIA, BRAZIL AND INDIA

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At the end of December 2019, cases of pneumonia of unknown etiology were registered in China. The cause represented by the novel coronavirus SARS-CoV-2 was established later. The infection has spread rapidly around the world. According to the latest official data, over 531,959,093 cases of the infection and over 6,299,068 confirmed COVID-19-related mortality cases were reported in 215 countries. The study aimed to examine characteristic features of the novel coronavirus pandemic in Russia, Brazil, and India from April 2020 to March 2022. Official statistical data on COVID-19-related morbidity, mortality, and vaccination from the websites of the Russian Federal State Agency for Health and Consumer Rights and Johns Hopkins Institute were collected for every country from April 01, 2020, to March 01, 2022. Out of the three examined countries, the highest incidence and mortality for COVID-19 per one million people were found in Brazil, followed by Russia and India respectively. The level of vaccination was the highest in Brazil (73%). It was followed by India (53%) and Russia (50%). The *Delta* variant of the virus was first identified in India in October 2020. In June of the next year, it accounted for the majority of COVID-19 cases registered in three countries. The same was true for the Omicron variant. Despite the efforts taken within the last two years to contain COVID-19 (development of vaccines, use of other anti-epidemic agents), the coronavirus infection is still of cyclical patterns along with increased morbidity. Based on the obtained data, massive vaccination effectively reduced mortality due to COVID-19 though many new variants occurred.

Keywords: COVID-19, global impact, vaccination, incidence, mortality

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Author contribution: Rocha Ferreira SS — official statistical data collection about the pandemic of novel coronavirus infection in three examined countries: calculation of COVID-19-related morbidity and mortality values in three studied countries, statistical processing of the obtained data analysis using *Windows Microsoft Excel 10*; Koreshkova KYu — official statistical data collection about the pandemic of novel coronavirus infection in Russia; calculation of COVID-19-related morbidity and mortality values in Russia, statistical analysis of the obtained data; Guduru Y — official statistical data collection about the pandemic of novel coronavirus infection in India, statistical analysis of the obtained data; Rocha LS— statistical processing of the study results; Perminova LA — academic guidance to students during the entire research, critical assessment, and correction of the developed scientific work.

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ПАНДЕМИЯ COVID-19 В РАЗНЫХ СТРАНАХ: РОССИИ, БРАЗИЛИИ И ИНДИИ

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В конце декабря 2019 г. в Китае были зарегистрированы случаи пневмонии неизвестной этиологии, позже была установлена причина — новый коронавирус (SARS-CoV-2). Инфекция быстро распространилась по всему миру, по последним официальным данным, зарегистрировано более 531 959 093 случаев инфекции и более 6 299 068 подтвержденных смертей от COVID-19 в 215 странах. Цель исследования — изучить особенности пандемии новой коронавирусной инфекции в России, Бразилии и Индии с апреля 2020 г. по март 2022 г. Собраны официальные статистические данные из веб-сайтов: Роспотребнадзора и Johns Hopkins Institute по числу заболеваемости, летальности и вакцинации от COVID-19 по каждой стране с 01.04.2020 по 01.03.2022. Из трех исследованных стран в Бразилии был самый высокий уровень заболеваемости и самая высокая летальность от COVID-19 на миллион жителей, затем следуют Россия и Индия, соответственно. Уровень вакцинации также был самым высоким в Бразилии — 73%, за ней следует Индия — 53% и Россия — 50%. Вариант *Delta* появился в Индии в октябре 2020 г., а в июне следующего года он уже представлял большинство случаев заражения от COVID-19, зарегистрированных в трех странах. То же самое наблюдалось со штаммом омикрон. Несмотря на усилия, предпринятые в течение последних двух лет для сдерживания пандемии COVID-19: разработки вакцин, использования других противоэпидемических средств, коронавирусная инфекция продолжает демонстрировать свой циклический характер с увеличением заболеваемости. Согласно полученным данным, массовая вакцинация оказалась эффективной в снижении летальности от COVID-19, несмотря на появление новых штаммов.

Ключевые слова: COVID-19, глобальное воздействие, вакцинация, заболеваемость, летальность

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Вклад авторов: С. С. Роша Феррейра — сбор официальных статистических данных о пандемии новой коронавирусной инфекции из трех изучаемых стран; расчет показателей заболеваемости и летальности населения от COVID-19 в трех исследуемых странах, статистическая обработка анализа полученных данных в *Windows Microsoft Excel 10*; К. Ю. Корешкова — сбор официальных статистических данных о пандемии новой коронавирусной инфекции в России; расчет показателей заболеваемости, летальности населения от COVID-19 в России, статистический анализ полученных данных; Я. Гудуру — сбор официальных статистических данных о пандемии новой коронавирусной инфекции в Индии, статистический анализ полученных данных; Л. С. Роша — статистическая обработка результатов исследования; Л. А. Перминова — академическое руководство студентами на протяжении всей научной работы, критическая оценка и исправление разработанной научной работы.

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At the end of December 2019, the World Health Organization (WHO) was informed about pneumonia cases of unknown etiology, detected in Wuhan City, China. On the 7th of January 2020, a novel coronavirus (temporarily called 2019-nCoV) was identified as the cause of the new infection by the Chinese government. In March 2020, Europe became the epicenter of the rapidly spreading global coronavirus pandemic. By the beginning of April 2022, SARS-CoV-2 infected 531,959,093 people and was the cause of mortality of 6,299,068 people in 215 countries [1].

Coronavirus is a large family of single-stranded enveloped RNA viruses of the *Coronaviridae* family that can cause both a mild respiratory illness and severe pulmonary involvement.

The pandemic launched a global race aimed at virus mapping and vaccine development. In the middle of December 2020, Russia started to vaccinate its people; Brazil and India did the same in January 2021. However, mutation of the virus and formation of new variants have been an important part of the pandemic development for over two years. Thus, a novel Delta variant was identified in India in October 2020 [1–4].

Despite global efforts associated with anti-epidemic activities and massive vaccination campaigns, novel variants of the virus continued to evolve. Omicron was one of the last variants first identified in South Africa in December 2021, rapidly spreading over all the continents [1–2]. The variant had high virulence and involved the pediatric population being less lethal among vaccinated people.

Since the novel coronavirus outbreak, specifics of the epidemic process in various countries were associated with geographical position, climate, social, economic, and demographic factors, and public health system resources [5].

The purpose of this study was to compare COVID-19 morbidity and mortality dynamics from the beginning of the pandemic to the present days taking into account new virus variants (delta and omicron) in the countries located in various world regions such as Russia, Brazil, and India, and analyze vaccination coverage in these countries and its influence on the novel coronavirus infection-associated morbidity and mortality.

MATERIALS AND METHODS

1) Collection of official statistical data on novel coronavirus morbidity and mortality, and COVID-19 vaccination coverage for every country from April 01, 2020, to March 01, 2022, using official data of the Russian Federal State Agency for Health and Consumer Rights and Johns Hopkins Institute.
2) Calculation of COVID-19-related morbidity and mortality values. Statistical processing of the obtained data in *Windows Microsoft Excel 10.*

STUDY RESULTS

The Russian Federation is located in Eastern Europe and Northern Asia. Being the largest country in the world, it is inhabited by 144,1 million people. Brazil with 212.6 million people is a country located in South America. India is a huge country in South Asia inhabited by 1.38 billion people.

In Russia, the first cases of COVID-19 were registered in two citizens of China on January 31, 2020. In Brazil, the first case was reported in a Brazilian citizen who came back from Italy on January 26, 2020. In India, the first case was noted in a girl who came back from Wuhan, China, on January 27, 2020.

The obtained data show that, in the absolute values, the total number of confirmed COVID-19 cases amounted to 16,260,000 people in Russia, with 28,820,000 and 42,940,00 cases found in Brazil and India respectively from April 01, 2020, to March 01, 2022. COVID-19 morbidity data per one million people were calculated for every country. It has been shown that Brazil occupied the first place with the morbidity of 134,671 confirmed cases per one million people followed by Russia and India with 111,421 and 30,815 cases per one million respectively.

Analyzing the morbidity dynamics during the pandemic caused by the novel coronavirus, its cyclicity can be traced (fig. 1). Five main rises have been registered in Russia. They occurred from May to June 2020, from November 2020 to January 2021, from June to August 2021, from October to November 2021, and from January to February 2022. Though Brazil and India are located in different hemispheres, they have similar cyclic forms. Four and three morbidity rises are found in Brazil and India respectively.

In Brazil, the first rise was registered from July to September 2020, during a Brazilian winter. The second rise was noted from January to February 2021 (in summer). The third rise was reported from April to July 2021 (autumn and winter). The fourth rise was from February to March 2022 (in the summer). In India, the first peak of incidence was in the middle of September 2020 (monsoon season), the second peak was from March to June 2021, and the third peak was in February, at the beginning of 2022 (spring).

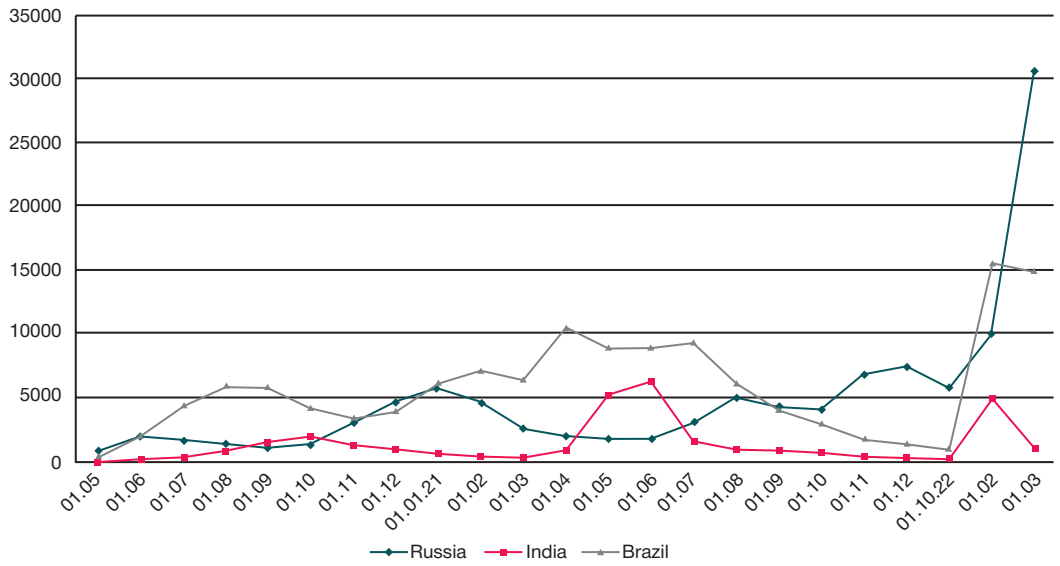

Fig. 1. Analyzing the dynamics of COVID-19 morbidity in Russia (A), Brazil (B) and India (C)

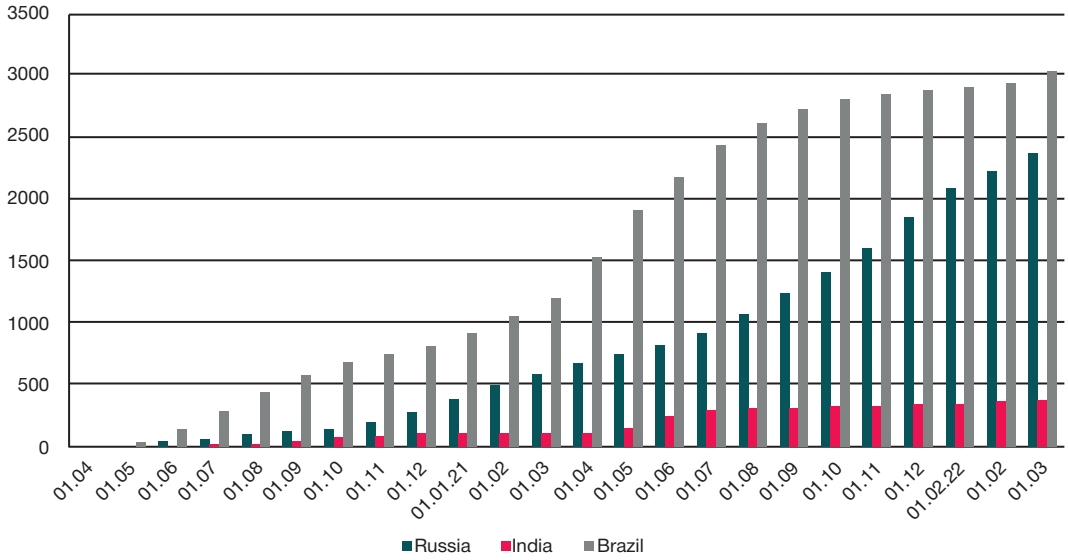

Fig. 2. COVID-19-related mortality in Russia, India, and Brazil from April 01, 2020, to March 01, 2022 (per million people)

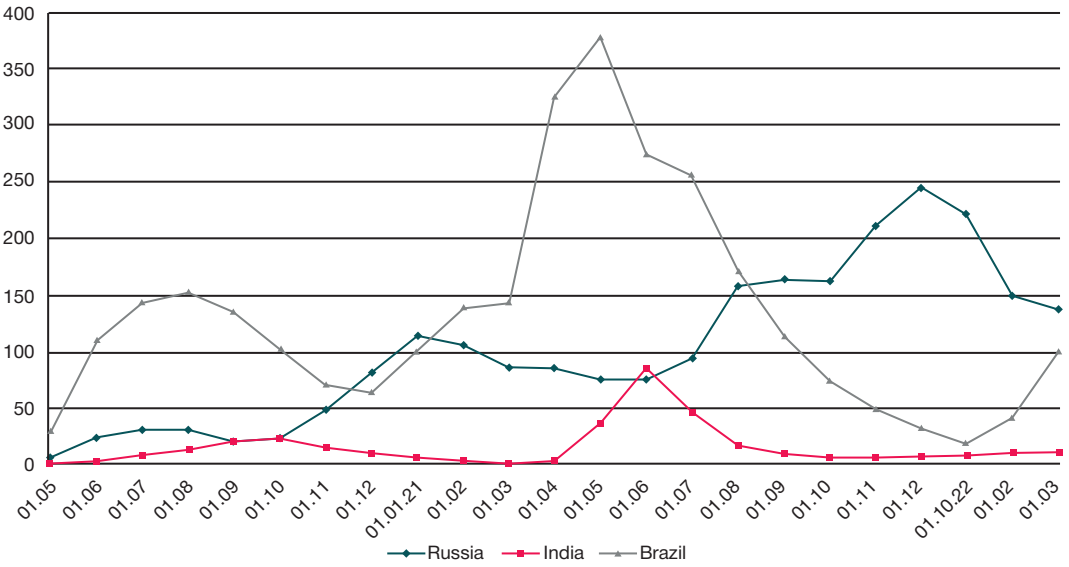

Fig. 3. Analyzing the dynamics of COVID-9-related mortality in Russia, Brazil and India from May 01, 2020, to March 01, 2022

A comparative analysis of the confirmed mortality rate due to the novel coronavirus was performed for the analyzed period. According to the obtained absolute values, India occupies the leading position among the analyzed countries with 514,246 COVID-19-related cases of death being confirmed, whereas in Brazil and Russia they amounted to 649,922 and 345,427 cases respectively. However, analysis of relative mortality rates per one million people has shown that the highest mortality value was reported in Brazil (3,037 cases per 1 million) followed by Russia and India (with 2,367 and 369 respectively) (fig. 2). Within the examined period, the highest percentage of lethal COVID-19-related outcomes (2.32%) was recorded in Brazil and followed by the Russian Federation (2.12%) and India (1.2%).

In Brazil, the mortality rate for people with novel coronavirus has two peaks: from July to September 2020 (first peak) and from April to May 2021 (second peak). In Russia, we have several periods of COVID-19-related mortality rise: in May-June 2020 (first peak), from December 2020 to January 2021 (second peak), from July to September 2021 (third peak), and from October to December 2021 (fourth peak) (fig. 3).

In India, the first mortality rise was in October 2020, the second one occurred from May to July 2021(fig. 3).

A reduced mortality rate was also found in Brazil from June 2021. In January 2022, the most minimal values were reported. Similar data were observed in India with decreased mortality rate from July 2021 and the lowest values in October 2021 (fig. 3).

To protect people from COVID-19, the studied countries used vaccines with different mechanisms of action. They used *Covaxin* (inactivated vaccine) in India and Sputnik V and Sputnik Light (vector vaccine) in Russia. In Brazil, Coronavac (inactivated vaccine); AstraZeneca and Johnson & Johnson (vector vaccines), and BioNTech Pfizer (mRNA vaccines) were utilized. Vaccination coverage was the highest in Brazil (73%), followed by India (53%) and Russia (50%).

Vaccination in Russia started at the beginning of December 2020. In the majority of cases, they used Sputnik V and EpiVacCorona vaccines. After the start of the vaccination campaign, military men, doctors, teachers, and social workers were given Sputnik V. Small lots of CoviVac vaccine were distributed from April 2021. Sputnik Light went into circulation on June 25, 2021 (fig. 4A).

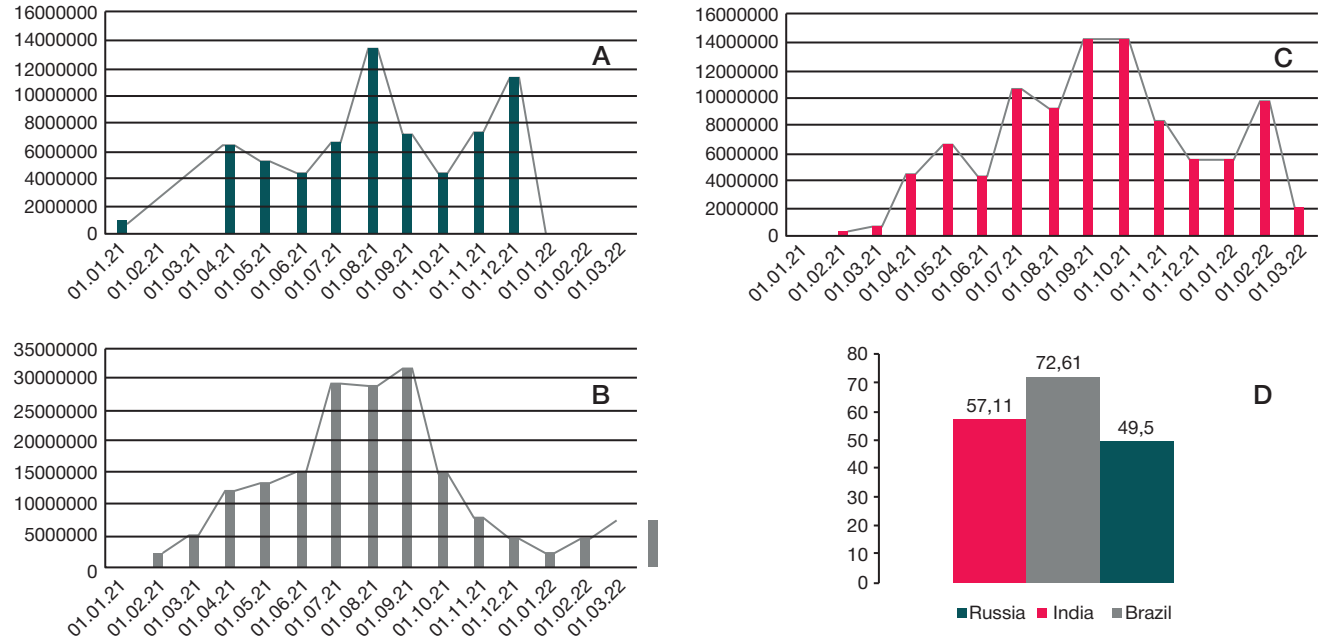

Fig. 4. Dynamics of COVID-19 vaccination from January 2021 to March 2022 in Russia (A), Brazil (B) and India (C). Percentage of the population vaccinated with at least one dose of COVID-19 vaccine available in the country (D)

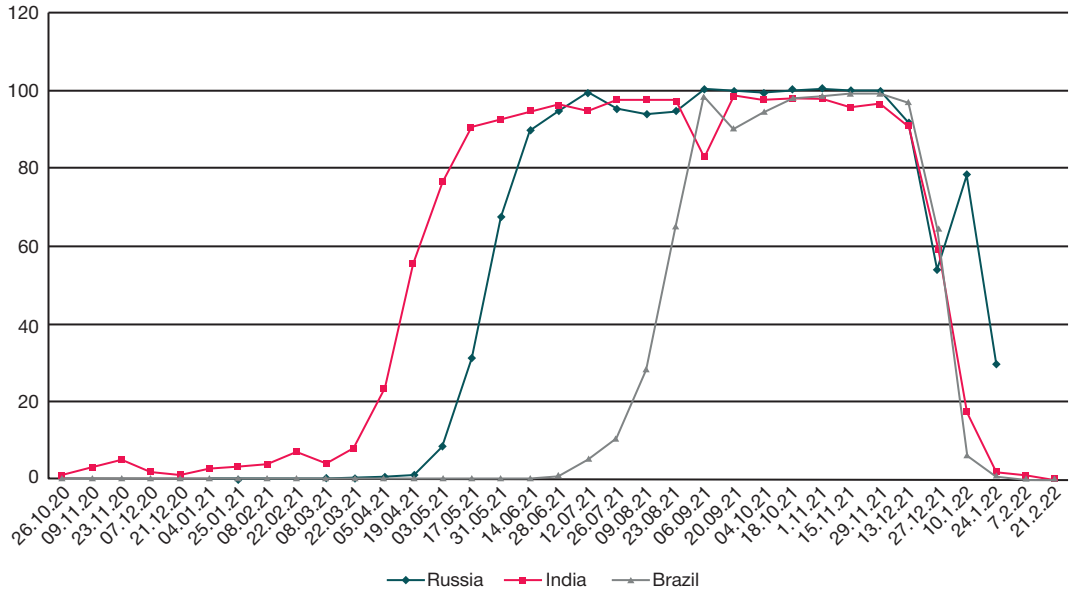

Fig. 5. The share of Delta variant among all the confirmed COVID cases in Russia, India and Brazil from October 26, 2020, to February 21, 2022

In Brazil, they started vaccination with *Coronavac* in January 2021. During the first months, only medical professionals and elderly people were vaccinated. As soon as the Brazilian government obtained more vaccine doses from other manufacturers, the rest part of the population was vaccinated by the age groups (from the eldest to the youngest ones). The vaccination peak is from July to September 2021. Currently, the population is being revaccinated already (third dose) and the main vaccines used for now are *Pfizer, AstraZeneca, and Johnson and Johnson* (fig. 4B).

In India, the vaccination campaign started in February 2021. Medical professionals, public officers, and frontline employees were the first ones vaccinated in India. The majority of the population was vaccinated in September and October 2021. The first vaccines used in India were *CoviShield* and *Covaxin*. It is lately recommended to obtain a booster vaccine dose there (fig. 4C).

In Brazil and India, the dynamics of vaccination have a similar pattern. This emphasizes gradually increased vaccination coverage with the highest peak of the obtained doses in the middle of 2021 when vaccination with the second dose has already begun and when widespread vaccination has already been available to the entire population, and not just to the groups of risk. When assessing vaccination development in Russia, variation in the number of applied doses with their rise in April, August, and December 2021 has been observed (fig. 4D).

The first cases of the Delta variant infection were first identified in India. It all began in October 2020 with the peak being reached by April 2021. Decreased incidence of the Delta variant was for the first time reported in December 2021, whereas the lowest values were registered in February 2022.

In Russia, the first cases of the Delta variant were reported in the middle of April 2021 (fig. 5). The maximum incidence was

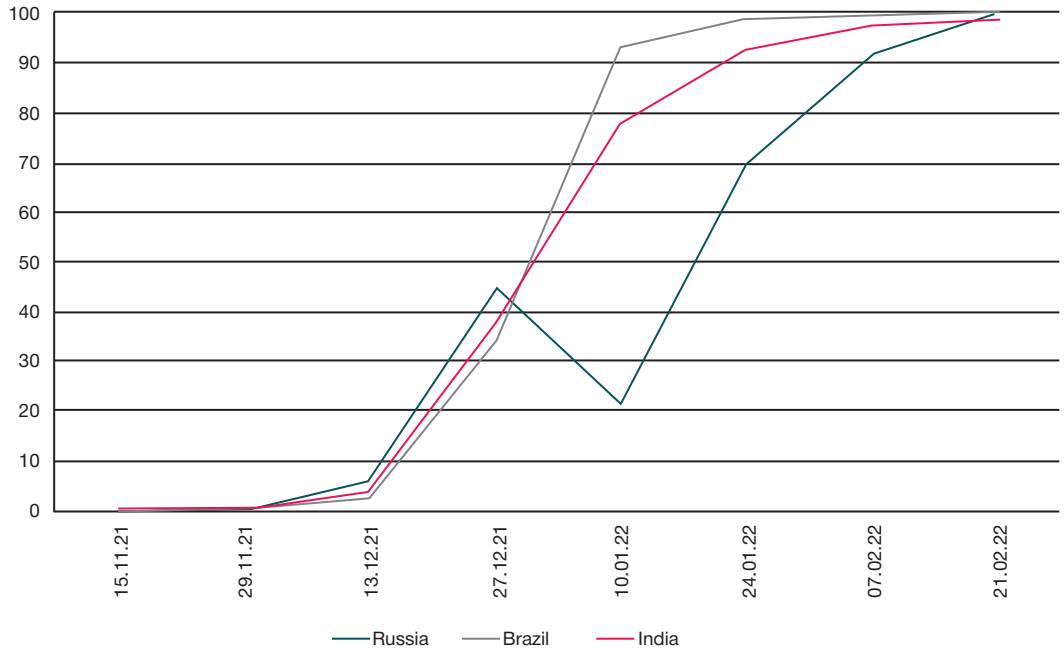

Fig. 6. The share of the Omicron variant among all confirmed cases of COVID in the studied countries from November 15, 2021, to February 21, 2022

reached at the end of June 2021, with a higher peak being found in Russia than in Brazil and India. A steep decline in cases of the Delta infection was seen from the end of November. Another rise was reported at the beginning of January, but by the end of the month, the morbidity reduced. The lowest values were found in February 2022.

In Brazil, the first cases of the COVID-19 delta variant infection were observed at the end of June 2021. It reached the maximum in September 2021 and accounted for the largest share of all COVID-19 cases in the country. In December 2021, the number of cases dropped with the level of infection being the lowest in January 2022 (fig. 5).

The Omicron variant was first detected in South Africa in November 2021. During this month, the highest incidence rates were identified in Russia as compared with other countries. The new peak was found at the end of January 2022. In India, the first cases of the Omicron variant were first registered in November 2021. The infection rate with the Omicron variant reached its maximum in January-February 2022 (fig. 6).

In December 2021, the lowest infection level was found in Brazil. However, in January 2022 Brazil came in first place by several new cases associated with the Omicron variant.

Almost 100% of the registered cases in the studied countries are represented by this variant, as shown in March 2022 (fig. 6).

DISCUSSION OF RESULTS

The COVID-19 pandemic is a global healthcare concern with certain differences in the dynamics of the epidemic process for different countries. The BRICS club is a political and economic group of countries (Brazil, Russia, India, China, and South Africa) with rapidly growing economies amounting to almost half of the world population. As of April 30, the number of SARS-CoV-2-infected in the BRICS countries reached 39.77 million, accounting for over a quarter (26.3%) of the worldwide total [6].

The greatest level of the relative incidence of the novel coronavirus infection is registered in Brazil. Based on the obtained data, we differentiated between four cycles of rise in the number of registered COVID-19 cases in Brazil (July-September 20; January-February 21; April-July 21; February-March 22). Russia with five cycles of rise in the incidence of COVID-19 (May-June 20; November-January 21; June-August 21; October-November 21; January-February 22) is in the second place by a relative number of incidences; the third place is occupied by India with three peaks of incidence (September 20; March-June 21; February-March 22). Similar cyclic processes were observed in India and Brazil. It was quite opposite for Russia. This can be explained by a similar climate in India and Brazil.

Zhu et al. [6] estimated the COVID-19 pandemic in the BRICS countries and showed that the population density correlates with the daily gain of new COVID-19 cases. This is how our data are confirmed. Moreover, social, economic, and demographic factors, health and resource vulnerability, and demographic and political measures were associated with the development of the COVID-19 pandemic.

Rocha et al. [7] have found that the initial spread of COVID-19 in the country was more influenced by the models of social and economic vulnerability than by the age structure of the population and the incidence of available chronic diseases. This is confirmed by data obtained during our research where India and Brazil had higher morbidity and mortality as compared to Russia.

During the first wave, the basic increase in the COVID-19 incidence in Brazil and India was reported in the summer and autumn of 2020. A maximum number of new COVID-19 cases was observed at the end of July in Brazil and in September in India [5]. In Russia, the first maximum incidence figures were registered in May 2020. The second maximum rise was reported in December 2020 [8], when the incidence rate in Brazil and India began to decline [5]. The presented data correlated with the results obtained in our research work (fig. 1).

The greatest level of COVID-9-related morbidity was registered in Brazil (July-September 20; April-March 21), the second position was occupied by Russia (May-June 20; December 20-January 21; July — September 21; October — November 21), the third position was occupied by India (October 20; May-July 21). According to the obtained results, it can be

noted that Brazil and India have two peaks of mortality rise with the second peak being higher. The fact can be possibly related to occurrence of new variants of coronavirus, which are more contagious and highly virulent. This is also supported by the disease dynamics, which increased in the both countries during the same period.

Tavilani A. et al. [9] demonstrated that Asians, Latinos, and Africans are more subjected to the risk for COVID-19 infection as compared with the Europeans, with the COVID-19 mortality rate being 4.2 times higher among black men and women.

The novel coronavirus mortality dynamics in Russia have four peaks. Every peak was higher than the previous one, which can be associated with the novel variants of coronavirus and lower levels of vaccination as compared with other countries.

Thus, we can conclude the protective effect of the vaccination. Though new variants emerged, the vaccination reduces mortality, just like it was in Brazil and India, where a number of lethal outcomes dropped below the values at the beginning of the pandemic. The conclusions can be confirmed during the analysis of vaccination development in the countries, as a significant decrease in mortality was demonstrated within several months following the highest vaccination level in Brazil and India.

Boguslansky DV et al. interviewed 5,822 Russian citizens from 85 regions of Russia and demonstrated that 42.15% of them had doubts the vaccination. Only 37.82% of them had concerns about quality, whereas all the others were more worried about the social aspect, conspiracy theory, and policy of QR-code checking [10]. In fig. 4, which shows the dynamics of vaccination development in Russia, the variations that demonstrate the low level of population compliance and the importance of state measures aimed at the rise in awareness can be observed. This could be the reason for the growing level of vaccination observed during some periods.

In the global study, Sallam Malik et al. [11] assessed the COVID-19 vaccine and showed that the percentage of those willing to be vaccinated in India varied from 78.6 to 83.6% in the period from June 2020 to March 2021 in various studies. The same study shows that the acceptance value in Russia amounted to 30.4% from November to December 2020. Later studies confirmed the result. Urrunaga-Pastor et al. assessed vaccination in Latin America and showed that the level of vaccine acceptance was 83% among 162,763 Brazilian subjects [12].

The study recently published by Shkoda AS et al. in June 2022 suggests that Sputnik V and Sputnik Light effectively reduced the risk of COVID-19 hospitalization when infected with the Omicron variant. A reduction in COVID-19 severity was observed as well [13].

In the attempt to explain the possible successful vaccination in Brazil, we can single out its success story with the national plan of vaccination, where 75% of the used vaccines are manufactured in Brazil and can be obtained by everyone. According to the Ministry of Health of Brazil, 38,000 vaccination rooms were opened in 5,500 municipalities, whereas during the COVID-19 vaccination campaign, there were 50,000 rooms with 114,101 medical professionals being involved [14].

Moreover, it should be noted that Brazil concluded a contract for vaccine purchase with COVAX as a self-financing agent and that the Federal Government of Brazil supplied its population with an access to vaccines within a shorter period of time, and that vaccination campaigns were widely advertised in mass media [14].

At the same time, the study by Briko NI et al. [15] has shown that the level of vaccination among Russian medical professionals was 35%, being higher among doctors than among nurses. The largest concerns were associated with the safety of vaccines and the scarcity of studies. The vaccination advertising rate among professionals was 29.4%. It again confirms the importance of the involvement of medical professionals in the vaccination campaign in order to make it successful.

The conducted studies had certain limitations, such as difficulty in obtaining similar data from three studied countries to perform an objective comparison. Moreover, some data for certain periods were not available on the visited websites, justifying the lack of data in some figures. We would like to emphasize again that it is important to collect statistical data, especially in medicine, making it possible to analyze the taken measures along with the effectiveness of the used prevention and plan the future measures.

CONCLUSIONS

In spite of the efforts taken within the last two years to contain the COVID-19 pandemic, developments, and the use of vaccines against the novel coronavirus infection, COVID-19 is still showing cyclical patterns along with increased morbidity. According to the obtained data, massive vaccination effectively reduced mortality due to COVID-19 in spite of the occurrence of many new variants leading to the increased number of infected people in the examined countries.

Subsequent monitoring of the dynamics of the epidemic process is required taking into account novel variants of coronavirus to improve anti-epidemic activities and resolve the issue of the necessary development of novel vaccines to prevent new variants of SARS-CoV-2 and reduce the related mortality. Moreover, longer studies have to be conducted to detect the effectiveness of the existing vaccines against the newest variants.

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MORBIDITY RATE OF COVID-19 AMONG THE EMERGENCY WARD WORKERS IN RYAZAN

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The biological factor is one of the leading adverse labor factors for medical workers. Establishing risk factors of exposure to COVID-19 within this occupational group is a relevant hygienic task. The purpose of the study is to examine the morbidity in coronavirus among the emergency ward workers and determine risk factors of occupational infection. The morbidity rate of COVID-19 among the emergency ward workers in Ryazan for 2020–2021 has been analyzed. The highest risk of COVID-19 infection was established for medical workers of mobile teams. The infection risks for drivers and medical workers were comparable. Comparative analysis of COVID-19 infection rates for drivers and employees of the ward not engaged in mobile teams confirms higher risks of infection of mobile team workers, including the ones who do not participate in provision of medical aid directly. High morbidity rates and statistically significant probability of a more severe course of the disease among mobile team medical workers as compared to drivers and employees not engaged in mobile teams are probably not accidental, and are due to a closer contact with a patient while providing medical aid and, as a consequence, a higher viral load that partially determines the disease severity. Emergency ward workers have a high occupational risk of exposure to COVID-19 during the pandemic. Mobile team medical workers and drivers are at higher risk of developing the novel coronavirus infection. Emergency care mobile team medical personnel are subjected to the highest risk of a more severe course of the disease.

Keywords: medical workers, emergency medical care, coronavirus infection, morbidity

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Author contribution: Bolobonkina TA — data collection and processing, preparation of the manuscript; Dementyev AA — development of the general concept and study design.

Compliance with ethical standards: the study was approved by the local ethics committee of the Ryazan State Medical University of the Ministry of Health of the Russian Federation (protocol No. 2 as of October 08, 2019).

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ЗАБОЛЕВАЕМОСТЬ COVID-19 РАБОТНИКОВ СТАНЦИИ СКОРОЙ МЕДИЦИНСКОЙ ПОМОЩИ ГОРОДА РЯЗАНИ

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Одним из ведущих неблагоприятных факторов труда медицинских работников является биологический фактор. Установление факторов риска заражения COVID-19 в этой профессиональной группе является актуальной гигиенической задачей. Целью данного исследования стали изучение заболеваемости коронавирусной инфекцией работников станции скорой медицинской помощи и определение факторов риска профессионального инфицирования. Выполнен анализ заболеваемости COVID-19 работников городской клинической станции скорой медицинской помощи города Рязани за 2020–2021 гг. Наиболее высокие риски инфицирования COVID-19 установлены среди медицинских работников выездных бригад. При этом риски заражения водителей были сопоставимы с рисками инфицирования медицинских работников. Сравнительный анализ показателей инфицирования COVID-19 водителей и сотрудников станции, не занятых в работе в выездных бригадах, подтверждает повышенные риски заражения работников выездных бригад, в том числе не принимающих непосредственного участия в оказании медицинской помощи. Высокая частота заболеваемости и достоверно большая вероятность более тяжелого течения болезни среди медицинских работников выездных бригад по сравнению с водителями и сотрудниками, не занятыми в работе в выездных бригадах, вероятно, носят не случайный характер, а обусловлена более тесным контактом с пациентом при оказании медицинской помощи и, как следствие, более высокой вирусной нагрузкой, отчасти определяющей тяжесть течения заболевания. Работники станций скорой медицинской помощи имеют высокий профессиональный риск инфицирования COVID-19 в условиях пандемии. Среди них к группам повышенного риска инфицирования новой коронавирусной инфекцией можно отнести медицинских работников выездных бригад и водителей. Наибольшему риску более тяжелого течения заболевания подвержен медицинский персонал выездных бригад скорой медицинской помощи.

Ключевые слова: медицинские работники, скорая медицинская помощь, коронавирусная инфекция, заболеваемость

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The spread of the new coronavirus infection produced a significant influence on the functioning of various areas of the society [1]. The disease has caused specific challenges for global healthcare aimed to mobilize all forces to struggle the pandemic and preserve all the functional resources to supply patients suffering from other pathologies with medical assistance.

Conditions of labor of emergency care medical workers commonly belong to a harmful class by the levels of hazards and risks [2, 3]. The biological factor that frequently determines the class of labor conditions leads among occupational hazards [4, 5]. In a number of studies, data on a wide range of bacterial load in indoor air of medical facilities have been obtained, occupational exposure of medical workers to the pathogens of tuberculosis, diphtheria, helicobacteriosis, cryptosporidiosis, parenteral viral hepatitis and HIV infection has been proven [6]. A higher risk of occupational infection was established for medical workers who can come in contact with infectious patients such as employees of infectious and antituberculosis institutions, medical workers who provide primary medical care, specialists providing urgent and emergency aid when reliable establishment of an infectious disease in a patient is not possible [7, 8].

An interrelation between occupational contacts with patients and development of infectious diseases in mobile team medical workers has been established [9, 10].

A number of COVID-19 infections continues to increase globally. A number of medical workers infected with SARS-CoV-2 is growing as well. Thus, identification of patterns and risk factors of exposure of emergency ward personnel to COVID-19 and scientific justification of preventive measures for the novel coronavirus infection within this occupational group belong to an essential hygienic task.

MATERIALS AND METHODS

The conducted study was approved by the local ethics committee of the Ryazan State Medical University of the Ministry of Health of the Russian Federation (protocol No. 2 as of October 08, 2019). The study was conducted on the basis of the city clinical emergency ward in Ryazan with 637 employees including 385 mobile team medical workers (320 paramedics and 65 doctors) and 129 drivers of specialized vehicles. The morbidity of the novel coronavirus infection in 2020–2021 has been studied.

In the study, they used data from the log of infectious diseases (form No. 060/y) among employees of the city clinical emergency ward in Ryazan. Clinical diagnoses confirmed in a laboratory were regarded as a case of COVID-19 infection of emergency care mobile team medical workers. Laboratory research data confirming that the employee is infected with COVID-19 were represented with detection of the RNA virus in 67% of cases and serological samples in 33% of cases. The relative values were compared with Student's test (*t*); the variables are presented as $M \pm tm$ (*M* is the arithmetic average in absolute terms; *m* is the mean error of the arithmetic average; *t* is a significance test for the given sample size). When calculating a relative risk (*RR*), the statistical significance of the effect produced by the factor on the outcome rate was calculated using an aggregate estimation of the *RR* value (values exceeding 1 were regarded as significant) and 95% of confidence limits excluding 1 ($p < 0.05$). Statistical processing was done with the Data Analysis add-in of *Microsoft Excel* 2007.

STUDY RESULTS

Analysis data of new coronavirus infection cases among the workers of the city clinical emergency ward in Ryazan during the studied period are presented in table.

The highest COVID-19 infection rate was found among mobile team medical workers (table) and amounted to 15.97 cases per 100 employees. This is 1.2 times more than among drivers ($p > 0.05$) and 3.0 times more than among employees not engaged in mobile teams (*RR* 3.27 [1.88–5.72], $p < 0.001$). Resuscitation team medical workers had a high relative risk of infection (*RR* 3.10 [2.47–3.90], $p < 0.05$) as compared to other teams. Infection rates of drivers were 2.48 times higher as compared with employees not engaged in mobile teams (*RR* 2.70 [1.47–4.97], $p < 0.001$). In 99.40% of cases, the diseases were mild and moderate. One very severe case with a lethal outcome was reported in a doctor of a general mobile team. Among mobile team medical workers, mortality was 1.30%. Meanwhile, diseases of moderate severity and hospitalizations were reported in 26.01 cases per 100 employees for mobile team medical workers, 2.90 cases per 100 employees for drivers, and 2.40 cases per 100 employees for those not engaged in mobile teams. In mobile team medical workers, a relative risk of a more severe course of COVID-19 was 8.84 [1.25–62.40] compared with drivers, and 10.66 [3.35–33.92] compared with employees not engaged in mobile teams.

It should be noted that the frequency of indoor exposure of the emergency ward mobile team medical personnel to the novel coronavirus was 4.46 cases per 100 employees being 9 times higher than under conditions not associated with an occupational activity ($p = 0.0003$). Both patients with the coronavirus infection, and their infected colleagues were the sources of infection.

DISCUSSION OF RESULTS

The highest risk of COVID-19 infection was found among mobile team medical workers. Significantly high COVID-19 morbidity rate among resuscitation team medical personnel was probably associated with the nature of the resuscitation medical manipulations provided by specialists. The manipulations are related to the procedures that can result in emission of *SARS-CoV-2* containing aerosol from the respiratory tract of a patient into the occupational air and ensure patency of the upper respiratory tracts, artificial pulmonary ventilation and cardiovascular resuscitation [11, 12].

The risks of drivers' infection were correlated with the risks of infection of medical workers. It can be associated with a high density of calls during the pandemic accompanied with the long-term stay of infected patients in a small and relatively contained space of a vehicle with limited abilities of ventilation and air/surface decontamination. Comparative analysis of

Table. The morbidity rate of COVID-19 among the workers of the city clinical emergency ward in Ryazan

Employees	Number of employees	Absolute number of infections	Cases per 100 employees
Mobile team medical workers	385	123	15.97 [13.56–18.73]
Mobile team drivers	129	34	13.18 [9.59–17.85]
Employees not engaged in mobile teams	123	12	5.31 [3.06–9.05]

COVID-19 infection rates of drivers and ward employees not engaged in mobile teams confirms the high infection risk of mobile team workers, including those who don't participate in provision of medical aid directly.

High rate of morbidity and significantly large probability of a more severe course of the disease among mobile team medical workers as compared with drivers and employees not engaged in mobile teams are probably not accidental. It is due to a closer contact with a patient while providing medical assistance and, as a consequence, a higher viral load, partially determining the disease severity.

CONCLUSIONS

1. Emergency ward mobile team workers have a high risk of COVID-19 infection during the pandemic.
2. The highest risk of occupational infection is found among resuscitation team medical workers.
3. The risks for drivers' infection are compatible with those for mobile team medical workers.
4. Emergency care mobile team medical personnel are subjected to the highest risk of a more severe course of the disease.

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ASSESSING THE SANITARY AND HYGIENIC CONDITION AND ORGANIZATION OF TRAINING AT AN ATHLETIC SCHOOL OF OLYMPIC RESERVE

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To achieve high results in sports and preserve health, athletes need favorable conditions for a training process, accommodation and medical supply. The purpose of the study was to assess the sanitary and hygienic condition and organization of a training process at a school of Olympic reserve. Objectives of the study included assessment of architectural and planning concepts for the school-related buildings and premises; examination of sanitary and hygienic condition of training rooms, sports facilities, hall of residence, parameters of air thermal and light regimen; assessment of how the training process is organized and developing the activities to correct the found violations. A hygienic assessment of training and athletic premises, physical factors, medical and pedagogical observation (two types of sports) is done in the trial. It has been established during the examination that no requirements to light furniture labeling, temperature and light regimen, regimen of cleaning and storage of cleaning utensils and sanitary condition of the hall of residence are followed. Training sessions are structured and specific as far as physical activity dynamics goes. By a number of parameters (selection and arrangement of premises, class timetable and equipment), favorable conditions for education and training are created at the school. The established violations of sanitary and hygienic conditions in the school-related premises and buildings can promote fatigue, injuries and infectious diseases. A more proper medical control over the sanitary conditions of education and residence at the school is required.

Keywords: sports school, athletes, sanitary and hygienic conditions, training

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ОЦЕНКА САНИТАРНО-ГИГИЕНИЧЕСКОГО СОСТОЯНИЯ И ОРГАНИЗАЦИИ УЧЕБНО-ТРЕНИРОВОЧНОГО ПРОЦЕССА В УЧИЛИЩЕ ОЛИМПИЙСКОГО РЕЗЕРВА

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Для достижения высоких спортивных результатов и сохранения здоровья спортсменам необходимо создание благоприятных условий для тренировочного процесса, проживания и медицинского обеспечения. Целью исследования была оценка санитарно-гигиенического состояния и организации учебно-тренировочного процесса в училище олимпийского резерва. Задачами исследования являлись оценка архитектурно-планировочных решений зданий и помещений училища; изучение санитарно-гигиенического состояния учебных помещений, спортивных сооружений, общежития, показателей воздушно-теплового и светового режимов; оценка организации учебно-тренировочного процесса и разработка мероприятий по коррекции выявленных нарушений. В ходе исследования проведена гигиеническая оценка учебных и спортивных помещений, физических факторов, врачебно-педагогического наблюдения (2 вида спорта). При обследовании установлено, что не соблюдаются требования к цветовой маркировке мебели, температурному и световому режиму, режиму уборки и хранению уборочного инвентаря, санитарному состоянию общежития. Тренировочные занятия структурированы, специфичны по динамике физических нагрузок. По ряду показателей (набор и взаиморасположение помещений, расписание занятий, оборудование) в училище созданы благоприятные условия для обучения и тренировок. Установленные нарушения санитарно-гигиенических условий в помещениях и зданиях спортивного училища могут способствовать развитию утомления, травматизма, инфекционных заболеваний. Требуется более тщательный медицинский контроль за санитарными условиями обучения и проживания в училище.

Ключевые слова: спортивная школа, спортсмены, санитарно-гигиенические условия, тренировочный процесс

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Formation of sports reserve and selection of gifted young athletes belong to an essential task of the country. Schools of Olympic reserve play a significant role in the preparation of high-class athletes [1, 2]. High sports results can be achieved due to development of physical culture and sports infrastructure and simultaneous creation of educational conditions.

Health of athletes depends on a complex interrelation between numerous factors such as a healthy lifestyle and quality of life, heredity, environmental quality including sports environment, where educational and training sessions along with competitions take place [3].

Improved sports effectiveness of young athletes is accompanied with not yet completed biological maturation

under the effect of significant and intense training and competitive loads [4]. Vigorous exercise, quality and properties of sports equipment, inventory, and microclimate parameters in sports halls and fitness rooms can produce a negative influence on an athlete's health. Under comfort conditions, the educational and training process is done in the most effective and efficient way without additional straining of thermal regulation mechanisms and analyzer functions with complete nervous process concentration [5].

Special requirements are given to round-the-clock sports educational institutions because these are places where the educational and training process, rest and leisure activities take place.

Such unfavorable factors as deficient area of educational, sports, residential premises, sanitary condition, microclimate parameters, and light environment of premises can result in impaired performance, slow rates of restoration, higher emotional load and traumatism of athletes [6, 7]. Optimal microclimate in sports facilities belong to the most important parameters that determine the working capacity of athletes and environmental safety.

The rational formation of a training process, special physical condition of athletes, and training conditions are essential to obtain better sports results and prevent traumatism [8].

The purpose of the study is to assess the sanitary and hygienic condition and organization of an educational and training process at an Olympic reserve school.

MATERIALS AND METHODS

The study object is a School of Olympic Reserve. Here, basic, general secondary and secondary professional education is provided. There are 12 types of sports for athletes. The sanitary and hygienic assessment was done in October-November 2021.

A method of sanitary and hygienic examination was used during the study to estimate the requirements for the facility accommodation, structure and maintenance and their compliance with Sanitary Rules (SR) 2.1.3678–20 'Sanitary and epidemiological requirements to maintenance of premises, buildings, facilities, equipment and transport, and operational conditions of the economic units that sell goods, execute work or provide services', SR 2.4.3648–20 'Sanitary and epidemiologic requirements to organization of upbringing and education, rest and health improvement of children and young people', Sanitary Rules and Regulations 1.2.3685–21 'Hygienic standards and requirements to safety and (or) harmlessness of environmental factors for people'.

To estimate the air thermal regimen and organize the light regimen, the microclimate and artificial lighting were measured for 13 training premises, 7 living rooms, 11 auxiliary premises, 5 gyms, including workout rooms, and a swimming pool. Microclimate measurements were done using Meteoscope M (measuring unit of microclimate parameters) in accordance with GOST 30494–2011 'Residential and public buildings. Microclimate parameters for indoor enclosures'. The light environment parameters were measured with a luxometer (ТК-ПКМ 08) in accordance with GOST 24940–2016 'Buildings and structures. Methods for measuring the illuminance'.

The educational and training process of two volleyball (men and women) and judo teams was estimated. The medical and pedagogical observation was conducted examining the structure, density of a training process, measurement of heart rate in dynamics. The athletes go through a training process, contest season and 3rd year of education.

STUDY RESULTS

The educational institution is located at a separate site where a training building, hall of residence and universal sports complex are placed. The training and residential buildings are accommodated as per requirements of SR 2.4.3648–20.

The educational process takes place in a three-floor training building. Within the building, the rooms are located in a rational way. Classrooms, separate restrooms for girls and boys, and premises to store cleaning utensils are available on every floor. The training building encompasses two gyms such as a gym hall, heavy athletics hall, a library with a reading hall and an assembly hall. The premises are located in a rational way. There is enough area per one training place. Classrooms have the necessary equipment. Furniture color-coding by height is lacking in one of 13 examined educational premises. Restrooms have enough cleaning appliances and utensils. The sanitary condition is satisfactory. Cabinets are designed to hold cleaning utensils; the inventory is labeled. At the time of the audit, the cleaning utensils were kept in the restroom, clearly contrary to the requirements of SR 2.4.3648–20.

There is natural, organized and forced-air-exhaust ventilation. While examining the microclimate parameters in the educational building it has been established that air temperature was above normal and relative air humidity was decreased (table).

Natural illumination is one-sided and lateral in classrooms, two-sided and lateral in the gym, with the natural illumination decreased coefficient being 23% in classrooms. Blackboards have additional artificial light sources directed right to the working field excluding two rooms. The level of artificial illumination (548.6 Lux in average) and pulsation coefficient (0.7% in average) in the rooms correspond to the hygienic requirements.

The training building is connected with three-storey men and women halls of residence through a heated cross-way passage. Apart from the rooms, every floor has a hall, room for trainers, rooms for self-preparation, toilets with basins, and laundry rooms. A set of premises is incomplete, there are no rooms to dry clothes. 1-, 2-, 3- and 4-person rooms are available in the hall of residence. The sanitary condition of residential premises is unsatisfactory. Some rooms require major and cosmetic repairs (for instance, replacement of windows or their cosmetic repairs, replacement of artificial lighting sources (lamps and illuminators)). The rooms have poor ventilation.

The showers are equipped with enough sanitary utensils, the decoration allows wet cleaning with disinfecting agents. Some showers require installation or replacement of shower heads.

The residential and shower rooms have natural organized ventilation. While estimating the microclimate parameters, a low relative air humidity was found in the rooms of the hall residence (the proportion of discrepancies was 42.8%) with decreased air temperature in the shower rooms (table). The rooms have natural lateral one-sided illumination with the level of artificial illumination (201.6 Lux in average) corresponding to the hygienic standards.

The sports complex building is three-storey and has a wardrobe for outer clothing, medical unit, hall for sports games, 3 gyms such as halls for choreography, strength training and dry land swimming, a 25 m swimming pool with six swim lanes and change rooms.

In the game halls, volleyball and rhythmic gymnastics training sessions are conducted. The floor is even and has

Table. Microclimate parameters in the school-based premises

Premises	Value	Standard Норматив	M ± m	Min	Max	Non-significant measurements, % (*n*)
Training rooms/gym in the training building	Air temperature,°C	18–24/ 18–20	23.9 ± 0.6/ 24.9 ± 0.4	22.7/ 24.1	25.8/ 25.5	61.5 (8 of 13) 100 (1 of 1)
	Relative air humidity,%	40–60	37.4 ± 3.9/ 27.9 ± 0.6	31.7/ 27	46/ 28.9	84.6 (11 of 13) 100 (1 of 1)
	Air velocity, m/s	не более 0.15	0.002 ± 0.004/ 0.015 ± 0.07	0/ 0.01	0.01/ 0.02	0/ 0
Rooms	Air temperature,°C	20–24	22.8 ± 0.8	21.2	23.6	0/ 0
	Relative air humidity,%	40–60	41.1 ± 9.1	25,1	50.7	42.8 (3 of 7)
	Air velocity, m/s	not more than 0,15	0.004 ± 0.005	0	0.01	0/ 0
Dressing rooms/ Shower rooms in the hall of residence	Air temperature, °C	20–24/ 24–26	22.7 ± 0.3/ 23.3 ± 0.1	22.5/ 23.2	23/ 23.4	0/ 100 (2 of 2)
	Relative air humidity,%	60–30/ not a normal value	46 ± 2.4/ 61.5 ± 9.0	44.3/ 55.2	47.7/ 67.9	0/ 0
	Air velocity, m/s	not more than 0,2/ not more than 0,1	0.04 ± 0.03/ 0.005 ± 0.007	0.01/ 0	0.06/ 0.01	0/ 0
Gym halls in a sports center	Air temperature, °C	15–21	23.4 ± 2.4	21.1	25.5	100 (4 of 4)
	Relative air humidity,%	60–30	27.35 ± 2.2	24.5	30	75 (3 of 4)
	Air velocity, m/s	not a normal value	0.02 ± 0.01	0.01	0.04	0/ 0
Dressing rooms/ shower rooms in a sports center	Air temperature, 0C	not below 25	22.75 ± 0.4/ 23.3 ± 0.1	22.5/ 23.2	23/ 23.4	100 (2 of 2)/ 100 (2 of 2)
	Relative air humidity,%	до 60	46 ± 2.4/ 61.6 ± 9.0	44.3/ 55.2	47.7/ 67.9	0/ 50 (1 of 2)
	Air velocity, m/s	not a normal value	0.035 ± 0.03/ 0.005 ± 0.007	0.01/ 0	0.06/ 0.01	0/ 0

no cracks. Floor covering intended for rhythmic gymnastics is available in the game halls. No break for wet cleaning between volleyball and rhythmic gymnastics training sessions is found during the examination. This is of an important hygienic value, as numerous equipment is used in these athletic disciplines. After the carpets are cleaned, dust particles remain on the floor. This can result in an injury of basketball athletes, when acceleration and more dynamic game are involved.

In the choreography hall, the carpet is in a satisfactory sanitary condition. The heating system includes radiators without enclosing structures. The premise lacks natural illumination. The ceiling is defective and equipped with hinged panels.

Various types of training devices are located in the gym. The interior finishing of the floor and walls corresponds to the requirements of SR 2.4.3648–20. The sanitary condition is satisfactory. The natural exhaust ventilation has mechanical draft. Air is properly conditioned with the help of two air conditioning units. Non-operational illuminators are present.

The hall of dry swimming is equipped with different types of training devices, mats, and a wooden wall bar. The sports inventory is stored at the ammunition room next to gyms. The sanitary condition is satisfactory.

When examining the parameters of microclimate in a sports building, an exceeding air temperature in sports halls is recorded; in change rooms and shower rooms it is below the accepted values (table).

The coefficient of natural lighting in sports halls corresponds to the hygienic standards (3.3 ± 3.8%). When artificial lighting is measured, a significantly exceeded pulsation coefficient is found in a game hall (63.0 ± 12.4%); the level of natural lighting corresponded to the hygienic standards.

The swimming pool is equipped with dressing rooms, shower rooms and toilets. Streamlining is properly organized. The dressing rooms are equipped with benches and cabinets. The most of the shower equipment has rusted. The interior is made of materials resistant to moisture, detergent and disinfecting agents (glazed tile), with no defects. The sanitary condition is satisfactory. Forced exhaust ventilation system. The parameters of microclimate and artificial illumination correspond to the hygienic requirements.

The regimen of educational activity corresponds to the hygienic requirements for all rooms, except for insufficient duration of breaks. Taking into account training sessions of sports departments, the sessions have three regimens (A, B, C). Duration of training sessions is as follows: 8 a. m. to 1:40 p. m. for regimen A, 10:30 a. m. to 4:40 p. m. for regimen B, and 8 a. m. to 10:20 a. m. and 1.40 p. m. to 4.40 p. m. for regimen C.

During a medical and pedagogical observation in three teams, the training session duration was 1.5 to 2 hours. The training structure included warming up, basic and final parts. It should be noted that the judo training sessions lacked the final part and had long breaks during the basic part. The motor density of every training session corresponds to hygienic requirements (82.9–96%). During the medical and pedagogical observation over athletes it has been established that every athlete's training session was of different efficiency. Some athletes failed to perform training sessions, i. e., they had low load activity.

DISCUSSION OF RESULTS

The issue of sanitary and hygienic support of sports objects is widely spread and well represented in the research by Kholser

AN, Popov VI, and Libina II [6, 9]. The most common problems include poor values of microclimate and light environment. Thus, according to Efimova NV and Setko NP, increased air temperature in a premise and violations of the light regimen can result in impaired working capacity and premature fatigue [10, 11]. A violated regimen of wet cleaning promotes an increased level of dust particles in the air an athlete breathes in and can lead to respiratory diseases. Organization of a training process is important for achievement of high sports results. According to Makarova GA and Achkasova EE, systematic control over the level of physical load and exercising technique forms an essential part of sports activity medical support [12].

CONCLUSIONS

Sanitary and hygienic conditions of accommodation, selection of premises, equipment, and timetables correspond to the hygienic requirements. The most frequent violations include exceeded temperature values for gyms, violated cleaning regimen both of sports premises, and residential rooms, poor sanitary condition of residential rooms and utility rooms, pulsation factor in a gym. A more proper control over the sanitary condition of residential and sports premises, and systematic medical control over the training process and sanitary condition of the premises are required.

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REGIME OF USING MOBILE ELECTRONIC DEVICES BY STUDENTS AS A RISK FACTOR OF VISION IMPAIRMENT

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The adverse impact of electronic devices, including mobile ones (smartphones, tablets), on the organism of children, adolescents and youth has been highlighted by many studies. The study was aimed to assess the regime of using mobile electronic devices and its impact on the students' vision. The data on the use of mobile electronic devices in educational and recreational activities by 1218 schoolchildren and students were acquired; their work-rest schedule when engaged with mobile electronic devices was characterized. A total of 943 schoolchildren and students were examined by ophthalmologist and with the use of the Armis hardware-software complex (Russia). A significant decrease in visual acuity (measured in diopters) and the increase in the rate of functional vision problems and chronic eye disorders in first-graders ($p \leq 0.05$) compared to their age-mates of the past decade were observed. During the learning process, a significant decrease in visual acuity ($p \leq 0.05$) in both eyes was observed starting from middle school, which persisted both in high school and during first years of the university. Students, who adhered to the work-rest schedule when engaged with mobile electronic devices, significantly less often ($p \leq 0.05$) complained of health problems. A regression model ($p \leq 0.05$) was constructed for the relationship between the students' visual acuity (OD, OS, diopters) and their work-rest schedule when engaged with mobile electronic devices. When assessing the regime of using electronic devices, medical stidents found that the time of use in both educational and recreational activities should be strictly regulated. To prevent functional vision problems and chronic eye disorders, it is necessary to limit the time of using mobile electronic devices by students. According to scientific research, this would have a beneficial effect on the finctional state of the organism and prevent fatigue.

Keywords: schoolchildren, students, visual acuity, mobile electronic devices, work-rest regime

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Compliance with ethical standards: the study was approved by the Ethics Commitee of Pirogov Russian National Research Medical University (protocol № 159 of 21 November 2016), did not endanger the subjects, and was consistent with the principles of biomedical ethics; the informed consent was submitted by all study participants.

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РЕЖИМ ИСПОЛЬЗОВАНИЯ МОБИЛЬНЫХ ЭЛЕКТРОННЫХ УСТРОЙСТВ ОБУЧАЮЩИМИСЯ КАК ФАКТОР РИСКА РАЗВИТИЯ ОТКЛОНЕНИЙ СО СТОРОНЫ ОРГАНА ЗРЕНИЯ

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Отрицательное воздействие электронных устройств (ЭУ), в том числе и мобильных (смартфон, планшет), на организм детей, подростков и молодежи отмечено во многих научных исследованиях. Целью работы явилось изучение режима использования мобильных электронных устройств и его влияния на состояние органа зрения обучающихся. Были получены данные об использовании мобильных электронных устройств в учебной и досуговой деятельности 1218 школьниками и студентами и дана характеристика их режима труда и отдыха при работе с мобильными электронными устройствами. Врачом-офтальмологом и с помощью АПК «Армис» (Россия) было осмотрено 943 школьника и студента. Было обнаружено достоверное снижение остроты зрения в дптр, а также увеличение частоты функциональных отклонений и хронических заболеваний глаза у первоклассников ($p \leq 0,05$), в сравнении со сверстниками предыдущего десятилетия. В динамике обучения отмечено достоверное снижение ($p \leq 0,05$) остроты зрения на оба глаза начиная со средней школы, которое и далее сохранялось на этом уровне и в старшей школе, и на первых курсах университета. У обучающихся, соблюдающих режим труда и отдыха при работе с мобильными электронными устройствами, достоверно реже ($p \leq 0,05$) встречались жалобы на нарушение здоровья. Получена регрессионная модель ($p \leq 0,05$), описывающая связь остроты зрения (OD, OS, дптр) обучающихся с режимом их труда и отдыха при работе с мобильными электронными устройствами. При оценке режима использования ЭУ студентами-медиками установлено, что как в учебной, так и в досуговой деятельности, время использования должно быть строго регламентировано. Для профилактики функциональных отклонений и хронических заболеваний органа зрения необходимо ограничить во времени использование мобильных электронных устройств обучающимися, что, согласно научным исследованиям, как благоприятно влияет на функциональное состояние организма в целом, так и предотвращает развитие переутомления.

Ключевые слова: школьники, студенты, острота зрения, мобильные электронные устройства, режим труда и отдыха

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Early 21st century was marked by booming development of digital environment. In 2000, the telecom company *Ericsson* used the term "smartphone" for a mobile electronic device for the first time. Smartphones became available in the general market after 2008. The UNISEF report "The State of the World's Children 2017: Children in a Digital World", published 10 years after the release of the first iPhone, showed the increasing role of Internet in education and socialization of children, adolescents and youth. Children and adolescents under the age of 18 make up about a third of Internet users worldwide. The age of first use of Internet is constantly decreasing: more and more 3–5-year-old children in European countries become Internet users, which involves the use of mobile electronic devices [1].

At the current stage domestic education moves on to the "digital school" and implementation of technologies of distance education that also involves the use of mobile electronic devices to access the educational process and electronic educational resources and therefore shapes the usual mode of using such devices in educational activities by the students [2, 3].

The impact of mobile electronic devices on the organism of children, adolescents and youth has been highlighted by many studies. It should be noted that students, who use mobile electronic devices, often complain of asthenopia. They also experience eye problems, musculoskeletal disorders, become psychologically addicted, etc. [4–12].

Earlier, the potential dangers of using mobile electronic devices were associated with exposure to physical factors and positioning of a mobile phone close to the human head. Today, smartphones are small but powerful computers that continuously receive audio and video data. Potential dangers of using smartphones are increasingly associated with the temporal characteristics of the use of mobile electronic devices [13–16].

The above-mentioned demands the analysis of the impact of various modes of using mobile electronic devices on the health status (particularly on the students' vision) that would make it possible to develop preventive measures aimed at reducing health risks in the younger generation.

The study was aimed to assess the regime of using mobile electronic devices and its impact on the students' vision.

METHODS

In 2017–2021 academic years, a single examination and blank questioning of 1218 schoolchildren and students in Moscow and Moscow region (among them 150 primary-level schoolchildren, 225 middle schoolers, 200 high school students, 643 undergraduate students) were carried out. Information about the usual mode of using mobile electronic devices (MEDs) was obtained from students having the experience with MEDs of a year or more using the standardized questionnaire. We also applied questionnaires that contained information about the conditions of using MEDs (availability of the organized workplace, possibility of maintaining working posture, adequate level of illumination of the working surface), modes of using MEDs (work breaks, their frequency and length), characteristics of the applied preventive measures (frequency, timeliness of work breaks, filling of those with preventive activities), the amount of "screen time" when using MEDs. High school students and undergraduate students were offered to fill out an online questionnaire [17]. A total of 200 high school students and 518 undergraduate students were surveyed.

The data of the student's examination were copied by ophthalmologist. Visual acuity was assessed in 943 schoolchildren and students. The examination results were recorded in the following way: UCVA (OD =…, OS =…). We also studied archival data of the examination of schoolchildren, who attended the Dolgoprudny Gymnasium, performed by the Board Certified ophthalmologist in 2000–2005.

Inclusion criteria: student (schoolchild or undergraduate student); availability of written informed consent; availability of the ophthalmic examination results; questionnaire, completed correctly by the respondent or his/her legal representative (for primary-level schoolchildren); no chronic eye disorders; experience with MEDs of a year or more. Exclusion criteria: different age group; no informed consent; no ophthalmic examination results; chronic eye disorder that makes it possible to attribute the subject to the health groups 4 and 5; no correctly completed questionnaire; experience with MEDs of less than a year.

The study did not endanger the subjects, it was consistent with the principles of biomedical ethics and the Declaration of Helsinki (1983). The study was approved by the Ethics Committee of Pirogov Russian National Research Medical University (protocol № 159 of 21 November 2016).

Statistical processing of the results was performed using the Statistica 13 PL software package.

RESULTS

The research allows us to consider inadequate regime of the use of MEDs by students, the conditions of using MEDs, and no elements of healthy lifestyle in the students' daily routine the major risk factors of health problems.

When assessing the regime of using MEDs by students, it was found that only 6.0% of them did not use MEDs every day and had at least one "day free from using mobile electronic devices", for example on weekends. The day free from using MEDs was mostly reported by the primary-level schoolchildren and middle schoolers, other students reported they used MEDs every day. Almost all the surveyed students (91.5%) not only used MEDs for calls and sending messages, but also treated MEDs as personal computers that could be used for educational purposes and in leisure time. Half of the respondents (50.0%) mentioned the use of MEDs to complete educational tasks, both urgent and those that could be completed later using fixed electronic devices (computers, laptops). Every second student (65.0%) mentioned that he/she worked with MEDs during meals; almost all the respondents (85.0%) used MEDs in transport, and continued using MEDs in low light conditions with no organized workplace (75.0%). The mobile device battery life was an indirect proof of the intensity of using MEDs. Only one in four respondents (24.0%) reported that the battery was enough for one day use. Half of the respondents (50.0%) mentioned that they never did ocular gymnastics or any other type of gymnastics during breaks when working with MEDs.

The regime of using MEDs by students can be characterized by the time of continuous use (Table).

A significant increase in the time of continuous working with MEDs in middle schoolers and high school students compared to the primary-level schoolchildren, and the increase in the time of continuous working with MEDs in undergraduate students compared to schoolchildren were revealed ($p \leq 0.05$).

It was found that the time of continuous use of MEDs in middle schoolers, high school students and undergraduate students exceeded one hour and increased on weekends and during vacations. The requirements of SanPiN 1.2.3685–21 "Hygienic Standards and Requirements for Ensuring Safety and (or) Harmlessness to Humans from Environmental Factors" set the acceptable time of using tablet in educational activities. Our findings suggest that the time of continuous use of tablet by the primary-level schoolchildren increased by 2.0 times during working days and by 2.9 times during vacations; in middle schoolers it

Table. The time of continuous use of mobile electronic devices by students in their leisure time, during working days, weekends, and vacations, M ± m

Students	Time of continuous use of tablet			Time of continuous use of smartphone		
	working days	weekends	vacations	working days	weekends	vacations
Primary school	32.8 ± 5.5*.**	–	43.8 ± 5.5*.**	25.0 ± 2.5*.**	–	35.5 ± 4.5*.**
Middle school	63.0 ± 20.0*	98.6 ± 27.0*	97.3 ±2 0.0*	88.0 ± 13.0*	96.9 ± 16.0*	112.5 ± 18.5*
High school	95.2 ± 8.0*	96.5 ± 9.0*	107.1 ± 11.0*	129.5 ± 16.5*	131.8 ± 16.0*	146.5 ± 18.0*
University (students)	143.5 ± 9.0	159.1 ± 10.0	155.8 ± 10.0	186.0 ± 11.0	184.5 ± 11.0	191.0 ± 17.5

* $p \leq 0.05$ — significance of differences between schoolchildren and undergraduate students
** $p \leq 0.05$ — significance of differences between the primary-level schoolchildren and middle schoolers/high school students

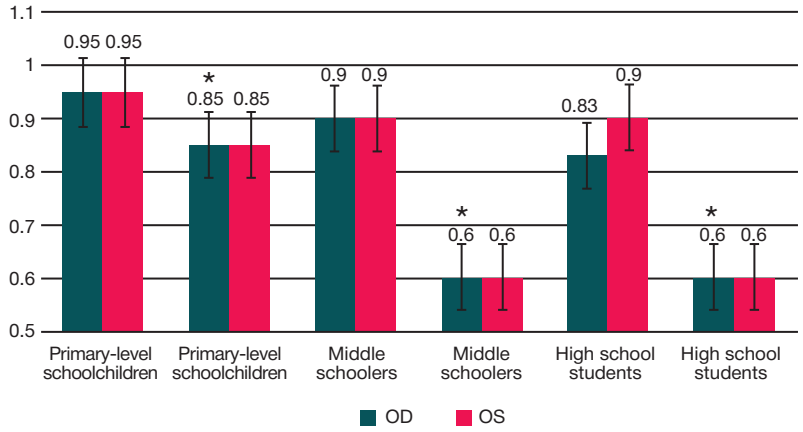


Fig. 1. Vusial acuity in schoolchildren and students, 2000–2005 and 2017–2021, diopters
* – $p \leq 0.05$

increased by 3.0 and 4.9 times, respectively; in high school students the time of continuous use of tablet increased by 4.9 and 5.3 times, respectively; in undergraduate students it increased by 7.0 and 7.8 times, respectively. However, educational activities never involved the use of smartphones by students.

Thus, it was shown that students took no timely breaks for rest, ocular gymnastics, increased motor activity or meals when working with MEDs. In accordance with the current safety regulations, such breaks should be taken every 10–15 of using an electronic device by the primary-level schoolchildren, and every 20 minutes by all other students.

The risk of health problems associated with using MEDs in students is aggravated by working in low light conditions, and the lack of workplace specially organized for this purpose. Among the students, almost every second person (40.0%) was at risk of health problems due to the features of unreasonable use of MED (wrong regime of use, wrong time of continuous use, poor lighting conditions at workplace, insufficient frequency and length of work breaks, wrong filling of breaks).

The dynamic changes in the students' vision had been assessed since 2000–2005 (before the release of the first iPhone in 2008) to 2017–2021 (the period of the mainstream use of iPhones) (Fig. 1).

In 2000–2005, conventional technical means of training were used in educational institutions. Furthermore, by the time of graduation from school decreased visual acuity was ($p \leq 0.05$) was observed only in the dominant eyes.

In 2017–2021, interactive boards, personal computers, laptops, readers and MEDs (tablets) were widely used in educational institutions. The more intensive use of these devices was reported in 2020 during the period of distance learning. During this time, visual acuity in first-graders was significantly lower ($p \leq 0.05$) compared to their age-mates of the past decade. In the course of learning a significant decrease ($p \leq 0.05$) in visual acuity in both student's eyes was revealed earlier (in middle school) and persisted during the subsequent stages of educational process. The students' visual acuity was significantly lower ($p \leq 0.05$) compared to that of their age-mates of the past decade.

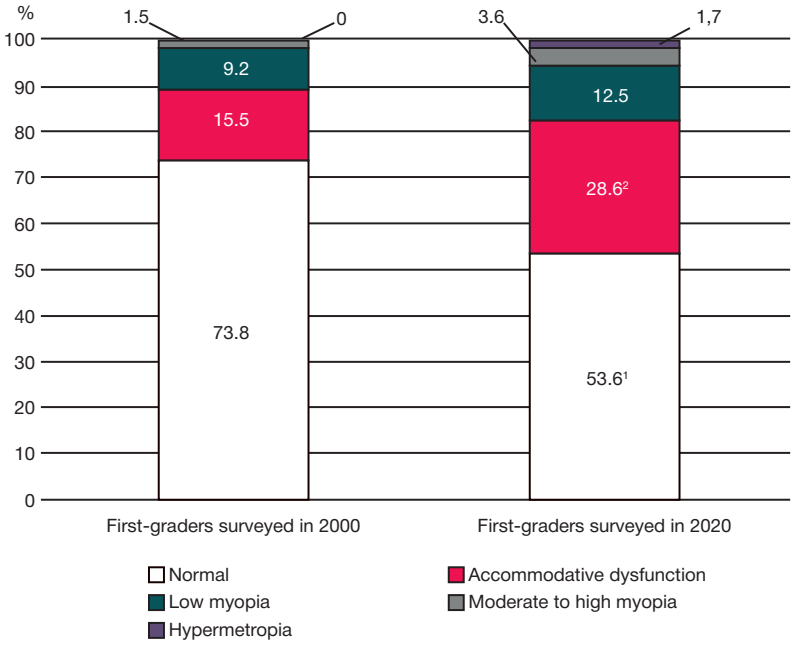
Studying the structure of eye diseases over time in 2000–2020 revealed a significantly increased share of students with various functional vision problems and chronic eye disorders in 2020. Among the surveyed first-graders, whose systematic education started in 2020, and who already had an experience with MEDs of at least a year, the share of students with no functional vision problems or chronic eye disorders (53.6%) was significantly lower ($p \leq 0.05$) compared to the data obtained in 2000 (73.8%). Disorders of accommodation were found in 28.6% and 15.5% of first-graders, and different degrees of myopia were found in 16.1% and 10.7%, respectively (Fig. 2).

The impact of the students' non-compliance with the regime of using mobile electronic devices on the development of vision impairment was studied. It was found that students, who adhered to the work-rest schedule when engaged with mobile electronic devices, significantly less often ($p \leq 0.05$) complained of health problems. Thus, only 7.5% of the respondents, who adhered to the safe regime of using MEDs, complained of heavy-headedness or headache. Among those who were non-compliant with the safety requirements, heavy-headedness or headache was reported by 92.5%; computer vision syndrome was found in 17.8% and 82.2% (contingency coefficient 0.51, $p \leq 0.05$), and carpal tunnel syndrome was reported by 3.9% and 96.1%, respectively.

A regression model ($p \leq 0.05$) was constructed for the relationship between visual acuity (OD, OS, diopters) and the regime of using mobile electronic devices:

$$Y = 0.43 + 0.31 \cdot X1 + 0.17 \cdot X2 - 0.09 \cdot X3 \quad (1),$$

where X1 was availability of the "day free from smartphone" (having no free day — 0, having free day — 1);
X2 — was availability of the "day free from tablet" (having no free day — 0, having free day — 1);



Note —
¹ — $p \leq 0.05$ — percentage of students with normal vision;
² — $p \leq 0.05$ — percentage of students with accommodative dysfunction.

Fig. 2. Dynamic changes in the prevalence of functional vision problems and chronic eye disorders in first-graders in 2000 and 2020,%

X3 — compliance with the regime of using mobile electronic devices (compliance — 0, non-compliance — 1).

DISCUSSION

Extensive use of MEDs by the vast majority of students, especially during the vacation period and leisure time, poses a significant threat to the health of the young generation. According to the data obtained, 40.0% are at risk due to inadequate regime of using MEDs. This, in turn, contributes greately to the impaired lifestyle and is a prerequisite for deterioration of health, including vision (both in terms of the increased prevalence and severity of eye disorders).

Some design features of MEDs that have an effect on the functional state of the student's organism are well known. A number of unresolved issues that determine the risk of health problems are reported: non-ergonomic keyboards (QWERTY); uncomfortable interface that complicates hand positioning; trouble using the device when walking (affects gait and increases the risk of injury) [18–20].

It has been determined that touch screens used in large mobile electronic devices have a distinct advantage over smaller touch screens in terms of space available for transferring of graphical data. The research has shown that users consider tablets the most useful in situations where precision of graphical interpretation is important and there are no time limits [21].

The text size and larger inter-line spacing (leading) significantly improve readability, the crowded display requires much greater time for reading and processing of information [22].

However, currently, it is hard to change some design features of mobile electronic devices, but today is necessary and possible to regulate the regime of using such devices.

Domestic hygienists have developed the regimes of using tablets in educational activities, as reflected in scientific papers and hygienic requirements for safe use [23, 24].

There are also some studies focused on assessing the impact of the regome of using mobile electronic devices (smartphones, tablets) in recreational activities [25].

The work-rest schedule of children, adolescents and youth when engaged with MEDs has become the key factor contributing to the health of the young generation in the context of distance learning. This factor affects the students' daily routine, their level of motor activity, functional and psychological state [26–29].

Meanwhile, the data on the impact of various regimes of the use of MEDs on the health of the young generation available in scientific literature are incomplete and address only some of its aspects. Thus, the study of young adults aged 18–23 with no eye disorders showed that 60 minutes of reading a book on the screen of smartphone resulted in the increased symptoms of eyestrain, drowsiness and fatigue, decreased binocular accommodation [30].

After 20 minutes of using smartphone, significant changes in the static balance and oculomotor function compared to the more short-term (5–10-minute) use, as well as dizziness were observed in healthy adults [31].

Thus, the use of MEDs (smartphones, tablets) both in educational and recreational activities should be strictly regulated. It is necessary to limit the time of using mobile electronic devices by students. According to scientific research, this would have a beneficial effect on the finctional state of the organism, prevent fatigue, and contribute to prevention of functional vision problems and chronic eye disorders [32–35].

Thus, the issues of adverse impact of the design features of various mobile electronic devices and the regimes of their use on the health of the young generation, and the development of measures to prevent health problems in future generations are still relevant and require further research.

CONCLUSION

The widespread use of mobile electronic devices (tablets and smartphones) among primary-level schoolchildren, middle schoolers, high school students, and undergraduate students is reported.

1. In 2000–2005 and 2017–2021, the more and more earlier detection of vision impairment in first-graders was observed.

2. High prevalence and increasing severity of eye disorders among students, including first-graders, were revealed.
3. The work-rest schedule of children, adolescents and youth when engaged with MEDs is a controllable risk factor for health problems in the younger generation.

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ESTIMATING HARMFUL EFFECTS OF MOBILE ELECTRONIC GADGETS ON HEALTH OF MEDICAL STUDENTS

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It is difficult to imagine a modern society without electronic gadgets (EG), as they promote rapid acquisition and exchange of data. At the same time, modern technologies do not only ensure information exchange, but also influence different organs and systems of users. As they are more commonly used by students and adolescents, it is important to have a holistic picture of the effect produced by the EG to estimate the harmful effects of various mobile EG. The harmful effects on health of medical students associated with the use of mobile electronic gadgets was assessed. Scientific articles considering the issues of how various environmental factors and harmful effects associated with the excessive use of electronic mobile gadgets influence the health of students were reviewed. The articles published in 2015 to 2021 were searched within ELIBRARY, PUBMED, PSYCINFO and CYBERLENINKA. Thus, taking into account literature data about the health of modern students, their way of life, role and place of electronic gadgets in their lives, and a special importance of forming health-preserving skills exactly among medical students, who are the future doctors, subsequent examination of harmful effects, associated with mobile electronic gadgets used in educational and leisure activity, on students' health, examining the effect of mobile electronic gadgets on other components of the students' way of life and development of modern technologies of hygienic education of medical students at Universities still belong to relevant issues. Development of electronic technologies enables acquisition and processing of large amounts of information. However, various factors producing a negative effect on health and a way of life of a human being are poorly understood. In spite of diversified information technologies, it is important to remember about the necessary skills used when the technologies are applied. Thus, health and skills related to a healthy lifestyle belong to an important factor for future medical students.

Keywords: students, mobile electronic gadgets, healthy lifestyle, hygienic education

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ОЦЕНКА РИСКА ИСПОЛЬЗОВАНИЯ МОБИЛЬНЫХ ЭЛЕКТРОННЫХ УСТРОЙСТВ ДЛЯ ЗДОРОВЬЯ СТУДЕНТОВ-МЕДИКОВ

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Современное общество сложно представить без какого-либо электронного устройства (ЭУ), так как ЭУ очень помогает в быстром получении и обмене информации. В то же время современные технологии не только помогают осуществлять информационный обмен, но также влияют на различные органы и системы пользователей. Так как основными пользователями чаще являются студенты и подростки, важно иметь целостную картину влияния ЭУ для оценки риска от использования разнообразных мобильных ЭУ. Проведен обзор научных статей, в которых рассматриваются вопросы влияния на здоровье студентов различных факторов среды и риски на фоне чрезмерного использования электронных мобильных устройств. Поиск статей осуществлялся по базам данных: ELIBRARY, PUBMED, PSYCINFO и CYBERLENINKA, которые были опубликованы преимущественно между 2015 и 2021 гг. Таким образом, учитывая литературные данные о состоянии здоровья современных студентов, их образе жизни, роли и месте ЭУ в их жизнедеятельности и особой важности формирования навыка здоровьесбережения именно у студентов-медиков — будущих врачей, остаются актуальными дальнейшее изучение риска для их здоровья использования мобильных электронных устройств в учебной и досуговой деятельности, изучение влияния использования мобильных электронных устройств на другие компоненты их образа жизни и разработка современных технологий гигиенического воспитания студентов-медиков на этапе обучения в вузе. Развитие электронных технологий помогает в получении и обработке большого количества информации, но вместе с тем мало изучены различные факторы негативного влияния на здоровье и образ жизни человека. И при всем разнообразии информационных технологий важно не забывать о необходимых навыках при их применении. Так важным фактором будущих врачей студентов-медиков является их здоровье и навыки здорового образа жизни (ЗОЖ).

Ключевые слова: студенты, мобильные электронные устройства, здоровый образ жизни, гигиеническое воспитание

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Development of electronic technologies enables acquisition and processing of large amounts of information. At the same time, various factors producing a negative effect on human health and way of life are poorly examined. In spite of diversified information technologies, it is important to remember about the necessary skills used when the technologies are applied.

The purpose of the research paper is to assess the harmful effects of mobile electronic gadgets on health of students.

MATERIALS AND METHODS

The research articles considering the issues of how various environmental factors and harmful effects associated with the excessive use of electronic mobile gadgets influence the health of students were reviewed. The articles predominantly published in 2015 to 2021 were searched within ELIBRARY, PUBMED, PSYCINFO and CYBERLENINKA.

RESULTS

During the educational period, medical students are exposed to huge mental and emotional burden resulting in violation of diet, sleep and declined sports activity. The cumulative burden effect leads to stress, overpressure, reduction in adaptive capabilities and subsequent development of various diseases. So, it is necessary to correctly substantiate and convey the importance

of hygienic activities to future doctors and form health-saving competence, knowledge, expertise and skills of healthy lifestyle maintenance even at the stage of education [1, 2, 3, 4].

Mobile electronic gadgets (MEG) that produce an increased load on the visual and locomotor apparatus and result in psycho-emotional dysfunction are not the last source of increasing loads and stress among modern students [2, 5].

It has been shown during the research that misuse of electronic gadgets (EG) by students (especially during leisure activities) violates sleep due to disturbed emotional background, results in eating disorders and decreases motor activity [2].

During the COVID-19 pandemic, the students were using more EG due to active implementation of distance learning with a high visual load [3, 6].

However, the literature describes not all MEG-associated harmful effects on students and especially medical students who are intended to take care not of their health only, but also of health of their patients, and consult them on a healthy lifestyle.

It has been established through the experiment that the visual apparatus experiences faster fatigue while reading poorly designed data on the screen [7]. To reduce the total negative effect not just on the visual analyzer, but also on various systems of the body, preventive activities are probably required considering various technical characteristics of different EG [8, 9].

Due to the increased visual load, medical students report different signs of visual fatigue as the principal factor, rapid fatiguability and reduced stress resistance. So, we can substantiate the necessity in hygienic requirements to font design text of e-learning materials [10].

Use of various EG (PC, smartphone, laptop) by students during not only educational, but also leisure activity with a wrong posture and insufficient lighting will result in such violations as common and excessive accommodation tension, different degrees of myopia, computer visual syndrome, postural disorder, carpal syndrome, loss of hearing while using head phones, possible faster fatigue during an educational process and, as a consequence, reduced stress resistance [4, 11, 12].

Indirect influence of EG via changed lifestyle components such as non-compliance with labor and rest, sleep disturbance and reduced motor activity can result in vegetative dystonia. Thus, in accordance with research data, direct correlations between the rate and duration of using gadgets, sleep disturbances and development of vegetative dystonia, which can be a leading factor that should be taken into account when developing preventive activities, have been identified. The syndrome of vegetative dystonia can result in maladaptation [1, 13, 14, 15].

Development of information and communication technologies results in negative effects associated with their application such as changed personality measures (including Internet addiction). High risks of addiction formation are more characteristic of people who are morally or spiritually weak [1, 3].

The issue of Internet dependency is relevant more than ever, especially now, when social apps were created. On the one hand, these inventions make communication limitless, with constant addiction to a certain level of communication, on the other hand [16].

People with instable adaptation possibilities and disturbances of socio-psychological measurements commonly have different types of addiction. Another addiction can be represented by becoming dependent in an attempt to deal with stress, avoiding rushing to a solution [17, 18].

Internet dependency reduces socialization and, as a consequence, prevents students from being fully included into the educational process and interferes with academic performance. Meanwhile, students with no addiction except for good academic performance display motives for self-development, self-improvement, etc. [19].

On the contrary, a rapid way of emotional release is escape from reality, communication in social networks, and, as a consequence, dependency on them. The alternative is represented by useful skills such as physical training, walks in the fresh air, real communication with like-minded people who are most important to students [20].

For proper formation of protection and adaptive skills to avoid dependencies it's important to comprehend which personal traits lead to this problem. It has been proven scientifically that it is about low self-esteem, tendency to depression, sense of insecurity and loneliness [21].

Stage-by-stage preventive work related to Internet dependency among students is required to increase effectiveness [22].

Formation of a holistic view about health and healthy way of life in a student is an important constituent of successful professional activity [9, 23].

This is especially true for medical students. Conducting preventive activities among medical students and teaching them a healthy way of life should be a fundamental component of the system of hygienic education of future doctors [24, 25].

Thus, hygienic education of medical students at universities using lectures, conversations, discussions, etc. is definitely necessary [8, 26].

It should be noted that 70.0% of medical students respect their teachers' opinions and consider the teachers as authoritative persons [12].

DISCUSSION

Finally, one shouldn't forget that state-of-art EG have useful advantages for a modern human being. Many useful apps for a healthy lifestyle have been developed currently. For instance, Screen Time app tracks how long the EG has been used; when the permissible limit is exceeded, a timer should be set to add 10–15-minute breaks to every work session of 40–45 minutes. Step Counter app monitors your motor activity within a day. It allows to plan the activity and increase it during a day due to correctly selected gymnastic or various physical exercises. There exist different platforms where you can share your achievements and run small competitions to achieve the set goals associated with a healthy way of life [27, 28].

Useful skills can be applied using Habit Tracker app that would enable to develop a useful habit during a certain period of time [29].

Check lists are important components utilized in formation of useful skills and preparation of materials for hygienic education. Their practical value has been proven already while using, sharpening and teaching the acquired skills to young people. A check list is a reminder to have all important points fixed with their subsequent application in work. This can look like a mini plan or algorithm of actions to prevent the problems with an organ of vision, stress, etc. [29, 30].

CONCLUSIONS

Not all methods of hygienic education of medical students that promote formation of health protection competence, correct assessment of MEG effects on health, risks of disruption of the visual apparatus, locomotor apparatus and formation of dependencies are described in the literature.

Health of future doctors can be formed at the stage of their education already, as acquisition of useful skills is important for subsequent consultation of future patients as far as a healthy way of life goes.

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ANALYZING THE COMPOSITION OF ENERGY DRINKS AND THE EFFECT THAT THEY CAN HAVE ON STUDENTS

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Consumption of energy drinks by young people has been increased due to various reasons. The drinks have potentially harmful effects. The purpose was to examine the frequency of and reasons for energy drink consumption by medical students, subjectively assess health effects related to energy drinks, and analyze composition of energy drinks. 150 students of the Voronezh State Medical University named after N. N. Burdenko were interviewed to find out the effect produced by energy drinks on their performance, health and attitude to energy drinks using Google Forms. Methods of statistical analysis were utilized during the assessment. Four energy drink labels were selected and analyzed with their composition being described. Students' health and adverse effects after consumption of the drinks underwent subjective assessment. 35% of those interviewed believe that energy drinks are effective. 70% of the students report increased performance after consumption of the drinks. However, 55% of them develop adverse effects such as tremor of the extremities (11.3%), increased excitability (20%), increased blood pressure (23.3%), heart arrhythmia (26%), allergic reactions (4%), and loss of consciousness (2%). A safe amount to be consumed (250 ml) is recommended after the analysis, whereas 60% of the respondents consume 450 ml. Every year energy drinks are gaining more and more popularity among young people. The found adverse effects of energy drinks require subsequent and a more elaborated examination.

Keywords: students, energy drinks, health, prevention

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АНАЛИЗ СОСТАВА ЭНЕРГЕТИЧЕСКИХ НАПИТКОВ И ИХ ВЛИЯНИЕ НА ЗДОРОВЬЕ СТУДЕНЧЕСКОЙ МОЛОДЕЖИ

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В молодежной среде по разным причинам увеличивается употребление энергетических напитков. Они потенциально вредны для здоровья. Цель работы — изучение частоты и причин употребления энергетических напитков среди студентов-медиков, субъективной оценки состояния здоровья и побочных эффектов после употребления напитков, проведение анализа состава энергетиков. При помощи Google-Формы мы опросили 150 студентов ВГМУ им. Н. Н. Бурденко относительно влияния энергетических напитков на их работоспособность и здоровье, а также отношение к употреблению энергетических напитков. В ходе оценки результатов применялись методы статистического анализа. Были выбраны четыре торговых марки энергетических напитков и был проанализирован и описан их состав. Проведена субъективная оценка состояния здоровья студентов и побочных эффектов после употребления напитков. 35% респондентов считают энергетические напитки эффективными. После употребления энергетиков 70% студентов отмечают у себя повышение работоспособности, однако у 55% отмечены нежелательные побочные явления: тремор конечностей (11,3%), повышенная возбудимость (20%), повышение артериального давления (23,3%), нарушение сердечного ритма (26%), аллергические реакции (4%), потеря сознания (2%). В результате проведенного анализа состава напитков рекомендован безопасный объем употребления (250 мл), в то время как 60% опрошенных употребляют 450 мл. Энергетические напитки с каждым годом становятся все популярнее среди молодежи. Выявленные побочные эффекты энергетиков требуют дальнейшего более детального изучения.

Ключевые слова: студенты, энергетические напитки, здоровье, профилактика

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Supply of energy drinks in Russia is increasing every year. On a percentage basis, supply of energy drinks in the Russian market was annually increased by 14.9–30.0% [1].

The issue of energy drink consumption is essential due to a possible negative effect of this product on various organs, systems of organs and entire body [2–5]. According to a number of researchers, caffein contained in energy drinks can induce drug dependence (withdrawal syndrome), when consumed on a long-term basis, and produce a psychostimulant effect. In her work devoted to the experimental study of a possible withdrawal syndrome in laboratory animals following 30 days of caffeine-containing energy drink consumption, Zemskova EA concluded that their motor activity was reduced, anxiety level was increased and that a number of signs available didn't exclude the withdrawal syndrome in tested animals as compared with the control group. A negative trend in weight of white rats was observed as well [6]. A number of data of foreign researchers [7, 8] demonstrated a negative effect of energy drinks on the cardiovascular system [9, 10]. In the experiment of scientists headed by Sachin A. Shah, various parameters

(QT, PR, QRS complex, HR, SBP, DBP, cSBP, cDBP) were compared. It was found out that the systolic and diastolic pressure values were increased by 5 mm Hg and 4 mm Hg following consumption of energy drinks [11]. A stable rise in BP by 2 mm Hg increases the risk for coronary heart disease by 7% and risk of stroke by 10% [11]. Based on the World Health Organization (WHO), 17.3 million people die of cardiovascular diseases annually, making 30% of all lethal cases [12]. There currently exists a trend towards an increased consumption of various energy drinks, especially among students.

The purpose was to examine the reasons for and frequency of energy drink consumption among medical students, subjectively assess health and adverse effects following consumption of the drinks, and analyze the quantitative and qualitative composition of popular drinks presented during questioning.

PATIENTS AND METHODS

First, a literature review was surveyed. Then, year 1 to year 6 students of therapeutic, pediatric and dental departments of the Voronezh State Medical University named after N. N. Burdenkohad to complete 30 question surveys using Google Forms [13]. Their responses were analyzed with IBM SPSS statistical data processing program, student opinion ratios were analyzed. The sampling included 150 students; its size wasn't preliminary determined. Then qualitative and quantitative composition of four different energy drinks was assessed.

We surveyed 150 volunteers from the Voronezh State Medical University named after N. N. Burdenko. 80% (120) of them were female, 20% (30) were male. The majority of those interviewed (93.3%) were 18–25 years old. Students from the departments of general medicine (43.3%), pediatric department (29.3%), dental department (17.3%) and that of preventive medicine (4.7%) along with year 1 to year 6 students from the Institute of International Education of the Global Institution of Medical Education and Cooperation (5.3%) participated in the study.

RESEARCH RESULTS

The survey consisted of four sections: what the students knew about energy drinks; the frequency of and reasons for consuming energy drinks by medical students; effect produced by energy drinks on students' health; and their personal attitude to these products. The students had to answer some questions regarding what an energy drink is, what labels they are aware of, what opinion they have about the price and quality relation. According to subsequent statistical processing, 93.3% of students are aware or have ever heard of the product. Adrenaline Rush (96%) and Red Bull (94.7%) were the most popular drinks among the students of the Voronezh State Medical University named after N. N. Burdenko. 59.3% of those interviewed noted that quality doesn't depend on price; whereas 40% believe that the greater the cost is, the safer and more qualitative the energy drink is.

It has been established during the analysis that 80% of the students consume energy drinks. The vast majority (85%) reported that the drinks help regenerate energy during the examination period. Many prefer consuming energy drinks while resting (15.3%). The main reasons for it included shortage of energy (56%), nice taste (46%) and proper price (9.3%).

When asked about the purpose of the consumption, the majority of students mentioned a chance to cheer up (65%), improved performance (40%), better mood and positive emotions (32%). During the questioning it has been found out that students mainly have energy drinks in the evening. The frequency of use was as follows: once or twice a month for 23.3%, once or twice half a year for 22.7%, once or twice a year for 15% and more frequently than once or twice a year for 14.9% only. Students prefer having a large 450 ml can (60%) or a small 180 ml can (40%) per day.

There was also a question about a possible combination of energy drinks and other caffeine-containing products on the same day. About 74% of respondents mentioned that it was undesirable to combine energy drinks and caffeine-containing products, whereas 26% admitted that they could combine them, though it was very bad for health. Based on subjective health assessment after consumption of energy drinks, it was found out that 35% of students believed energy drinks to be effective. The effect was almost immediate or occurred within 30 minutes and within one hour after the consumption in 14.7%, 37.3% and 16.7% students, respectively. Improved performance was noted in 70% of those interviewed. A half of respondents (54.7%) reported that adverse events developed after consumption of different energy drinks. Thus, they mentioned tremor of the extremities (11.3%), headaches (5.3%), loss of consciousness (2%), allergic reactions (4%), increased excitability (20%), high blood pressure (23.3%), and disturbed cardiac rhythm (26%).

Having analyzed quantitative and qualitative composition of such energy drinks as Adrenaline rush, Flash energy, Burn (zero sugar) and Red Bull, we have calculated the energy value per 100 ml of these products. It amounted to 230 kJ/54 kcal, 210 kJ/50 kcal, 10 kJ/2 kcal and 195 kJ/46 kcal. Thus, the least energy value was calculated for sugar-free Burn, with the difference being not over 20 kJ for other drinks. As far as the qualitative composition goes, all the presented energy drinks contained water, acidity regulators, taurine (synthetic analogue of caffeine) (Adrenaline rush — 240 mg/100 ml, Flash energy — 120 mg/100 ml, Burn (zero sugar) — 240 mg/100 ml, Red Bull — 400 mg/100 ml), flavoring agents, *caffeine* (Adrenaline rush — 30 mg/100 mg, Flash energy — 27 mg, Burn (zero sugar) — 32 mg, Red Bull — 32 mg), vitamin B6 (Adrenaline rush — 0.8 mg, Flash energy — 0.6 mg, Burn (zero sugar) — 0.4 mg, Red Bull — 2 mg), colorants, and sugar (with exception of Burn, zero sugar). Other components varied depending on the manufacturer. Adrenaline rush also contained L-carnitine, stabilizing agents, inositol, guarana seed extract, ginseng root extract, and vitamin B12. Flash energy composition was supplemented with antioxidant, niacin, pantothenic acid, potassium sorbate and sodium benzoate, sweetening agents and maltodextrin. Red Bull also included niacin and pantothenic acid.

Special attention should be paid to the content of caffeine and taurine in the presented samples, as they are responsible for the main 'refreshing' effect. The combination can be harmful for people with cardiovascular or nervous disorders. Ginseng and guarana (extracts) ensure rapid removal of lactic acid from skeletal muscles, facilitating functioning of muscles and producing an analgesic effect. Vitamins of group B are essential participants of many biochemical reactions, though their excess can't improve mental activity, as many manufacturers promise. However, they produce not only a positive effect. Long-term consumption that exceeds the daily requirement can result in disturbance of water-salt balance, anxiety, irritation, chronic headache, increased spinal reflex excitability, stimulation of the respiratory center and decreased resistance of cellular membrane receptors to insulin. Taurine is a 'synthetic caffeine

analogue'. It can accumulate in the muscular tissue and has anticonvulsant properties [14]. In large amounts, it can result in over-excitation and even exhaustion of the nervous system, increase the risk of dangerous cardiac arrythmias and peripheral circulation disturbances [14, 15].

To avoid adverse effects, it is necessary to remember about the acceptable values of energy drink components and not exceed the dosage. Energy drinks are marketed in different volumes: 250 ml (small can) and 450 ml (large can). As cited in literature, a safe daily amount of caffeine is 150 mg. This amount comes in two small cans (or one large 0.45 l can). The maximum daily dose of taurine is 300 mg. The 450 ml can, which is most frequently used by the majority of young people (60%), has 540–1800 mg of taurine, which significantly exceeds the daily allowance. So, it is safer to use a small can of energy drink (180 ml) per day.

DISCUSSION OF RESULTS

It has been found out that 80% of medical students consume medical drinks, mainly, to replenish the shortage of own energy (56%) and improve performance (40%). A medical student digests enormous data within a short period of time, has frequent emotional overload, high energy expenditure and improper daily regimen. These can be the reasons for the increased consumption of different energy drinks by medical students. However, the students are poorly aware of the effect produced by energy drinks on the body (26% of those interviewed combine energy drinks and caffeine-containing products), which can lead to serious health problems in the future. We also concluded that a safer amount of an energy drink is 250 ml, though 60% prefer 450 ml. There exist various negative adverse events that require special attention and subsequent examination, because bad mental and physical condition can produce a negative effect on the educational process and, as a consequence, work of future healthcare professionals [5].

CONCLUSIONS

Energy drinks are becoming increasingly popular among young people. They produce various effects on the body, and it is commonly justifiable when they are used to improve performance. However, in our opinion, their adverse effects require a subsequent detailed examination. A person who consumes energy drinks is loaded with imaginary well-being and cheerfulness, as the body actually uses its own reserves, which are depleted over time. Energy shortage can be replenished with normal sleep and rest and good nutrition. Any student who follows the simple recommendations will feel fresh and energetic.

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