RUSSIAN BULLETIN OF HYGIENE

SCIENTIFIC MEDICAL JOURNAL
FOUNDED BY: BURDENKO VORONEZH STATE MEDICAL UNIVERSITY AND
PIROGOV RUSSIAN NATIONAL RESEARCH MEDICAL UNIVERSITY

SUBMISSION https://rbh.rsmu.press/
COLLABORATION editor@rsmu.press
ADDRESS Ostrovityanov St. 1, Moscow, 119997, Russia

Indexed in RSCI. IF 2018: 0,5

Open access to archive

Issue DOI: 10.24075/rbh.2023–04
The mass media registration certificate PI series № FS77-80908 dated April 21, 2021
Founders: Burdenko Voronezh State Medical University (Voronezh, Russia)
Pirogov Russian National Research Medical University (Moscow, Russia).
Publisher: Pirogov Russian National Research Medical University; adress: Ostrovityanov Street 1, Moscow 119997 Russia

Approved for print 31.12.2023
Circulation: 100 copies. Printed by Print.Formula
www.print-formula.ru

РОССИЙСКИЙ ВЕСТНИК ГИГИЕНЫ

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

ПОДАЧА РУКОПИСЕЙ https://rbh.rsmu.press/
СОТРУДНИЧЕСТВО editor@rsmu.press
АДРЕС РЕДАКЦИИ ул. Островитянова, д.1, г. Москва, 119997, Россия

Журнал включен в РИНЦ. IF 2018: 0,5

Здесь находится открытый архив журнала

DOI выпуска: 10.24075/rbh.2023–04
Свидетельство о регистрации средства массовой информации серия ПИ № ФС77-80908 от 21 апреля 2021 г.
Учредители: Воронежский государственный медицинский университет им. Н.Н. Бурденко (Воронеж, Россия);
Российский национальный исследовательский медицинский университет имени Н.И. Пирогова (Москва, Россия)
Издатель: Российский национальный исследовательский медицинский университет имени Н.И. Пирогова; адрес: 117997, г. Москва, ул. Островитянова, д.1, тел.: 8 (495)434-03-29

Подписано в печать 31.12.2023
Тираж 100 экз. Отпечатано в типографии Print.Formula
www.print-formula.ru

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CURRENT DIRECTIONS OF THE DEPARTMENT OF HYGIENE, FACULTY OF PEDIATRICS, PIROGOV RUSSIAN NATIONAL RESEARCH MEDICAL UNIVERSITY (115TH ANNIVERSARY OF THE DEPARTMENT)

Milushkina OYu, Skoblina NA, Korolik VV, Sheina NI, Bokareva NA, Kozyreva FU, Markelova SV ✉, Bulatseva MB, Dubrovina EA, Tikhonova YuL

Pirogov Russian National Research Medical University, Moscow, Russia

The paper provides the analysis of the research and practical work done at the Department of Hygiene, Pirogov Russian National Research Medical University, for the period between 2018 and 2023 aimed to determine the today's directions of the Department and demonstrate their relevance, scientific and practical significance; prospective directions of further research are defined. Statistical data processing was performed using the Statistica 13 PL software and the tag (word) cloud service. Staff of the Department did extensive educational and methodological, organizational and methodological, expert and consulting, research work (paragraphs 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12 of the academic passport for the specialty 3.2.1. "Hygiene"); a total of 10 textbooks and three toolkits, three guidelines, two software products, one patent for invention and 39 database certificates, 11 collective monographs were published; two hygienic standards were approved; the activity outcomes were presented during 95 scientific and practical events, including that with international involvement. A total of 150 articles were published: 46 in the journals indexed in international databases (Scopus, Web of Science), 58 in the journals indexed by HAC under the Ministry of Education and Science of the Russian Federation, one in the Nature journal. Two candidate and two doctoral theses on the specialty 3.2.1. "Hygiene" were prepared and defended. The activity outcomes provided helped to address the hygienic challenges currently faced by professional community to achieve the national goals of the Russian Federation in the fields of demography, public health and digitalization.

Keywords: Department of Hygiene, educational and methodological work, scientific and practical activities, publication activity, children, adolescents, youth, students, children with disabilities, physical development, health assessment, disease prevention, food hygiene, sanitary microbiology, toxicology, hygienic education

Author contribution: Milushkina OYu — study planning, manuscript draft preparation; Skoblina NA — study planning, data acquisition, analysis and interpretation, analysis of publication activity using the tag (word) cloud service, manuscript draft preparation; Korolik VV, Sheina NI, Bokareva NA, Kozyreva FU, Bulatseva MB, Dubrovina EA, Tikhonova YuL — data acquisition; Markelova SV — data acquisition, analysis and interpretation, manuscript draft preparation.

Compliance with ethical standards: the study was approved by the Ethics Committee of the Pirogov Russian National Research Medical University (R&D project state registration number AAAA-A19-119021890068-7 of 18 February 2019; protocols № 159 dated 21 November 2016, № 203 dated 20 December 2020, № 209 dated 28 June 2021). The study was compliant with the principles of biomedical ethics and did not endanger the subjects.

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Received: 23.10.2023 **Accepted:** 27.10.2023 **Published online:** 11.11.2023

DOI: 10.24075/rbh.2023.079

СОВРЕМЕННЫЕ НАПРАВЛЕНИЯ ДЕЯТЕЛЬНОСТИ КАФЕДРЫ ГИГИЕНЫ ПЕДИАТРИЧЕСКОГО ФАКУЛЬТЕТА РНИМУ ИМЕНИ Н. И. ПИРОГОВА (К 115-ЛЕТНЕМУ ЮБИЛЕЮ КАФЕДРЫ)

О. Ю. Милушкина, Н. А. Скоблина, В. В. Королик, Н. И. Шеина, Н. А. Бокарева, Ф. У. Козырева, С. В. Маркелова ✉, М. Б. Булацева, Е. А. Дубровина, Ю. Л. Тихонова

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Представлен анализ научно-практической деятельности кафедры гигиены РНИМУ имени Н. И. Пирогова за период с 2018 по 2023 г. с целью определить современные направления деятельности кафедры и продемонстрировать их актуальность и научно-практическую значимость; определены перспективные направления дальнейших исследований. Статистическую обработку проводили с использованием программного обеспечения Statistica 13 PL и сервиса «облако тегов (облако слов)». Сотрудниками кафедры проведена большая учебно-методическая, организационно-методическая, экспертно-консультационная, научная работа (п.п. 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12 Паспорта научной специальности 3.2.1. «Гигиена»); опубликованы 10 учебных и три учебно-методических пособия, три методические рекомендации, два программных продукта, один патент на изобретение и 39 свидетельств на базы данных, 11 коллективных монографий; утверждены два гигиенических норматива; результаты деятельности доложены более чем на 95 научно-практических мероприятиях, в том числе с международным участием. Опубликованы 150 статей, из которых 46 — в журналах, индексируемых в международных базах данных (Scopus, Web of Science), 58 — в журналах, индексируемых ВАК Минобрнауки России, одна публикация в журнале Nature. Подготовлены и защищены две кандидатские и две докторские диссертации по специальности 3.2.1. «Гигиена». Представленные результаты деятельности способствовали решению гигиенических проблем, стоящих в настоящее время перед профессиональным сообществом, для достижения Национальных целей Российской Федерации в сфере демографии, здравоохранения и цифровизации.

Ключевые слова: кафедра гигиены, учебно-методическая работа, научно-практическая деятельность, публикационная активность, дети, подростки, молодежь, обучающиеся, дети с ограниченными возможностями, физическое развитие, оценка здоровья, профилактика заболеваний, гигиена питания, санитарная микробиология, токсикология, гигиеническое воспитание

Вклад авторов: О. Ю. Милушкина — планирование исследования, подготовка черновика рукописи; Н. А. Скоблина — планирование исследования, сбор, анализ, интерпретация данных, анализ публикационной активности с помощью сервиса «облако тегов (облако слов)», подготовка черновика рукописи; В. В. Королик, Н. И. Шеина, Н. А. Бокарева, Ф. У. Козырева, М. Б. Булацева, Е. А. Дубровина, Ю. Л. Тихонова — сбор данных; С. В. Маркелова — сбор, анализ, интерпретация данных, подготовка черновика рукописи.

Соблюдение этических стандартов: исследование было одобрено этическим комитетом РНИМУ имени Н. И. Пирогова (номер государственного учета НИОКТР АААА-А19-119021890068-7 от 18 февраля 2019 г.; протоколы № 159 от 21 ноября 2016 г., № 203 от 20 декабря 2020 г., № 209 от 28 июня 2021 г.). Исследование соответствовало требованиям биомедицинской этики и не подвергало опасности участников.

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Статья получена: 23.10.2023 **Статья принята к печати:** 27.10.2023 **Опубликована онлайн:** 11.11.2023

DOI: 10.24075/rbh.2023.079

In 2023, the Department of Hygiene of the Faculty of Pediatrics, Pirogov Russian National Research Medical University, celebrates its 115th anniversary. Historically, the departments of hygiene and their research schools are used to sum up the results, commemorate teachers and mentors, set out prospects to the memorable dates [1–8].

Preventive healthcare departments often having a common ancestry and history still have some historical evolution features and demonstrate unique directions of scientific research, teaching aids preparation, student research society activities, etc. [9–10].

The study involved the analysis of current directions of the Department over time (five years), since the analysis of the earlier period had been comprehended and published as a substantial monograph [11].

It was shown that the directions of the department were different in different historical periods, considering the sanitary and epidemiological, environmental, social and economic situation in the country. Thus, the issues of municipal hygiene related to establishing the link between chemical composition of water and water contamination were addressed under the guidance of Professor M.B. Kotsyn (1860–1917). His successor, Professor P.N. Diatroptov (1859–1934), continued the Department's work in the field of municipal hygiene and sanitary microbiology. Academician of AMS USSR, Professor N.K. Ignatov (1870–1951), resumed the research in the field of municipal hygiene and started the research in the field of food hygiene. Corresponding member of AMS USSR, Professor N.N. Litvinov (1893–1971), introduced the research in the field of radiation hygiene into the Department's activities, he resumed the research in the field of municipal hygiene focused on ambient air and food hygiene related to food poisoning and focused on the hospital hygiene. His successor, Professor A.S. Arkhipov, who headed the Department for a short time, dealt with issues of occupational hygiene and occupational disorders. Professor V.A. Spassky, who also headed the Department for a short time, focused on activities in the field of general and military hygiene. The Department's research in the field of municipal and food hygiene was resumed under the guidance of academician AMS USSR, Professor G.I. Sidorenko (1926–1999). His student and successor, RAS academician Professor Yu.P. Pivovarov (1936), supplemented the issues of nutritional hygiene and sanitary microbiology with the issues related to environmental problems and anthropogenic pollution of the environment. The work done by Yury P. Pivovarov and scientific cooperation made the Department of Hygiene one of the reputable hygiene schools. Thus, the research work at the Department of Hygiene of the Faculty of Pediatrics, Pirogov Russian National Research Medical University, was conducted in accordance with paragraphs 1, 2, 3, 5, 6, 8, 9 of the academic passport for the specialty 3.2.1. "Hygiene" throughout the period of its existence.

Our study was aimed to determine the today's directions of the Department of Hygiene and demonstrate their relevance, scientific and practical significance.

We conducted the analysis of the research and practical activities, scientific papers of the Department of Hygiene published in periodicals indexed in E-Library, PubMed, Scopus, Web of Science for the period between 2018 and 2023. Assessment of the effects of the factors of educational environment and daily routine components on the students' health status was the main research focus. Statistical processing of the data obtained was performed using the Statistica 13 PL software package (StatSoft; USA) and the tag (word) cloud service for visualization of text using the most abundant words.

Today, the professor staff of the Department is represented by the RAS academician, RAS corresponding member, six doctors of science, eight candidates of science and four staff members having no scientific degrees, who are engaged in preparation of dissertations. Over five years, the average age of the Department's professor staff has decreased from 62.5 to 52.0 years ($p \leq 0.01$). The average teaching experience is 20.4 years. The share of teachers under the age of 39.0 years is 25.0%. The existing team represents a mix of experience and youth, collaboration of graduates of the preventive medicine, general medicine, preventive, and biological faculties. According to the publication activity data and the citation impact (Hirsch Index), the staff members of the Department of Hygiene are among top 100 professors of the Pirogov Russian National Research Medical University. Over five years, two candidate and two doctoral theses on the specialty 3.2.1. "Hygiene" were prepared and defended at the Department, six postgraduate students have undertaken or are currently undertaking postgraduate study. The Department's staff members regularly pass advanced training in pedagogy, update their knowledge and practices using the system of continuing medical education, a half (50.0%) of the Department's staff members have qualification certificates or have been accredited in accordance with the existing specialty.

Extensive organizational and methodological work is done at the Department. The Department's staff are members of the Dissertation Council 21.2.058.12 at the Pirogov Russian National Research Medical University and the Dissertation Council 24.1176.01 at the Izmerov Research Institute of Occupational Health, stand as opponents and reviewers of the third party research and practical experience. The research hygienists are members of editorial boards of the following journals: Russian Journal of Occupational Health and Industrial Ecology, Health Risk Analysis, Public Health and Life Environment — PH&LE, Hygiene and Sanitation, Current Problems of Health Care and Medical Statistics, Volgograd Journal of Medical Research, Pediatric Nutrition, Russian Medical Journal, Russian Bulletin of Hygiene.

The Department's staff members initiated, led in the creation and are currently actively engaged in publication of the journal "Russian Bulletin of Hygiene", the first issue of which was published in 2021. This is a peer-reviewed academic journal of the Eastern European Cluster for Medical Research and Education of the Central Federal District founded by the Pirogov Russian National Research Medical University and Burdenko Voronezh State Medical University. On July 11, 2023 the journal entered the list of peer-reviewed research and practical journals recommended by the HAC under the Ministry of Education and Science of the Russian Federation (in accordance with the HAC List as at 17.07.2023, No. 2260). The journal accepts papers on the specialty 3.2.1. "Hygiene" (health sciences) and 3.2.1. "Hygiene" (biological sciences).

Specialists of the Department of Hygiene conduct expert and consulting work in various fields of medical knowledge. They are members of the Profile Commission on Hygiene in Children and Adolescents of the Ministry of Health of the Russian Federation, members of the Problem Commission of the RAS Academic Council for hygiene, Presidium of the Russian Society for Development of School and University Medicine and Health, European Anthropological Association, Academic Council of Rospotrebnadzor, they are experts of RAS, members of the Commission on State Sanitary and Epidemiological Standards under the Federal Service for the Oversight of Consumer Protection and Welfare, members of the HAC Expert Council under the Ministry of Education and

Science of the Russian Federation for medical and preventive research.

Olga Yu. Milushkina, Head of the Department since 2015, is the main supernumerary specialist in hygiene of children and adolescents at the Ministry of Health of the Russian Federation, Secretary for higher medical and non-medical education at the Central Accreditation Commission of the Ministry of Health of the Russian Federation, Vice-Rector for Academic Affairs at the Pirogov Russian National Research Medical University since 2020. During the past period she was awarded the Gratitude of the Minister of Health of the Russian Federation (2017, 2020), Honorary Diploma of the Ministry of Health of the Russian Federation (2021), medal "For Contribution to Implementation of State Policy in the Field of Education and Science and Technology Development" (2022). The Department's staff members were awarded Honorary Diploma and Gratitude of the Pirogov Russian National Research Medical University, Gratitude of the Minister of Health of the Russian Federation, Honorary Diploma of the Ministry of Health of the Russian Federation, orders and medals of the Russian Federation.

In the reporting period, the Department's material and technical foundation was improved: educational and support facilities were renovated, lighting systems were replaced, technical foundation of the computer class and the teachers' workplaces was renovated, three classrooms were equipped with multimedia facilities.

In 2019–2023, about 13,000 of students of the general medicine, pediatrics, dentistry, biomedical and international faculties were trained at the Department, among them 667 foreign students, who were taught in English. The average annual number of students trained at the Department is 2500, while that of residents is about 150.

The Department's professor staff does extensive educational and methodological work. A total of 10 textbooks, three toolkits, and three guidelines have been issued. Methodological materials on the subjects of lessons are regularly updated, video-lectures are recorded. Informational and educational materials to be posted on the portal of continuing medical and pharmaceutical education of the Ministry of Health of the Russian Federation have been prepared.

The educational and methodological publications issued with the help of the Department's staff members receive public recognition and awards. First prize of the Pirogov Russian National Research Medical University Contest was awarded for the best educational and methodological performance in 2021 (textbook "Hygiene of Nutrition in Pregnancy, Lactation and Children in Their First Year of Life" (Milushkina OYu, Tikhonova YuL, et al.)). The paper "Working Conditions and Occupational Diseases of Medical Professionals" (Milushkina OYu, et al., editors) won in the nomination Discovery of the Year of the IX All-Russian Book Award "Golden Fund" in 2022; in 2023, the gold medal of participant of the 36th Moscow International Book Fair was awarded for the textbook "Hygienic Education of Students in Terms of the Safe Use of Electronic Devices in Educational and Leisure Activities" compiled in direct coordination with O.Yu. Milushkina, N.A. Skoblina, S.V. Markelova, A.A. Tatarinchik, O.V. Ievleva, as well as for the textbook "Hygienic Aspects of Preventing the Diseases Associated with Exertion of Body's Adaptive Mechanisms During Acclimatization" compiled in direct coordination with O.Yu. Milushkina and N.A. Skoblina.

The Department's staff members closely cooperate and conduct joint research with the friendly research teams of the Cluster for Medical Research of the Central Federal District of Russia uniting experts from Moscow, Voronezh and Ryazan, as well as with their colleagues from Moscow, Ekaterinburg, Kazan, Nizhny Novgorod, Samara, Omsk, Krasnoyarsk, Saratov, Vladivostok, Arkhangelsk, Astrakhan, et al.; they are engaged in international scientific cooperation with the colleagues from Belarus, Kazakhstan, Tajikistan, Uzbekistan, Kyrgyz Republic, keep in touch with experts from the USA, Italy, Netherlands; cooperate within the framework of activities of the association of organizations and experts in hygiene "Union of Hygienists" (http://iuh.su).

To promote the National Goals of the Russian Federation in digital transformation, the open access software products have been developed together with friendly research teams and are used for training at the Department: Standards for Physical Development of Children and Adolescents (registration certificate of a computer program RU 2018661994, 25.09.2018, application № 2018619420 of 27.08.2018) and the anthro-prof software product "Program for Assessing Physical Development of Schoolchildren" (registration certificate of a computer program 2022669375, 19.10.2022, application № 2022668886 of 13.10.2022).

The software product "Program for Assessing Physical Development of Schoolchildren" makes it possible to estimate the child's physical development in accordance with the Order No. 514n "On the procedure for conducting preventive medical examinations of minors" of the Ministry of Health of the Russian Federation (Fig. 1).

A total of one patent for invention, 39 database certificates were registered, 11 collective monographs were published, two hygienic standards were approved together with friendly research teams.

The results of the Department's research, methodological and other activities for the past period were reported during more than 95 international, all-Russian with international involvement, and other scientific and practical events. The knowledge accumulated was popularized via media: Russia-1, Zvezda, TV Center TV channels, RIA Novosti news agency, Trud and AiF Za Kaluzhskoj Zastavoj newspapers, Medical Newspaper, Teacher's Newspaper.

As for scientific papers reflecting the today's directions of the Department of Hygiene of the Faculty of Pediatrics, Pirogov Russian National Research Medical University, a total of 150 articles were published over a five-year period, among which 46 in the journals indexed in international databases (Scopus, Web of Science), 58 in the peer-reviewed journals recommended by HAC under the Ministry of Education and Science of the Russian Federation. Furthermore, the results of the global study "Diminishing Benefits of Urban Living for Children and Adolescents' Growth and Development" involving the researchers of the Department of Hygiene from the Russian Federation were published in the British journal "Nature" on March 29, 2023.

The Department's staff members continue research in the field of sanitary microbiology, thereby developing the scientific ideas of the RAS academician, Professor Yu.P. Pivovarov. Methodological approaches to assessment of the engineered microorganisms

Fig. 1. QR code leading to a webpage of the anthro-prof software product "Program for Assessing Physical Development of Schoolchildren"

Fig. 2. Visualization of the content of scientific papers using the most abundant words

and appropriate preparations' safety for environmental objects were developed; the criteria to estimate toxicity and hazard of the single-component and multicomponent medications based on the engineered microbial strains and the approaches to development of the methods to control their levels in air were determined. The team of the Department's toxicologists (Professor N.I. Sheina, Professor V.V. Korolik, E.D. Drugova) takes part in pre-clinical trials of novel active substances; coordinates and conducts collaborative research focused on determining the tentative safe exposure levels (TSEL) taking into account specific effects of chemical compounds being the substances of drugs and disinfectants; a total of 26 MACs in the working area air and atmospheric air for the engineered microbial strains (Komagataella pastoris, *Pichia pastoris*, *E.coli*, *Beauveria bassiana*) and biologics (Fitosporin, Arkoil, Lovchij, TurinBash, etc.) have been determined, which have been included in the SanPiN 1.2.3685-21 "Hygienic Standards and Requirements for the Environmental Factor Safety and/or Harmlessness to Humans". The study results have also provided the basis for the updated guidelines "MAC Experimental Substantiation and Regulation of the Levels of Engineered Microbial Strains and Biologics Containing Them in Industrial and Environmental Objects" (authors: Professors N.I. Sheina and V.V. Korolik, RAS academician Professor Yu.P. Pivovarov, candidates of science E.G. Skryabina, L.P. Sazonova, L.I. Myalina, V.V. Kolesnikova), which are now awaiting approval by Rospotrebnadzor.

Today, the Department's toxicologists are engaged in the development of express methods allowing for fast and early detection and identification of the toxic agent effects on the organism, the use of which is promising for express diagnosis to be used in clinical practice and experimental settings.

The Department's staff members conduct research in the field of food hygiene (academician Yu.P. Pivovarov, RAS corresponding member O.Yu. Milushkina, D. Sci. (Med.) N.A. Bokareva, Cand. Sci. (Med.) Yu.L. Tikhonova). Preventive measures aimed at reducing the chemical contaminant nutritional load associated with poor nutrition in children in their first year of life resulting from unreasonable refusal of breastfeeding, abnormal timing of introduction of complementary foods have been substantiated at advanced methodological levels. The proposed preventive measures have been introduced into the activities of obstetrics hospitals, maternity clinics and volunteer work with puerperas, thereby reducing the risk of disorders in the child population.

The global growth of childhood disability over the recent years has become a worldwide problem impacting all spheres of public life (economic, political, social, spiritual). This trend gives relevance to the search for measures contributing to improving quality of life of children with dosabilities. The Department's researchers (RAS corresponding member O.Yu. Milushkina, Cand. Sci. (Med.) E.A. Dubrovina) have conducted research focused on assessing the differences in perception of the educational material rationally presented to children with various disorders during the lessons. The mass and individual timing protocols for the classes, where children with disabilities are taught, have been developed for the study, the guidelines on arranging educational activities in this cohort of children and disabled schoolchildren have been proposed. Such work in organizations of secondary and higher vocational education involving the Department employees is continued.

The analysis of the Department's professor staff publication activity using the tag (word) cloud service is provided in Fig. 2.

Visualization of the analysis of publication activity presented using the tag (word) cloud service clearly illustrates the research objects over a five-year period, including mainly children, adolescent and youth, i.e. students (schoolchildren and medical and non-medical university students). Estimation of their health status and physical development has been the research subject. The impact of such factors, as the use of electronic (including mobile) devices in educational activities has been assessed, specifically during distance learning and in leisure time. The studies conducted (RAS corresponding member O.Yu. Milushkina, Professor N.A. Skoblina, D. Sci. (Med.) S.V. Markelova, D. Sci. (Med.) F.U. Kozyreva, Cand. Sci. (Med.) A.A. Tatarinchik, O.V. Ievleva, A.V. Kirillova) have resulted in the development of preventive and health-promoting measures, lifestyle correction, including using the hygiene training forms and methods focused on prevention of diseases of the eye and adnexa, functional impairments of the body's cardiovascular, musculoskeletal, nervous and other systems.

Great attention was paid to developing new forms of teaching hygiene (business games, online quests, etc.) and to hygiene training of medical students (RAS corresponding member O.Yu. Milushkina, Professor N.A. Skoblina, D. Sci. (Med.) S.V. Markelova, associate professors M.B. Bulatseva, R.S. Volkova, Cand. Sci. (Med.) G.G. Chub, Cand. Sci. (Med.) A.A. Tatarinchik, O.V. Ievleva, D.D. Kaminer, A.V. Kirillova).

Thus, the directions of the Department of Hygiene of the Faculty of Pediatrics, Pirogov Russian National Research Medical University, maintaining the scientific school continuity and conducting research in conventional areas, include research on the new paragraphs of the academic passport for the specialty 3.2.1. "Hygiene" (paragraph 10 (Information and Analytical Hygiene), paragraph 11 (Hygiene of Health Preservation) and paragraph 12 (Hygiene Training)), as well as on the conventional paragraph 4 (Hygiene of Children and Adolescents).

The National Healthcare Project is implemented in Russia in 2019–2024. According to the Passport of the project, it is planned to increase coverage of the child population with routine check-ups aimed at preservation of health along with the national reproductive and labor potential. In 2017, this indicator accounted for 38.7% of the total number of children subject to check-ups; it is planned to increase this value to 80.0% by 2024. Currently, it is stated in the standard and methodical base of the Ministry of Health of the Russian Federation, specifically in the Order № 514n "On the procedure for conducting preventive medical examinations of minors" (current version), that assessment of the child's physical health is the key criterion of assessment of his/her health status essential for identification of children at risk aimed at developing new guidelines on shaping healthy lifestyle, daily routine, nutrition, physical exercise, and the guidelines on dispensary supervision, treatment, medical rehabilitation and resort treatment. Given the actual goals and priorities of the modern society development, the Department's research was focused mainly of health protection in children, adolescents and youth, i.e. on preservation of the national labor, reproductive and defense potential. The studies considered the most relevant factors, such as widespread use of electronic devices, distance learning, restrictions associated with the pandemic, etc. [12–17].

The problem of unregulated use of electronic devices was also solved for other cohorts, specifically for the working population (teachers and healthcare professionals) [18–19].

New hygienic research methods were substantiated, specifically the use of online questionnaire surveys, their sensitivity, specificity and validity were demonstrated [20].

Pursuit of healthy lifestyle in today's children, adolescents and youth, as well as their parents, teachers and even healthcare professionals are primarily associated with having no harmful habits. Students do not realize that the key role is played by proper diet, enough sleep, optimal physical activity, etc., which demonstrates their insufficient awareness of these issues and the lack of shaped health preservation skills [21–28].

In recent years, the hygiene training programs aimed to prevent health problems in the population were seldom or never used. At the same time, the potential of measures for hygiene training of various population groups using advanced forms is considered to be the most important and promising area of hygiene showing the research and practical significance. Due to changes in the population living conditions and lifestyle is was necessary to update the hygiene training forms and methods, as well as to develop and test the new ones. Furthermore, special attention should be paid to students of medical universities and colleges, medical volunteers as future custodians of knowledge and skills related to shaping adherence to healthy lifestyle in patients and the population [29–30].

The Department of Hygiene has always attached great importance to training of researchers. The research activities of many Department's professors started from studentship. Numerous scientists and teachers were involved in research in the student's scientific circle and resumed scientific activity in during their postgraduate course. This is still implemented today, when the students being members of the circle conduct studies, publish the reports in the peer-reviewed journals, win prizes at the International Pirogov Scientific Medical Conference and other forums [31].

We can say that the work done by the Department's staff continues the work of the acknowledged founders of hygiene. Thus, if we turn to history, in Russia hygiene had been just an academic discipline for a long time. Only the research conducted by Alexey P. Dobroslavin, who started conducting routine studies (including experimental studies) to substantiate the hygienic provisions, which showed is usefulness and compliance with the requirements of the times. Moreover, he made students familiar with practical application of hygienic knowledge to the real life conditions when examining the objects of practical interest: hospitals, waterworks, canteens, barracks. He attached the utmost importance to sanitary public education and promotion of hygienic knowledge using a wide range of forms for this purpose: public lectures, publication of the sanitary educational brochures and articles [32].

CONCLUSION

The research and practical work done at the Department of Hygiene covers almost all areas of research for the specialty "Hygiene" and actively develops the toxicology research methods. The professor staff demonstrates high publication activity, develops educational and methodological materials together with standards, actively cooperates with the colleagues in both Russia and the countries near and far abroad, improves qualification in pedagogy and medical specialty, teaches students and residents, trains researchers. The outlined prospects for the development of scientific directions, the Department's staff great interest to their work and high rate of publications in the journals showing high citation impact make it possible to expect further professional growth of the Department's employees and scaling up the results of their research and practical activities.

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RELATIONSHIP BETWEEN MAJOR CARDIOVASCULAR SYSTEM PARAMETERS AND BODY MASS INDEX IN ADOLESCENTS OF MAGADAN REGION

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Excess weight and obesity detected in adolescence are likely to be detected in adulthood, which increases the risk of cardiovascular disorders. The study was aimed to assess the features of cardiovascular system parameters in adolescent males considering their body mass index (BMI). For this purpose a total of 208 adolescent males aged 15–16 were surveyed. The major indicators of physical development and cardiovascular system function were evaluated by standard method. BMI was calculated, based on which three groups were distinguished: underweight adolescents, adolescents with normal and excess body weight. It was found that 23% of subjects were underweight, 62% had normal body weight, and excess body weight was reported in 15% of adolescents. It has been shown that the growth of strain on the cardiovascular system from the group of underweight adolescents to the group with excess weight is observed (4, 16, and 37%, respectively), which is confirmed by the correlation analysis results. The findings suggest the less effective cardiovascular system functioning mode in overweight adolescents compared to other assessed groups. The data obtained can be used to develop the guidelines on managing excess body weigth in the group of individuals being through the adolescent ontogeny period as a target group for health promotion and applying preventive measures.

Keywords: male adolescents, body mass index, cardiovascular system, North

Funding: the study was conducted at the expense of budget financing of the "Arctic" Research Center, Far Eastern Branch RAS, under the theme "Study of Intersystem and Intrasystem Response Mechanisms in Formation of the "Northern Type" Human Body Functional Adaptive Reserves at Different Ontogeny Stages in Individuals Living in Uncomfortable and Extreme Environment Involving Determination of Integral Informative Health Indices" (ID AAAA-A21-121010690002-2).

Author contribution: Khorosheva IV — study concept and design, data acquisition and processing, manuscript writing and editing.

Compliance with ethical standards: the study was performed in accordance with the ethical principles for medical research involving human subjects enshrined in the Declaration of Helsinki (2013); the study protocol was approved by the Ethics Committee of the "Arctic" Research Center, Far Eastern Branch, Russian Academy of Sciences (report № 002/021 of 26 November 2021).

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Received: 18.06.2023 **Accepted:** 08.07.2023 **Published online:** 28.11.2023

DOI: 10.24075/rbh.2023.080

ЗАВИСИМОСТЬ ОСНОВНЫХ ПОКАЗАТЕЛЕЙ ДЕЯТЕЛЬНОСТИ СЕРДЕЧНО-СОСУДИСТОЙ СИСТЕМЫ ОТ ИНДЕКСА МАССЫ ТЕЛА У ПОДРОСТКОВ МАГАДАНСКОЙ ОБЛАСТИ

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Выявленные в подростковом возрасте избыточная масса тела и ожирение с большой вероятностью будут обнаружены и во взрослом возрасте, что повышает риск развития сердечно-сосудистых заболеваний. Целью исследования было изучить особенности показателей сердечно-сосудистой системы мальчиков-подростков с учетом величины индекса массы тела (ИМТ). Для этого были обследованы 208 подростков мужского пола в возрасте 15–16 лет. Оценка основных показателей физического развития и сердечно-сосудистой системы проведена стандартными методами. Выполнен расчет ИМТ, на основе которого выделены три группы: подростки с дефицитом массы тела, подростки с нормальной и избыточной массой тела. Установлено, что дефицит массы тела имел место у 23% обследованных, 62% имели нормальную массу тела, избыточная масса тела отмечена у 15% подростков. Выявлено, что от группы подростков с дефицитом массы тела к группе с избыточной массой тела наблюдается рост напряжения в работе сердечно-сосудистой системы (4, 16 и 37% соответственно), что подтверждают результаты корреляционного анализа. Результаты исследования свидетельствуют о менее эффективном режиме функционирования сердечно-сосудистой системы у подростков с избыточной массой тела по сравнению с другими обследованными группами. Полученные данные можно использовать для разработки рекомендаций по коррекции избыточной массы тела в группе лиц подросткового периода онтогенеза как целевой группе по укреплению здоровья и проведению профилактических мероприятий.

Ключевые слова: подростки мужского пола, индекс массы тела, сердечно-сосудистая система, Север

Финансирование: работа выполнена за счет бюджетного финансирования НИЦ «Арктика» ДВО РАН в рамках темы «Изучение межсистемных и внутрисистемных механизмов реакций в формировании функциональных адаптивных резервов организма человека «северного типа» на разных этапах онтогенеза лиц, проживающих в дискомфортных и экстремальных условиях, с определением интегральных информативных индексов здоровья» (регистрационный номер АААА-А21-121010690002-2).

Вклад авторов: О. О. Алёшина, А. А. Суханова — сбор данных, обзор литературы, написание текста рукописи; И. В. Аверьянова — разработка концепции и планирование научной работы, интерпретация полученных данных.

Соблюдение этических стандартов: исследование проведено в соответствии с этическими принципами проведения медицинских исследований с участием человека в качестве субъекта, закрепленными в Хельсинской декларации (2013 г.); протокол исследования был одобрен этическим комитетом Федерального государственного бюджетного учреждения науки Научно-исследовательского центра «Арктика» Дальневосточного отделения Российской академии наук (заключение № 002/021 от 26 ноября 2021 г.).

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Статья получена: 18.06.2023 **Статья принята к печати:** 08.07.2023 **Опубликована онлайн:** 28.11.2023

DOI: 10.24075/rbh.2023.080

Anthropometry is among methods most widely used to assess body composition in epidemiology studies due to its ease of use, low cost, and high reliability relative to other human morphology evaluation methods [1]. Indicators of physical development obtained during anthropometric measurements enable estimation of adolescent's development and health [2, 3]. It should be noted that the state and endurance of cardiovascular system also represent good predictors of health across the life-course that are inversely related to such morphological parameters, as body mass index (BMI), waist circumference, body weight (BW), body fat percentage, and skinfold thickness [4–7].

BMI is a synthetic direct indicator of the human body harmony and an indirect indicator of adequate diet and general health based on the ratio between BW and body length. BMI calculation is essential for detection of excess BW and obesity being important risk factors of a number of cardiometabolic disorders [8, 9].

It should be noted that adolescent obesity is strongly associated with multiple comorbidities [10], especially with cardiovascular and metabolic disorders [11, 12]. There is evidence that the increase in BW being a multifaceted process also affects the child's body growth and development, as well as psychoemotional state [13]. Consequently, careful monitoring of BW and BMI throughout childhood and adolescence ontogeny periods can represent not only a method to detect excess weight and obesity, but also a simple and powerful method to prevent the disorders associated with the above, including reducing the risk of cardiovascular disorders in adults [9]. This subject is becoming particularly important due to the spread of obesity in this age group observed in the past decade [14]. Thus, according to global forecast, 268 and 124 million children and adolescents will be overweight or obese by 2025 [15]. It should be noted that a pronounced increase in the prevalence of these conditions in adolescents observed in the 20th century was followed by the increase in the prevalence of arterial hypertension (AH) and prehypertension [16].

Based on the foregoing, the study was aimed to evaluate and analyze the main cardiovascular system characteristics in the group of adolescent males living in the North considering their BMI.

METHODS

A total of 208 male Caucasian adolescents aged 15–16, who had comparable living conditions and were permanent residents of the Magadan Region, were assessed. Inclusion criteria: age 15–16 years, availability of the informed consent, health group 1–2. Exclusion criteria: history of chronic disease, being outside the age range, no informed consent. Assessment was performed in fall/winter 2022.

Basic somatometric characteristics were determined in the subjects: body length (cm) and BW (kg) that were used to calculate BMI (kg/m^2) according to the following formula:

$$BMI = BW/BL^2,$$

where BL was body length (cm), BW was body weight (kg). Differentiation of adolescents based on BMI involved taking into account the percentile ranges in accordance with the guidelines issued by the World Health Organization (WHO) [17].

The assessed sample was divided into three groups according to the WHO criteria: group 1 — underweight adolescents (n = 48, 23%) with the average age of 16.2 ± 0.0 years; group 2 — subjects with normal weight (n = 128, 62%) with the average age of 16.2 ± 0.1 years; group 3 included overweight adolescents (n = 32, 15%) with the average age of 16.2 ± 0.1 years.

The Nessei DS-1862 blood pressure monitor (Nissei; Japan) was used to measure systolic blood pressure (SBP, mmHg), diastolic blood pressure (DBP, mmHg), heart rate (HR, bpm) three times and calculate mean values. The following indicators were calculated based on the data obtained: rate-pressure product (RPP, AU), stroke volume (SV, mL), cardiac output (CO, mL/min), systemic vascular resistance (SVR, dyn · s · cm^{-5}) [18].

Statistical processing of the results was performed using the Statistica 7.0 software package (StatSoft; USA). The distribution of measured variables was tested for normality using the Shapiro–Wilk test. The results of applying parametric methods were presented as mean (M) and error of the mean (± m). No preliminary calculation of the sample size was performed. Significance of differences was determined using the Student's t-test. The critical significance level (p) was set as 0.05.

RESULTS

The Table provides the main cardiovascular system parameters and their values calculated in adolescent males living in the North based on their BMI. The results obtained show that 23% of subjects were underweight, 62% of adolescents had normal weight, and 15% were overweight. There were no significant differences in body length between the studied groups, which suggested that the samples were comparable.

The data provided show that overweight adolescent boys are characterized by significantly higher SBP, HR, SV, and CO values, as well as RPP, along with no significant intergroup differences in SVR. Optimal cardiovascular system characteristics in the form of the lowest HR and DBP values have been revealed in the group of individuals with normal weight. Underweight adolescents have significantly lower SBP, RPP, SV, and CO values. However, it should be noted that no differences in DBP and HR between groups with the weight deficit and normal weight have been revealed. When differentiating the studied groups based on the share of individuals with the high-normal blood pressure (HNBP) and AH based on SBP and SBP, it has been determined that such cardiovascular system abnormalities are most common in overweight adolescents.

DISCUSSION

The findings suggest that the lowest SBP values are typical for underweight adolescent boys, and the corresponding indicator grows in each subsequent group. The lowest DBP values are reported in the group with normal BW, while the highest values are observed in overweight individuals. It is well-known that excess BW and obesity detected in early childhood are likely to be found in adolescence and adulthood [19, 20], which increases the risk of cardiovascular disorders [21], type 2 diabetes mellitus and musculoskeletal disorders [22].

Differentiation of the assessed group by BP [23] showed that the share of individuals with HNBP and AH along with underweight based on SBP was 0% and 4%, while no similar deviations were revealed based on DBP. No individuals with HNBP based on SBP were found among adolescents with normal weight, the share of individuals with HNBP based on DBP was 5%, AH based on SBP was reported in 8% of adolescents, and AH based on DBP was found in 3%.

Table. Main cardiovascular system parameters of adolescents living in the North based on BMI, significance of differences (M ± *m*)

Studied parameters	Assessed groups			Significance of differences		
	Underweight (1)	Normal weight (2)	Overweight (3)	1–2	2–3	1–3
Body length, cm	179.6 ± 0.7	179.0 ± 0.8	178.0 ± 0.7	$p = 0.58$	$p = 0.35$	$p = 0.11$
BW, kg	55.6 ± 0.5	65.4 ± 0.8	86.9 ± 1.3	$p < 0.001$	$p < 0.001$	$p < 0.001$
BMI, kg/m^2	17.2 ± 0.1	20.3 ± 0.8	27.4 ± 0.4	$p < 0.001$	$p < 0.001$	$p < 0.001$
SBP, mmHg	114.9 ± 1.4	118.3 ± 1.1	123.6 ± 1.1	$p < 0.05$	$p < 0.001$	$p < 0.001$
DBP, mmHg	70.4 ± 0.7	68.4 ± 0.9	71.3 ± 0.8	$p = 0.08$	$p < 0.05$	$p = 0.39$
HR, bpm	71.0 ± 1.0	70.8 ± 1.3	75.6 ± 1.1	$p = 0.91$	$p < 0.01$	$p < 0.01$
RPP, AU	81.6 ± 1.4	83.7 ± 1.6	93.7 ± 1.8	$p < 0.05$	$p < 0.001$	$p < 0.001$
SV, mL	71.3 ± 0.7	75.2 ± 0.9	74.6 ± 0.8	$p < 0.001$	$p = 0.62$	$p < 0.01$
CO, mL/min	5025.8 ± 58.0	5286.5 ± 93.5	5654.3 ± 112.1	$p < 0.05$	$p < 0.01$	$p < 0.001$
SVR, dyn · s · cm^{-5}	1433.0±18.9	1403.7 ± 31.4	1372.6 ± 31.6	$p = 0.42$	$p = 0.48$	$p = 0.11$

Among overweight adolescents, HNBP based on DBP was found in 6%, this group had the largest share of subjects with AH (25% based on SBP, 6% based on DBP).

Due to high prevalence, both arterial hypertension and obesity are considered to be a non-communicable pandemic [24]. We have interpreted the total rate of individuals with HNBP and AH based on SBP and DBP as strain on the cardiovascular system, it was 4% in the group of underweight adolescents, 16% in the group with the weight within normal range, 37% in the sample characterized by excess BW.

SV reflects the amount of blood ejected by the ventricles with each contraction and depends on the body's functional state [25]. Our findings show that the highest average SV values are typical for individuals with normal BW and the lowest values have been revealed in underweight individuals.

CO is the most important parameter determining blood flow. Adequate CO values suggest optimal oxygen supply to tissues and organs, which, in turn, is equivalent to cardiovascular health [26]. The highest CO values, being indirect indicators of energy metabolism, are typical for overweight adolescents. In this group high CO values result from higher HR and SV agaist the background of higher SBP relative to other assessed groups. High values of these parameters reflect the consumptive and energy-draining level of the cardiovascular system functioning [27]. The lowest CO values are typical for underweight adolescents.

SVR is a stationary component of cardiovascular system that ensures resistance to permanent blood flow and regulates the pressure gradient between the venous and arterial systems [28, 29]. The data obtained show that there are no intergroup differences in SVR.

RPP characterizes the cardiovascular system functional status and reflects the processes underlying its mechanical activity. It should be noted that RPP ≥ 100 AU is indicative of high heart energy production [30]. The RPP value close to the upper limit of normal range has been revealed in overweight adolescents, which reflect the increased need for myocardium in oxygen. At the same time, significantly lower RPP values have been revealed in the group of underweight individuals, which is indicative of the more energy-conserving and effective cardiovascular system functioning in this group.

Thus, all the assessed samples show the values of cardiovascular system parameters that correspond to normal ranges for these parameters, however, overweight individuals are characterized by strain on the cardiovascular system reflected in significantly higher SBP, HR, CO values. The correlation analysis results provided in Figure are also indicative of strain on the cardiovascular system.

The data obtained by correlation analysis show that BMI has no effect on the cardiovascular system characteristics in the groups of underweight adolescents and adolescents with normal weight. Correlations have been revealed in overweight individuals: DBP and SV increase with increasing BMI. Furthermore, there is a weak negative correlation between BMI and SVR.

CONCLUSIONS

Thus, the findings show strain on the cardiovascular system in the group of overweight adolescents. The increase in strain on the cardiovascular system has been revealed, which is 4% in the group of underweight adolescents, 16% in the group with BW within normal range, 37% in the sample characterized by excess BW. It has been shown that the cardiovascular system of overweight adolescents functions more effectively, which is reflected in significantly higher SBP, HR, SV, and CO values observed against the background of enhanced

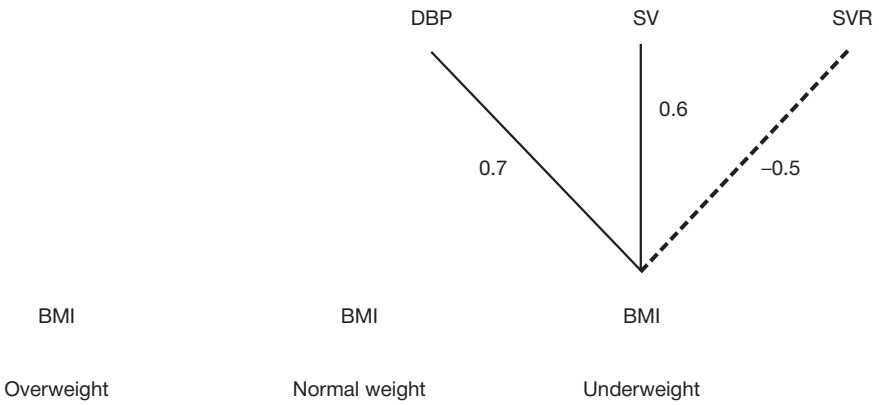

Fig. Correlation analysis of the relationship between body mass index and the major cardiovascular system characteristics

processes underlying mechanical activity of the heart. This is well correlated to the correlation analysis results. The findings can be used to produce the guidelines aimed at managing excess BW in the group of individuals being through the adolescent ontogeny period as a target group for health promotion and applying preventive measures.

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CARBON DIOXIDE: PROBLEMS OF STANDARD SETTING, CONTENT CONTROL AND PREVENTION OF ADVERSE EFFECTS IN EDUCATIONAL INSTITUTIONS

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This article is a review of data published in Russian and foreign studies that reflect current problems concerning content of carbon dioxide in spaces of residential and public buildings, including children's educational organizations. We consider: mechanisms of action of high concentrations of carbon dioxide on the human body, which manifests as acute and delayed disruptions of metabolic processes in circulatory, central and respiratory systems; existing carbon dioxide content measurement methods used for indoor spaces; principles of setting microclimate and air quality standards for temporarily and constantly occupied indoor spaces and the respective parameter control principles. This analytical review revealed the need for standard-setting efforts, development and approval of a methodology enabling measurement of the actual carbon dioxide concentration in children's educational institutions, since routine measures adopted for the purpose lack in effectiveness or realization, which prevents normalization and stabilization of all qualitative and quantitative air parameters at the levels making the environment of a classroom safe and optimal for education-related activities given high occupancy of the space.

Keywords: carbon dioxide, educational organizations, health effects, high concentrations, standard setting problems, prevention

Author contribution: Novikova II — study conceptualization, design, text editing, approval of the final version of the article; Semenikhina MV, Zubtsovskaya NA, Shcheveleva VA, Nazimkin NI — search for and review of publications, fragmentary analytics; Sorokina AV, Lobkis MA — search for and review of publications, article authoring and editing.

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Received: 05.09.2023 **Accepted:** 26.09.2023 **Published online:** 02.12.2023

DOI: 10.24075/rbh.2023.081

УГЛЕКИСЛЫЙ ГАЗ: ПРОБЛЕМЫ НОРМИРОВАНИЯ, КОНТРОЛЯ И ПРОФИЛАКТИКИ НЕБЛАГОПРИЯТНОГО ВОЗДЕЙСТВИЯ В ОБРАЗОВАТЕЛЬНЫХ ОРГАНИЗАЦИЯХ

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В статье представлен обзор литературных данных по российским и зарубежным исследованиям, отражающих современные проблемы, касающиеся содержания углекислого газа в помещениях жилых и общественных зданий, в том числе детских образовательных организаций. Рассмотрены механизмы влияния высоких концентраций двуокиси углерода на организм человека, проявляющиеся острыми и отсроченными негативными эффектами в виде нарушения обменных процессов кровеносной, центральной и дыхательной систем, существующие методы оценки содержания двуокиси углерода в воздухе помещений, а также принципы нормирования и контроля оптимальных параметров микроклимата и качества воздуха в помещениях, предназначенных для временного и постоянного пребывания людей. По результатам аналитического обзора установлена необходимость нормирования, а также разработки и утверждения методики оценки фактических показателей концентрации углекислого газа в детских образовательных организациях в силу неэффективности или невозможности обеспечения достаточного объема режимных мероприятий до нормализации и стабилизации всех качественных и количественных показателей воздушной среды, обеспечивающих оптимальные и безопасные условия воспитания и обучения при высокой ежечасной наполняемости учебных кабинетов.

Ключевые слова: углекислый газ, диоксид углерода, образовательные организации, влияние на здоровье, высокие концентрации, проблемы нормирования, профилактика

Вклад авторов: И. И. Новикова — концепция, дизайн, редактирование текста, утверждение окончательного варианта статьи; М. В. Семенихина, Н. А. Зубцовская, В. А. Щевелева, Н. И. Назимкин — поиск и обзор публикаций, фрагментарная аналитика; А. В. Сорокина, М. А. Лобкис — поиск и обзор публикаций, написание и редактирование текста статьи.

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Статья получена: 05.09.2023 **Статья принята к печати:** 26.09.2023 **Опубликована онлайн:** 02.12.2023

DOI: 10.24075/rbh.2023.081

Carbon dioxide (CO_2) is a metabolic product necessary for human survival. When there is an excessive amount of CO_2 in the air, it can have an adverse effect on the body, and high concentrations are toxic. The actual content of CO_2 in enclosed spaces is an important hygienic indicator of air quality that should be thoroughly studied in the context of development of preventive measures aimed at minimization of health risks. This compound is the key air contamination factor in residential and public spaces, therefore, its action is an actively researched subject, since concentration of CO_2 most often leads to deterioration of a person's wellbeing, as well as acute and delayed adverse effects. Such research efforts are especially important for educational organizations for children, where large number of them stay for a long time, since children and adolescents are most susceptible to adverse environmental influences. It should also be noted that there are no regulations setting standards for CO_2 concentration in Russia, neither for residential nor for public spaces. However, considered from the perspective of prevention of negative effects on students, the matter of setting CO_2 concentration standards for educational institutions, as well as development of a methodology to assess the actual content of CO_2 in rooms intended for children (daycare, educational purposes), requires careful attention.

This study aimed to examine Russian and foreign scientific publications covering problems of exposure to carbon dioxide, principles of setting respective standards, feasibility of indoor air quality monitoring, measures designed to ensure conformity to hygienic requirements in terms of air.

We searched various electronic databases (E-library, PubMed, Cyberleninka) for scientific publications covering problems of CO_2 content in residential and public spaces, principles of setting CO_2 content standards, respective effects on health and prevention methods. Over 100 works by foreign and domestic authors, most of them published from 2004 to 2023, and regulatory materials were analyzed. The key research method utilized for the study was analytical.

For a long time, CO_2 was believed to be the final product of metabolism that has negative effect on the body, but from the 2nd half of the 19th century, it is considered a metabolic product necessary for vital activity [1, 2]. The optimal composition of breathing air for human beings is 21.5% oxygen and 0.03–0.04% CO_2, with the remaining volume filled by nitrogen, the most common element on Earth. Such composition underpins normal metabolism [3, 4]. Authors of the monograph [2] cite the study [5] pointing out that both gas molecules (CO_2, reactive oxygen species (ROS) and nitric oxide) and their derivatives of radical and non-radical nature, which model all neuroendocrine and metabolic processes in the body, participate in the unified physico-chemical regulation of biological processes. Carbon dioxide, unlike nitric oxide (NO) and ROS, does not produce a pathological and cytotoxic effect. Relying on the experimental data, the authors hypothesized that CO_2 plays a protective part, inhibiting ROS and regulating free radical homeostasis in the body.

Studies of the recent decades confirm that human body needs CO_2. Partial pressure of carbon dioxide (pCO_2) is an indicator that reflects the effect on cerebral cortex, respiratory and vasomotor centers; it is used to assess the content of CO_2 in the body. The compound regulates the tone of blood vessels, bronchi, metabolism, hormone secretion and blood electrolytes. Indirectly, it affects enzymatic activity and the rate of biochemical reactions in the body. Oxygen concentration fluctuations, e.g., drop to 15.0% or growth to 80%, do not have a significant effect on the body, while a 0.1% change in CO_2 concentration causes considerable adverse changes, which indicates the greater importance of CO_2 for the body [3].

However, inhaling too much CO_2 leads to pathological changes [6]. In the international classification, CO_2 is an asphyxiating gas (hazard class IV), same as with ammonia. Concentration of CO_2 in the atmospheric air started increasing as industrial revolution developed: it boosted anthropogenic nitrogen dioxide emissions and disrupted the carbon cycle, which is undoubtedly one of the most important factors affecting people's lives and health, and the situation is gradually deteriorating, since the problems of carbon dioxide level regulation remaining unsolved [7]. CO_2 is a greenhouse gas, and reduction of its emissions to atmosphere is an environmental policy priority for a country that signed the Kyoto Protocol. In a human body, this gas affects cardiovascular and respiratory systems, causing drowsiness, nausea, weakness, loss of consciousness when accumulated to a high concentration. Therefore, it is important to understand the trends of industrial atmospheric emissions, because CO_2 is the main component thereof in many regions [8]. Studies investigating the greenhouse effect of CO_2 have uncovered its effect on human genetic activity, which means it affects health in general. The respective mechanism relies on the "greenhouse effect" with involvement of membranes of certain skin cells [9].

Arterial blood CO_2 concentration is an important indicator reflecting the state of blood supply to body tissues, which means it is connected to the human body's adaptive potential [10], and, controlled, can help improve bodily functions in general [11]. In the body, CO_2 is part of chemical compounds (carbonic acid, carbonates, bicarbonates) and carbohemoglobin. The content of CO_2 in the blood depends on its partial pressure, which reflects the balance between the amount of carbon dioxide formed and the amount of CO_2 released by the lungs. The normal level (normocapnia) of CO_2 in the blood is pCO_2 40 mm Hg for arterial blood and 47 mm Hg for venous blood. High pCO_2 causes hypercapnia (gas acidosis), excessive release of CO_2 and low pCO_2 in arterial blood — hypocapnia (gas alkalosis) [12]. It is the increased CO_2 content in the atmospheric air (more than 7.6 mm Hg) that can up the amount of CO_2 in the lung alveoli and arterial blood above physiological thresholds (over 40 mm Hg and over 46-49 mm Hg, respectively), turning the vital gas toxic to the body [13].

Clinical signs of CO_2 toxicity in a hypercapnia case are shortness of breath at rest, nausea, vomiting, headache, dizziness, mucous membranes and facial skin cyanosis, severe sweating, visual impairment [2]. When CO_2 concentration goes up by no more than 2%, the body reacts on the part of cardiovascular (first tachycardia, then bradycardia) and central nervous systems, with nerve endings excitability growing up and then down. If CO_2 concentration increases to 5–6%, brain suffers inhibition of electrical activity [14]. Carbon dioxide concentration above 10–12% leads to rapid loss of consciousness and death [15].

CO_2 is acknowledged as the indicator of quality of air (content of harmful substances therein) in office spaces, catering facilities, banquet halls and auditoriums, medical institutions, classrooms, preschool spaces, transport, etc. The established optimal carbon dioxide level for such spaces is that which is closest to CO_2 concentration in the atmospheric air [16]. Until recently, this indicator was the only one used to assess quality of air in non-industrial enclosed environments, since it was assumed that there is a direct correlation between CO_2 content in an occupied room and the level of chemical and bacterial contamination [17, 18].

Numerous studies confirm that CO_2 is the most important indicator of air quality, since it is the main pollutant indoors, even given many other contaminating elements and compounds [19–25]. When a large number of people occupy a room for a long time, the concentration of carbon dioxide in that room grows rapidly, and if ventilation there is inefficient or impossible, the environment acquires qualities harmful for well-being and health. It was also found that the quality of air in a space deteriorates proportionally to the number of persons and the time of their stay therein [26].

The matter of hygienic assessment of CO_2 content and its impact on health has attracted attention both in Russia and abroad, where the interest towards the subject is further advanced because of the growing number of so-called "sick buildings" (Sick Building Syndrome) [27].

The concentration of CO_2 is measured in ppm, parts per million or *pro pro mille*. Essentially, it is a cubic centimeter of carbon dioxide per cubic meter of air (cm^3/m^3). However, some Russian and foreign studies, as well as regulatory documentation, provide CO_2 content in mg/m^3 or percentages. The relationship between these units of measurement should be clarified on the example of normal conditional concentration of CO_2 in atmospheric air. Thus, 400 ppm (or 400 $million^{-1}$) means that 1 m^3 of air contains 400 cm^3 of CO_2, or 0.04%, since 1 ppm = 0.0001%. At the same time, conversion

from mg/m^3 requires a more complex formula that factors in molecular weight of the gas, gas mixture pressure and temperature. Conventionally, the content of CO_2 in 1 mg/m^3 equals approximately 0.510725 cm^3/m^3.

Russian studies have shown that well-being begins to deteriorate at the concentration of 1000 ppm: people start complaining of stuffiness, general discomfort, weakness, headache, poor attention capacity. Additionally, the frequency and depth of breathing grow up, bronchi narrow, and at concentrations above 15% glottis spasms. A long stay in a room with excessive amount of CO_2 alters condition of the circulatory, central nervous, respiratory systems, perception, operative memory, and attention distribution [3, 20, 22].

The content of carbon dioxide in bedroom air affects how well people sleep therein, and some researchers believe the quality of air is more important for a good sleep than the quantitative indicators [28]. Studies show that increased CO_2 content in a room's air translates into more complaints of rapid fatigue, which manifests as hindered attention concentration ability, drowsiness, headache [29, 30]. The key effect of carbon dioxide on a body is the arrest of blood's ability to absorb oxygen. The degree of poisoning with this compound depends on the time of exposure and its concentration in the atmospheric air [31].

According to the research done by the domestic scientist, concentration of CO_2 in a room should not exceed 1000 ppm, regardless of the source of the compound (for example, plants emit CO_2 at night). Using a special research methodology, the author concluded that short-term inhalation of CO_2 by healthy people at concentrations of 500 and 1000 ppm causes certain shifts in external respiration function, blood circulation and electrical activity of the brain [32]. Studies have shown that air in a residential or public space may be considered safe when the level of CO_2 therein is 1000 ppm (0.1%) [20]. This is the concentration recommended for indoor air in most foreign countries.

Another research has shown that when the content of CO_2 in the air is at 2–2.5%, people in the respective space suffer no noticeable alterations of well-being and ability to work [33]. Concentration of 4–5% causes shortness of breath, boosted cardiac activity; there is a direct link between CO_2 content and ability of a person to work. CO_2 at 6% impairs mental activity significantly, triggers headaches and temporary insanity. When the concentration of CO_2 grows up to 7%, people become physically unable to control their actions, faint, in some — die. If carbon dioxide content reaches 10%, death is the outcome that occurs quickly, and at 15% — instantly, because of respiratory paralysis.

Increasing partial pressure of CO_2 in human alveoli causes functional disruptions. Carbon dioxide becomes more soluble in the blood, which yields a weak carbonic acid ($CO_2 + H_2O = H_2CO_3$) that subsequently decomposes into H^+ and HCO_3^-. The first sign of acidosis is a poor perception of new information. The higher the concentration of CO_2 in the air breathed by a person, the lower his/her blood pH and the more acidic it is. People who spend a lot of time in spaces with high CO_2 levels are 3.5 times more likely to have dry cough and twice as likely to have rhinitis [33]. This is consistent with earlier studies reporting that if the concentration of carbon dioxide in a room exceeds 500 ppm, pH of the blood of people therein may decrease [34], and prolonged exposure to CO_2 concentrations of 0.5–1% can lead to increased calcium deposition in body tissues, including kidneys [35].

Studies conducted by Belarusian scientists point to a correlation between poor ability to work and increased CO_2content in the air. When it approaches 1%, a person's motor reaction time goes up, and the accuracy of tracking reaction deteriorates; at 1.5–2%, there appear qualitative changes in mental activity, disruptions of functions of differentiation, perception, operative memory, and attention distribution. Longer periods of work while exposed to air with 3% CO_2 content translate into pronounced disorders of thinking ability, memory, fine motor coordination, hearing, vision, and the number of typos and errors goes up sharply [14].

Investigation of effect of conditionally permissible concentrations of CO_2 in the air yielded quite interesting data. According to foreign studies, carbon dioxide content above 600–800 ppm causes 30% deterioration of attention, above 1500 ppm — fatigue (reported by 79% of participants of the respective study), above 1000 ppm — headaches in 97% of people suffering migraines [36]. Prolonged exposure air with high concentration of carbon dioxide can be considered a risk factor leading to development of chronic fatigue syndrome, more frequent upper airway disorder cases [20, 37]. Finnish researchers staged an experiment in an office space and learned that symptoms like eye inflammation, nasal congestion, inflammation of the nasopharynx, problems with respiratory system, headache, fatigue, and impaired ability to concentrate, all of which are associated with high CO_2 levels, ceased to manifest acutely when the concentration of carbon dioxide dropped below 800 ppm (0.08% vol.) [38].

Exposure to air with CO_2 at 2000 or 4000 ppm induced inflammatory reactions in neutrophils *ex vivo* (human and mice) and *in vivo* (mice), caused vascular damage in muscle tissues, brain and distal colon, which persisted for 13 hours after two hours of exposure. Exposure to a concentration of 1000 ppm caused inflammatory reactions *ex vivo*, but not *in vivo*. In addition, mice exposed to air with CO_2 at 5000 ppm could exhibit increased inflammation in the bronchial epithelium [39], and people exposed to air with 3000 ppm of carbon dioxide — mild inflammation in the nasal cavity [40]. A randomized double-blind controlled experimental study showed that 8-hour (working day) exposure to air with increased content of CO_2 adversely affects cognitive performance of people. The experiment considered three concentrations, 550, 945 and 1400 ppm, in an office environment; compared to 550 ppm, 945 ppm slowed cognitive performance by 15%, 1400 ppm — by 50%. On average, the participants' indicators decreased by 21% as concentration of carbon dioxide increased by 400 ppm [41].

Recently, researchers started investigating the effects of stay in spaces of educational organizations occupied by many students simultaneously and, therefore, presenting certain risk factors. The problem is urgent because elements and compounds from indoor air shape the hazard index more actively than those found in atmospheric air. This necessitates reinforcement of measures aimed at supervision and control of the sources of chemical toxicants, as well as at ensuring conformity with the standardized aeration patterns and room occupancy limits [42].

For spaces of educational organizations, the level of CO_2 considered optimal is 800–1000 ppm. The threshold is set at 1400 ppm. If there is more carbon dioxide in the air, its quality is considered to be low, because more CO_2 means deterioration of the ability to concentrate and process the study-related workload. However, several studies exploring the subject point that the said threshold should be moved down to 1000 ppm. The data reported therein indicate that at that concentration, over half of the participants feel the effects of poor microclimate: their pulse speeds up, they suffer headache, fatigue, and they complain of having "nothing to breathe" [14].

Another study models carbon dioxide concentration fluctuations depending on the number of students in the room, its volume and ventilation capacities. It was established that by the end of classes, the content of CO_2 in the respective space reaches 2500 ppm, which is unacceptable. If the room is small (up to 200 m^3, for 25–30 people), growing CO_2 concentration also brings up the air temperature to 27 °C and alters air humidity to 30.0–40.0% [43].

One experiment set up in an educational establishment has shown for more than half of school hours, the amount of CO_2 in the air exceeds 1300 ppm, and sometimes approaches 2500 ppm. It is impossible to concentrate in such environment; a person's ability to perceive information is disrupted critically. Other symptoms likely to manifest when the content of CO_2 in the air is excessive are hyperventilation, sweating, eye inflammation, nasal congestion, and difficult breathing [44].

Another group of researchers investigated carbon dioxide concentrations in standard and non-standard gyms under different hygienic conditions. They analyzed changes in the general well-being of students before, during and after physical activity in spaces with normal and elevated concentrations of CO_2. Results: increase of content of carbon dioxide adversely affects students' abilities, their concentration, coordination abilities and general well-being. There is a clear correlation between CO_2 concentration and well-being, performance and effectiveness of students during physical activity [45]. A study [46] uncovered that by the end of classes, carbon dioxide content in gyms grows up by 1.5–3, which indicates unsatisfactory operation of their ventilation systems.

The available studies demonstrate the importance of regulation of CO_2 content and the tasks of indoor air quality assessment and monitoring. This is especially relevant for organization providing educational services, where children stay for a long time, exposed to various chemicals contained in the air, with CO_2 being the main among them. In Russian Federation, there is an Interstate Standard [47] that sets out general requirements for optimal and acceptable conditions of microclimate in occupied portions of residential, preschool, public, administrative and household buildings. This Standard regulates indoor air quality, which depends on the CO_2 percentage. The Standard prescribes air of quality class 1 for children's institutions, hospitals and polyclinics, and for residential and public spaces, air quality indicators may be accepted as per the design assignment that factors in pollution of outdoor air, which is the source of contamination of indoor air.

In addition to the Interstate Standard, regulations for residential and public spaces are contained in the National Standard [48] based on the 2004 European indoor air quality standard for occupied spaces [49]. Under the National Standard [48], air quality depends on the level of ventilation (air exchange rate), which ensures acceptable CO_2 values. European Standard [49] allows indoor air quality to differ from that of outdoor air by 350 ppm CO_2 only, but the overall CO_2 content therein should not exceed 1000 ppm. In Russia, the level of CO_2 is not measured, therefore, there are no baseline values to calculate the volumes of air that a room needs from this point of view.

Hygienic regulations covering microclimate in educational establishments prescribe values for three quantitative indicators only: temperature, relative humidity and air velocity. The respective documents are 2020 Sanitary Rules [50] and 2021 Sanitary Rules and Regulations [51]. As for the quality of air in educational establishments, the Rules state that "concentration of contaminants in excess of the thresholds stipulated by the regulations is forbidden" [50]. The list of atmospheric pollutants set out in the hygienic standards [51] does not include CO_2. However, there are threshold values limiting concentration of CO_2 in the air of working spaces. Carbon dioxide, a gaseous chemical, is on the list of contaminants (№ 2124), and international hazard classification puts CO_2 in the same hazard class IV as ammonia (asphyxiating gas) [51]. At the same time, the maximum permissible concentration (MPC) of CO_2 in the working space air is 27000 mg/m^3 (13,790 ppm or cm^3/m^3), and the average daily (per-shift) MPC of CO_2 is 9000 mg/m^3 (4597 ppm or cm^3/m^3) [51]. For comparison, excerpt from the US Occupational Safety and Health Standards [52]: "...toxic and dangerous substances, air pollutant limit values: carbon dioxide permissible exposure limit (PEL, baseline 8-hour time weighted average (TWA)) is 5000 ppm; short-term exposure limit (STEL) — 30,000 ppm..." In other units of measurement, 30,000 ppm is 58,740 mg/m^3, which is a STEL twice as big as required in the Russian regulations, and 5000 ppm is 9790 mg/m^3, which is a TWA almost equivalent to the Russian per-shift concentration of CO_2.

In Russia, such concentrations were first established by Hygienic Standards in 2006 [53]. In the USSR, the first scientific justification of CO_2 MPC was study [54], which investigated the effect of concentrations of 1000 ppm (0.1%) and 5000 ppm (0.5%) in residential and public spaces.

However, in the world, the important problem is that of ensuring high quality of the environment in school buildings, since there are no legally binding limit values setting thresholds for most indoor air pollutants [55]. In Finland, the CO_2 MPC in an occupied space under normal weather conditions is 1200 ppm. The Norwegian and Swedish standards covering residential buildings, schools and offices set the maximum for CO_2 concentration at 1000 ppm. Japan, Portugal, Korea, France, Denmark have also taken 1000 ppm as upper limit for specified spaces, including schools and office buildings. Standards and guidelines regulating CO_2 content in residential, school and office buildings were summarized in a single document as part of the air carbon dioxide content assessment by the ANSES, French National Health and Safety Agency [56, 57]. In Germany, the accepted CO_2 concentration is 0.15%, or 1500 ppm, which is a hygienic guideline value. Such values were also published by the Indoor Air Hygiene Commission of the Federal Ministry of Environment and the State Health Agency [58].

The various methods and guidelines for design and evaluation of indoor air quality and thermal comfort in school buildings are outlined in the European Standard [59], the British Building Bulletin [60] and the ANSI Standard [61]. European Standard gives input parameters for indoor environment to be factored in the design and assessment of energy efficiency of buildings; these parameters account for various indoor environment quality aspects. In this document, the calculated CO_2 concentrations are grouped in four categories by the expected percentage of those dissatisfied with air quality (the lower the category, the lower the expected share of dissatisfied people, with the minimum at 15% and maximum at 40%). Thus, the upper threshold for the 1st category is 550 ppm, 2nd category — 800 ppm, 4th category — 1350 ppm. The normal level is that of category 2. A lower level may be chosen for students with special needs. A higher level does not pose a health hazard, but may make the space less comfortable.

The British Building Bulletin [60] sets rules, standards and recommendations concerning ventilation, thermal comfort and indoor air quality for school buildings. In case of classrooms, the bulletin sets different indoor air quality requirements for different ventilation strategies. Mechanical systems and hybrid systems

used in mechanical mode should let in sufficient amount of outdoor air to have the average daily CO_2 concentration less than 1000 ppm during the working period. In addition, maximum concentration should also not exceed 1500 ppm for more than 20 minutes running, every day during the working period. Natural ventilation and mixed systems incorporating natural ventilation should ensure the average daily CO_2 concentration of 1500 ppm when the space is occupied, and the maximum concentration should not exceed 2000 ppm for more than 20 minutes running in a day.

The limit CO_2 content value was removed from the ANSI standard [61] in 1989, a deliberate omission (previously used value — 1000 ppm) allowing to downplay the importance of this indicator in the overall indoor air quality assessment, while this concentration is at best an indicator of the outdoor air intake rate per person. Comparison of ANSI standard [61] and European Standard [59] shows that the current minimum ventilation rate for classrooms as per the ANSI regulations is half the threshold value of the European Standard (5 instead of 10 l/s per person). On the other hand, the no longer used value of 1000 ppm will be approximately equivalent to the 1st category of the European Standard (950 ppm, with outdoor CO_2 concentration of 400 ppm).

A comparative assessment of air quality in schools of South Tyrol (Italy), which referenced different standards, showed comparable, but not identical results. The study revealed that when a class is not aerated throughout the lesson, CO_2 levels can exceed 2000 ppm or even 3000 ppm. The threshold of 1000 ppm is reached after 13–18 minutes without active ventilation, and the value of 1500 ppm may be exceeded after 23–35 minutes if there is no aeration. Carbon dioxide concentrations measured in classrooms were below 1000 ppm most of the time; the threshold of 2000 ppm was exceeded rarely (0–2%), which indicates that these spaces were aerated at least once per lesson [62].

Currently, there are several methods of determining the level of CO_2 in the air practiced in Russia. The M. Pettenkofer's method, suggested in the 19th century, is an indirect integral sanitary indicator of air purity, which is mentioned in the National Standard of the Russian Federation [63]. For several decades now, the value has been used as a baseline of satisfactory air quality in an enclosed space, and in the context of designing air conditioning and ventilation systems, as per the current edition of the European [64] and National Standards [65], which establish technical requirements for ventilation and air conditioning systems.

Volumetric methods used to measure CO_2 content: Holden, Kudryavtsev, Kalmykov gas analyzers; Subbotin-Nagorsky and Hess titrometric methods; the comparative Prokhorov method [66]. For express assessment, the methods are: a) D.V. Prokhorov's method that involves comparative assessment of indoor air and outdoor air that has CO_2 at 0.03–0.04% (300–400 ppm or cm^3/m^3); b) reaction of carbon dioxide with a soda and phenolphthalein solution, which is applicable even in school laboratories. The main current approved methods have been developed in accordance with the National Standard [63], which is identical to the International Standard [67]. These standards outline the key provisions regulating measurements of carbon dioxide content in the air of enclosed spaces.

GANK-4 gas analyzers, used as prescribed in the operating manual [68], enable direct measurements of concentration of chemicals and deduction of quantitative values from their content in the atmospheric air, working area air, enclosed and residential spaces, industrial emissions, vented emissions and technological processes. The data acquired are used in the context of environment protection, occupational safety, technological processes optimization measures. GANK-4FEx stationary gas analyzer is used to measure concentration of carbon dioxide under the certain current certified measurement methods and operational documentation of the unit. As per Federal Law of the Russian Federation № 102 of 26.06.2020 "On ensuring uniformity of measurements" [69], all measurement methods used in situations regulated by the state should be applied in accordance with the procedure established in the respective certification documentation.

The need for standards regulating carbon dioxide concentrations in educational establishments arises from inefficiency of ventilation or impossibility to aerate duly in order to normalize and stabilize all microclimate parameters to their optimal values in enclosed classrooms with high hourly occupancy (for example, when the break between lessons is not enough for this purpose, and aerating a room when there are children in it is prohibited [50]). Another factor contributing to the urgency of CO_2 concentration problem is the widespread replacement of wooden window frames with plastic windows, which turn classrooms into sealed chambers that, with an imperfect air exchange system, promote growth of concentration of CO_2 [70, 71].

Carbon dioxide content measurement and control in enclosed spaces will minimize the risks of its adverse effects on the body. In this connection, much attention has been paid recently to the development of systems enabling automated registration and analysis of carbon dioxide indicators in indoor air with their further centralized processing [72]. This is especially important for educational organizations, as allows timely detection of CO_2 level and subsequent appropriate remedial measures. Installing temperature, relative humidity and CO_2 concentration measurement systems in spaces with forced ventilation ensures conformity of the gas-air environment therein with sanitary standards and rules. This goal is achieved through upgrading forced ventilation systems with automatic start-up devices that launch them when the concentration of CO_2 exceeds the optimal level (1200 ppm (0.12%)) [73].

An important prevention measure is installation of plenum ventilation, which can steadily reduce the level of CO_2 and thus mitigate its harmful effects on health, and installation of sensors to monitor the concentration of CO_2. It should be noted here that ventilation systems designs are driven by the air exchange standards. In Russia, the standard minimum air exchange rate is 30 m^3/h (in Europe — 72 m^3/h); it does not depend on the area and volume of the room, only on the "breathing rate" and the volume of ventilation. Thus, when the occupants of the room are a state of calm wakefulness, the concentration of CO_2 will increase to 1000 ppm, and when they practice physical activity, it will exceed the threshold. Thus, the air exchange rate of 30 m^3/h, adopted through the Russian regulations, does not ensure comfortable indoor environment. Moreover, as suggested in the CO_2 control recommendations, its optimal concentration in a room requires increase of the air exchange rate: to have carbon dioxide at 1000 ppm, the rate should be 33 m^3/h, at 500 ppm — 200 m^3/h [3].

With the constant growth of CO_2 content in the atmosphere of cities, maintaining a safe and comfortable level of this compound in an enclosed space using ventilation systems is more energy-consuming if there are no systems removing it therefrom. Currently, it becomes widely recognized that the most effective way is to purify the air in occupied rooms with the help of devices absorbing indoor air pollutants. The right combination of such purifiers and a reasonable ventilation system can give a very good result along with better energy

efficiency, as provided by developments described in the scientific publications of recent years [74–80].

CONCLUSION

The analysis of studies published both in Russia and abroad confirms that there is a significant interest in the problem of CO_2 content, substantiated by the rapid increase of its concentration in indoor air. Numerous authors focus on investigation of the influence of various concentrations of indoor air CO_2 on the people's functional state and health, and the results of this investigation indicate that even small deviations from the recommended (in particular, for educational and preschool establishments) permissible concentrations cause adverse changes in individual body systems, with acute and delayed negative effect on the general well-being of students, as well as deterioration of their performance and mental activity, increased fatigue and low resistance to infectious and non-infectious agents, and more frequent upper airways diseases. The analytical review emphasizes the need to study the issue of setting standards for the actual CO_2 content while perceiving the compound as one of the risk factors peculiar to school and preschool environments. Another highlighted problem is that of development and approval of a methodological framework enabling monitoring and control over this indicator with the ultimate goal of preventing the negative effects.

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HEALTH STATUS OF CHILDREN AND ADOLESCENTS IN THE FAR EASTERN FEDERAL DISTRICT

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It is well-known that investigation of the features of incidence among children and adolescents in certain human environment aimed at identification of promising prevention vectors in the region is a priority in the development of healthcare system and the state's social policy. The study was aimed to explore the regional features of the pediatric population health in the regions of the Far Eastern Federal District (FEFD). A retrospective analytical study was conducted; the values and structure of incidence in children and adolescents in 11 FEFD regions were assessed. It was found that classes X (Diseases of the respiratory system) and XIX (Injury, poisoning and certain other consequences of external causes) occupied the leading places in the structure of the long-term average annual incidence by disease classes in FEFD among children aged 0–14 and adolescents aged 15–17. The lowest incidence was reported for class III (Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism). Significant differences in the long-term average annual levels of the studied indicator between age groups in FEFD and significant differences from the all-Russian values were revealed. The findings can be used to predict the health status of the younger generation and determine the strategic direction of healthcare system in the macroregion.

Keywords: children, adolescents, population health, incidence, structure, prevalence

Author contribution: Gritsina OP, Pozdeeva ES, Trankovskaya LV — study concept and design; Gritsina OP, Yatsenko AK, Zmitrovich PA, Izbaskhanova VE — data acquisition and processing; Gritsina OP, Bodraya IS — statistical processing; Gritsina OP, Yatsenko AK, Pozdeeva ES — manuscript writing; Gritsina OP, Yatsenko AK, Trankovskaya LV — editing.

Compliance with ethical standards: the study methodology was compiled in accordance with the guidelines of Good Clinical Practice of the Russian Federation and the World Medical Association Declaration of Helsinki, it was approved at the meeting of the Ethics Committee of the Pacific State Medical University (protocol № 7 of 27 March 2023). The study involved public statistics; the research design did not envisage inclusion of personal data.

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Received: 18.07.2023 **Accepted:** 09.08.2023 **Published online:** 07.12.2023

DOI: 10.24075/rbh.2023.082

СОСТОЯНИЕ ЗДОРОВЬЯ ДЕТЕЙ И ПОДРОСТКОВ ДАЛЬНЕВОСТОЧНОГО ФЕДЕРАЛЬНОГО ОКРУГА

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Как известно, одним из приоритетных направлений развития системы здравоохранения и социальной политики государства является изучение специфики первичной заболеваемости детей и подростков в определенной среде обитания человека с целью идентификации перспективных векторов профилактики в регионе. Целью работы было исследовать региональные особенности популяционного здоровья детского населения в субъектах Дальневосточного федерального округа (ДФО). Выполнено ретроспективное аналитическое исследование, изучены уровень и структура показателей первичной заболеваемости детского и подросткового населения в 11 субъектах ДФО. Установлено, что в структуре среднемноголетней первичной заболеваемости по классам болезней в ДФО среди детей 0–14 лет и подростков 15–17 лет лидирующие позиции занимали классы X («Болезни органов дыхания») и XIX («Травмы, отравления и некоторые другие последствия воздействия внешних причин»). Наименьшую первичную заболеваемость регистрировали по классу III («Болезни крови, кроветворных органов и отдельные нарушения, вовлекающие иммунный механизм»). Установлены значимые различия среднемноголетних уровней анализируемых показателей между возрастными группами в ДФО и значимые отличия от общероссийских показателей. Полученные данные могут быть применены для прогнозирования состояния здоровья подрастающего поколения и определения стратегического направления развития системы здравоохранения в макрорегионе.

Ключевые слова: дети, подростки, популяционное здоровье, первичная заболеваемость, структура, распространенность

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Соблюдение этических стандартов: методология исследования была составлена в соответствии с «Правилами клинической практики в Российской Федерации» и Хельсинкской декларацией Всемирной медицинской ассоциации и утверждена на заседании Междисциплинарного комитета по этике ФГБОУ ВО ТГМУ Минздрава России (протокол № 7 от 27 марта 2023 г.). Исследование предполагало использование открытых статистических данных, дизайн исследования не предусматривал включение персональных данных.

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Статья получена: 18.07.2023 **Статья принята к печати:** 09.08.2023 **Опубликована онлайн:** 07.12.2023

DOI: 10.24075/rbh.2023.082

Public health, by which we mean the state of absolute biological and mental well-being associated with the balance of the vital process functioning and the components of the sub-State entities, is the most important indicator of the modern society living standards [1, 2]. Health preservation is relevant throughout human life, however, the fundamental basis of physical well-being, active longevity, and intellectual potential is provided in childhood [3, 4].

In the recent decades, both deterioration and stabilization of health indicators of the younger generation was observed globally, however, improvement was reported for some areas [1, 5]. At the same time, pediatric morbidity depends on the socio-economic and ecological-geographical characteristics, as well as on the sanitary and epidemiological condition of educational institutions and the level of medial care in each region of the country [2, 3, 6, 7]. Thus, investigation

of the features of incidence among children and adolescents in certain human environment aimed at identification of promising prevention vectors in the region is a priority in the development of healthcare system and the state's social policy.

The study was aimed to explore the regional features of the population health of children in the regions of the Far Eastern Federal District (FEFD).

METHODS

We conducted a retrospective analytical study based on assessing the data provided by the Federal State Statistics Service and its territorial bodies. The long-term average annual incidence in pediatric (under the age of 14) and adolescent (15–17 years) populations, the first diagnosed cases, by the disease classes per 1000 people was assessed as a criterion to estimate health status. The incidence among children and adolescents in 11 regions of FEFD was studied. The indicator values and structure were subject to analysis. The disease classes I–IV, VI–XIV, XVII, XIX according to the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) for the period 2013–2020 were considered.

Statistical data processing involved comparative analysis of the long-term average annual incidence in FEFD and the Russian Federation in general, as well as comparison of the studied age groups in the macroregion and comparison with the all-Russian indicators (mean value for the assessed period (M) and error of the mean (m_p) were calculated) using Student's *t*-test. The data were considered significant at $p < 0.05$; the criterion values and appropriate significance levels were reported [8]. The Statistica 10.0 software package (StatSoft; USA) was used to perform statistical calculations.

RESULTS

The leading places in the structure of the long-term average annual incidence among children and adolescents by desease classes in FEFD were occupied by classes X (Diseases of the respiratory system) and XIX (Injury, poisoning and certain other consequences of external causes). Third place in children aged 0–14 years went to class XI (Diseases of the digestive system), while in adolescents it went to class XII (Diseases of the skin and subcutaneous tissue). The lowest incidence levels in children under the age of 14 were reported for classes III (Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism), IX (Diseases of the circulatory system), II (Neoplasms) (ranked 13, 14, 15, respectively); in adolescents, 13th place was occupied by the same item, 14th place went to class II (Neoplasms), 15th one went to class XVII (Congenital malformations, deformations and chromosomal abnormalities), while class IX (Diseases of the circulatory system) moved to the 12th place (Table 1).

Such ranking of incidence by the disease classes in the macroregion was generally similar to the all-Russian ranking, however, there were some differences. Thus, in children aged 0–14 in Russia, class XII (Diseases of the skin and subcutaneous tissue) occupied third place, class XI (Diseases of the digestive system) ranked fifth, 13th place was occupied by class XVII (Congenital malformations, deformations and chromosomal abnormalities), class III (Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism) ranked 12th. Distribution of the leading places and positions, for which the lowest incidence was reported, in adolescents aged 15–17 in FEFD and Russia was the same (Table 1).

Variability of the ranking positions distribution in the structure of the long-term average annual incidence by the disease classes were reported in the FEFD regions. It was found that class X (Diseases of the respiratory system) ranked first in both age groups in all the regions. In pediatric population, the second place was occupied by classes I (Certain infectious and parasitic diseases) in the Jewish Autonomous Region, XI (Diseases of the digestive system) in the Republics of Buryatia and Sakha (Yakutia), Trans-Baikal Territory, Amur and Sakhalin regions, XIX (Injury, poisoning and certain other consequences of external causes) in the Kamchatka, Primorsky and Khabarovsk Territories, Magadan region and Chukotka Autonomous Okrug. In individuals aged 15–17 of all regions, the second place was occupied by class XIX (Injury, poisoning and certain other consequences of external causes); only in the Sakhalin region this disease class ranked fourth, and the second place was occupied by class XI (Diseases of the digestive system). The third ranking position in children aged 0–14 was occupied by classes I (Certain infectious and parasitic diseases) in the Republic of Buryatia, Primorsky and Khabarovsk Territories, Magadan and Sakhalin regions, XII (Diseases of the skin and subcutaneous tissue) in the Kamchatka Territory and Jewish Autonomous Region, XIX (Injury, poisoning and certain other consequences of external causes) in the Republic of Sakha (Yakutia), Trans-Baikal Territory, Amur region. In adolescents aged 15–17, third place was occupied by classes VII (Diseases of the eye and adnexa) in the Magadan region and Chukotka Autonomous Okrug, XI (Diseases of the digestive system) in the Republics of Buryatia and Sakha (Yakutia), Trans-Baikal Territory and the Amur region, XII (Diseases of the skin and subcutaneous tissue) in the Kamchatka, Primorsky and Khabarovsk Territories, Sakhalin region and Jewish Autonomous Region.

The lowest long-term average annual incidence among children and adolescents in the FEFD regions for the assessed period was reported for classes II (Neoplasms), III (Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism), IV (Endocrine, nutritional and metabolic diseases), IX (Diseases of the circulatory system), XVII (Congenital malformations, deformations and chromosomal abnormalities). At the same time, variability of incidence for the listed above disease classes in both studied groups was reported in the FEFD regions. In children aged 0–14, class II (Neoplasms) ranked 13th in the Sakhalin region and the Chukotka Autonomous Okrug, 14th in the Republic of Sakha (Yakutia), Kamchatka and Primorsky Territories, and 15th in other regions of the macroregion. Class III (Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism) ranked 13th in the Republic of Sakha (Yakutia), Kamchatka, Primorsky and Khabarovsk Territories, Amur region and Jewish Autonomous Region and 14th in the Magadan and Sakhalin regions. Class IV (Endocrine, nutritional and metabolic diseases) ranked 14th in the Jewish Autonomous Region and Chukotka Autonomous Okrug. Class IX (Diseases of the circulatory system) occupied the 13th ranking position in the Magadan region, 14th position in the Republic of Buryatia, Trans-Baikal and Khabarovsk Territories, Amur region, and 15th position in the Republic of Sakha (Yakutia), Kamchatka and Primorsky Territories, Sakhalin region. Class XVII (Congenital malformations, deformations and chromosomal abnormalities) ranked 13th in the Republic of Buryatia and Trans-Baikal Territory, 15th in the Chukotka Autonomous Okrug. In the population of adolescents aged 15–17 of the FEFD regions, the last ranking positions were occupied by classes II (Neoplasms), III (Diseases of the blood and blood-forming organs and certain disorders involving the immune

Table 1. Long-term average annual values, ranking and comparative characteristics of incidence among children and adolescents by major disease classes

Disease class according to ICD-10	Long-term average annual values and comparative characteristics of incidence among children and adolescents by major disease classes						Comparative characteristics of incidence in appropriate age groups in FEFD and Russia	
	FEFD			Russia				
	0–14 years, M ± m_p (rank)	15–17 years, M ± m_p (rank)	*t*; *p*	0–14 years, M ± m_p (rank)	15–17 years, M ± m_p (rank)	*t*; *p*	0–14 years, *t*; *p*	15–17 years, *t*; *p*
I. Certain infectious and parasitic diseases	72.22 ± 10.56 (5)	40.86 ± 2.75 (8)	2.87; 0.004*	70.26 ± 3.37 (4)	34.29 ± 1.56 (10)	9.69; < 0.001*	0.13; 0.89	2.08; 0.04*
II. Neoplasms	5.34 ± 0.36 (15)	5.09 ± 0.26 (14)	0.56; 0.57	4.69 ± 0.11 (15)	4.89 ± 0.09 (14)	1.41; 0.16*	1.73; 0.08	0.73; 0.47
III. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	9.76 ± 0.55 (13)	6.97 ± 0.31 (13)	4.42; < 0.001*	12.72 ± 0.8 (12)	8.79 ± 0.35 (13)	4.5; < 0.001*	3.05; 0.002*	3.89; < 0.001*
IV. Endocrine, nutritional and metabolic diseases	11.28 ± 0.61 (11)	24.1 ± 1.15 (11)	9.85; < 0.001*	15.03 ± 0.34 (11)	27.2 ± 0.8 (11)	14.0; < 0.001*	5.37; < 0.001*	2.21; 0.03*
VI. Diseases of the nervous system	34.71 ± 3.04 (8)	35.29 ± 1.87 (9)	0.16; 1.87	36.25 ± 1.5 (8)	38.48 ± 1.18 (8)	1.17; 0.24	0.45; 0.64	1.44; 0.15
VII. Diseases of the eye and adnexa	53.96 ± 2.93 (6)	54.27 ± 1.76 (6)	0.09; 0.93	55.55 ± 2.68 (6)	60.94 ± 2.15 (5)	1.57; 0.12	0.4; 0.69	2.40; 0.02*
VIII. Diseases of the ear and mastoid process	42.79 ± 2.23 (7)	28.7 ± 0.8 (10)	5.95; < 0.001*	47.23 ± 2.11 (7)	35.2 ± 0.97 (9)	5.18; < 0.001*	1.45; 0.15	5.17; < 0.001*
IX. Diseases of the circulatory system	5.63 ± 0.34 (14)	15.1 ± 0.48 (12)	16.1; < 0.001*	6.73 ± 0.35 (14)	16.16 ± 0.54 (12)	14.65; < 0.001*	2.25; 0.02*	1.47; 0.14
X. Diseases of the respiratory system	1305.01 ± 32.54 (1)	736.92 ± 7.7 (1)	16.99; < 0.001*	1150.6 ± 20.18 (1)	684.91 ± 4.52 (1)	20.18; < 0.001*	4.03; < 0.001*	5.83; < 0.001*
XI. Diseases of the digestive system	84.22 ± 6.03 (3)	76.2 ± 4.79 (4)	1.04; 0.3	67.65 ± 4.23 (5)	67.66 ± 3.79 (4)	< 0.001; 0.99	2.25; 0.02*	1.40; 0.16
XII. Diseases of the skin and subcutaneous tissue	75.73 ± 6.61 (4)	77.72 ± 5.59 (3)	0.23; 0.82	71.94 ± 3.62 (3)	75.24 ± 3.96 (3)	0.62; 0.54	0.50; 0.62	0.36; 0.72
XIII. Diseases of the musculoskeletal system and connective tissue	27.02 ± 1.61 (10)	48.36 ± 1.76 (7)	8.95; < 0.001*	31.71 ± 1.51 (9)	56.19 ± 2.14 (7)	9.35; < 0.001*	2.12; 0.03*	2.83; 0.004*
XIV. Diseases of the genitourinary system	28.78 ± 2.19 (9)	64.16 ± 3.59 (5)	8.41; < 0.001*	27.07 ± 1.22 (10)	56.99 ± 2.44 (6)	10.97; < 0.001*	0.68; 0.49	1.65; 0.098
XVII. Congenital malformations, deformations and chromosomal abnormalities	10.92 ± 0.92 (12)	2.69 ± 0.24 (15)	8.66; < 0.001*	10.6 ± 0.32 (13)	3.09 ± 0.19 (15)	20.18; < 0.001*	0.33; 0.74	1.31; 0.19
XIX. Injury, poisoning and certain other consequences of external causes	106.4 ± 4.39 (2)	191.36 ± 11.59 (2)	6.86; < 0.001*	103.59 ± 1.72 (2)	169.41 ± 4.7 (2)	13.15; < 0.001*	0.60; 0.55	1.76; 0.08

Note: * — Student's *t*-test at the significance level $p < 0.05 – p < 0.001$.

mechanism), XVII (Congenital malformations, deformations and chromosomal abnormalities).

Regions with the highest and lowest values for the disease classes were revealed. Thus, the Chukotka Autonomous Okrug was the leader by five classes in the age group of 0–14 years and by seven classes in adolescents aged 15–17. Primorsky Territory occupied the leading places by three disease classes in pediatric population and by class XIX (Injury, poisoning and certain other consequences of external causes) in adolescents. The Amur region, Kamchatka Territory and Jewish Autonomous Region demonstrated the highest values of the assessed indicator in one disease class, but in two age groups. The lowest long-term average annual incidence for some classes was many times reported in the Republic of Buryatia, Magadan region and Jewish Autonomous Region (Table 2).

Comparative analysis of the long-term average annual incidence by disease classes in the studied age groups in FEFD revealed significantly higher values of the assessed indicator in the younger age group for classes I (Certain infectious and parasitic diseases), III (Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism), VIII (Diseases of the ear and mastoid process), X (Diseases of the respiratory system), XVII (Congenital malformations, deformations and chromosomal abnormalities) and in the older age group for classes IV (Endocrine, nutritional and metabolic diseases), IX (Diseases of the circulatory system), XIII (Diseases of the musculoskeletal system and connective tissue), XIV (Diseases of the genitourinary system), XIX (Injury, poisoning and certain other consequences of external causes). Similar differences were reported in Russia in general. Furthermore, it was found that in FEFD the long-term average annual incidence was significantly lower compared to the all-Russian indicators for classes III (Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism), IV (Endocrine, nutritional and metabolic diseases), XIII (Diseases of the musculoskeletal system and connective tissue) in both age groups, IX (Diseases of the circulatory system) in children aged 0–14, I (Certain infectious and parasitic diseases), VII (Diseases of the eye and adnexa), VIII (Diseases of the ear and mastoid process) in the group of adolescents aged 15–17. Higher values of the studied indicator in FEFD relative to Russia in general were reported for classes X (Diseases of the respiratory system) in children and adolescents and XI (Diseases of the digestive system) in the age group of 0–14 years (Table 1).

DISCUSSION

We believe that the identified features of the long-term average annual incidence by disease classes in the FEFD regions may be indicative of the unique factors involved in health formation in children and adolescents of the macroregion. Thus, diseases

Table 2. FEFD regions with the highest and lowest long-term average annual incidence by disease classes

Disease class according to ICD-10	Regions with the highest long-term average annual incidence		Regions with the lowest long-term average annual incidence	
	0–14 years; region, M ± m_p	15–17 years; region, M ± m_p	0–14 years; region, M ± m_p	15–17 years; region, M ± m_p
I. Certain infectious and parasitic diseases	Sakhalin region, 105.22 ± 7.96	Kamchatka Territory, 56.39 ± 6.02	Republic of Buryatia, 46.61 ± 3.79	Republic of Buryatia, 17.5 ± 1.1
II. Neoplasms	Chukotka Autonomous Okrug, 8.07 ± 0.62	Chukotka Autonomous Okrug, 9.66 ± 1.51	Republic of Buryatia, 2.05 ± 0.1	Republic of Buryatia, 1.98 ± 0.2
III. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	Trans-Baikal Territory, 18.29 ± 1.42	Chukotka Autonomous Okrug, 13.78 ± 2.06	Kamchatka Territory, 5.15 ± 0.67	Khabarovsk Territory, 3.94 ± 0.24
IV. Endocrine, nutritional and metabolic diseases	Amur region, 19.25 ± 1.42	Amur region, 40.51 ± 2.29	Jewish Autonomous Region, 4.15 ± 0.38	Jewish Autonomous Region, 14.54 ± 2.71
VI. Diseases of the nervous system	Republic of Sakha (Yakutia), 48.93 ± 8.17	Republic of Sakha (Yakutia), 51.06 ± 6.64	Trans-Baikal Territory, 17.75 ± 1.49	Jewish Autonomous Region, 14.64 ± 1.38
VII. Diseases of the eye and adnexa	Chukotka Autonomous Okrug, 78.73 ± 5.7	Chukotka Autonomous Okrug, 91.89 ± 6.57	Republic of Buryatia, 37.47 ± 1.61	Jewish Autonomous Region, 34.49 ± 4.69
VIII. Diseases of the ear and mastoid process	Chukotka Autonomous Okrug, 70.66 ± 6.29	Chukotka Autonomous Okrug, 45.34 ± 2.06	Jewish Autonomous Region, 26.95 ± 3.78	Jewish Autonomous Region, 19.98 ± 1.12
IX. Diseases of the circulatory system	Chukotka Autonomous Okrug, 11.21 ± 2.95	Jewish Autonomous Region, 26.26 ± 2.74	Republic of Buryatia, 3.21 ± 0.48	Sakhalin region, 9.8 ± 1.11
X. Diseases of the respiratory system	Chukotka Autonomous Okrug, 1903.14 ± 105.49	Chukotka Autonomous Okrug, 1159.46 ± 49.15	Republic of Buryatia, 730.11 ± 7.23	Republic of Buryatia, 474.7 ± 12.53
XI. Diseases of the digestive system	Sakhalin region, 146.68 ± 8.52	Republic of Sakha (Yakutia), 123.09 ± 15.81	Magadan region, 37.73 ± 2.56	Magadan region, 26.95 ± 1.8
XII. Diseases of the skin and subcutaneous tissue	Kamchatka Territory, 92.94 ± 4.88	Kamchatka Territory, 110.69 ± 12.15	Magadan region, 38.82 ± 9.2	Republic of Buryatia, 32.64 ± 3.28
XIII. Diseases of the musculoskeletal system and connective tissue	Primorsky Territory, 43.6 ± 1.93	Chukotka Autonomous Okrug, 68.41 ± 10.64	Jewish Autonomous Region, 10.3 ± 1.08	Republic of Buryatia, 28.84 ± 2.09
XIV. Diseases of the genitourinary system	Primorsky Territory, 41.46 ± 2.76	Khabarovsk Territory, 82.76 ± 5.57	Magadan region, 13.8 ± 1.67	Republic of Buryatia, 24.93 ± 2.42
XVII. Congenital malformations, deformations and chromosomal abnormalities	Jewish Autonomous Region, 27.89 ± 3.76	Magadan region, 5.09 ± 0.84 Jewish Autonomous Region, 5.09 ± 0.57	Republic of Buryatia, 3.58 ± 0.39	Republic of Buryatia, 0.96 ± 0.19
XIX. Injury, poisoning and certain other consequences of external causes	Primorsky Territory, 153.45 ± 8.92	Primorsky Territory, 304.34 ± 15.36	Republic of Buryatia, 31.88 ± 1.78	Jewish Autonomous Region, 73.88 ± 3.39

of the respiratory system traditionally dominate among the disease classes. The highest indicator value was reported for the Chukotka Autonomous Okrug, while the lowest values were observed in the Republic of Buryatia [2]. The researchers note that the incidence of congenital malformations among children dominates in the Jewish Autonomous Region, Amur region, Trans-Baikal Territory, Republic of Buryatia [7]. Furthermore, the authors point to the lowest incidence of neoplasms in the age group of 15–17 years in the Republic of Buryatia. The data obtained for the Khabarovsk Territory are compliant with the data of the earlier studies of this region [9].

At the same time, there are a number of patterns typical for other country's administrative territorial units as well. Thus, similar studies conducted in other regions show that in the previous decade classes X (Diseases of the respiratory system), XIX (Injury, poisoning and certain other consequences of external causes), XII (Diseases of the skin and subcutaneous tissue), XI (Diseases of the digestive system), and VII (Diseases of the eye and adnexa) predominated among the disease classes in pediatric and adolescent populations [1, 4, 5, 10, 11]. At the same time, it should be noted that diseases of the digestive system that ranked second in a number of the FEFD regions ranked fourth and fifth in the Tumen region children and adolescents, respectively [11]. Diseases of the respiratory system predominate in the structure of incidence in the Chechen Republic, while second place is occupied by diseases of the eye and adnexa, diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism rank third, diseases of the ear and mastoid process rank fourth. The authors explain the unique structure of incidence in their region by lower accessibility of primary medical care [12]. In 2017–2019, diseases of the respiratory system, injury, poisoning and certain other consequences of external causes predominated in children and adolescents of the Udmurt Republic. The only exception was the year 2018, when third place was occupied by diseases of the skin and subcutaneous tissue [13]. Diseases of the respiratory system predominated in the structure of incidence in the pediatric population of Saint-Petersburg for 20 years, followed by injury, poisoning and certain other consequences of external causes, infectious and parasitic diseases, diseases of the skin and subcutaneous tissue, diseases of the digestive system; diseases of the respiratory system, injury, poisoning, diseases of the skin and subcutaneous tissue, diseases of the genitourinary system predominated in adolescents [14]. Thus, the data obtained are confirmed by the research performed by other scientists.

CONCLUSIONS

The assumption that there are some features of incidence in pediatric population in the FEFD regions was proven. Both similarity and nuances of the pediatric and adolescent incidence ranking by certain disease classes in the macroregion relative to the all-Russian indicators were determined. Wide variability was revealed when ranking the assessed indicators in the FEFD regions. The leading regions in certain disease classes were defined along with the regions with the lowest incidence in these classes. Significant differences in the long-term average annual levels of the studied indicator between age groups in FEFD and significant differences from the all-Russian values were revealed. The findings can provide the basis for further investigation of the regional health risk factors in children and adolescents and can be used to predict the health status of the younger generation and determine the strategic direction of the healthcare system in the macroregion. We consider it expedient to to improve preventive areas in FEFD due to rather high incidence in the majority of disease classes. The identified features the incidence ranking by disease classes in the regions of the district will make it possible to base on the principle of appropriate expenditures when planning medical care provision to the population.

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FEATURES OF TEACHING HYGIENE IN THE MEDICAL UNIVERSITY CONSIDERING SPECIALIZATION AND DIGITALIZATION

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The issue of organizing the teaching of hygiene considering specialization of the medical university faculties is relevant in the context of digitalization. Proficiency in digital skill determines the modern professional physician's competitiveness. The paper provides analysis of the use of digital technologies to study the relevant issues of hygiene. Educational process at the Department of General Hygiene of the Voronezh State Medical University is built on the principle of uniformity and consistency. Professional educational trajectory, including that on digital platforms, considers the teaching continuity, from fundamental theoretical subjects to clinical and specialized ones. Within the framework of educational process, issues of special hygiene, such as specifics of structure and use of medical institutions, features of professional activity of physicians of various specialties, are considered. Conventional methods to teach hygiene are supplemented with the differentially used innovative teaching techniques. The business game method is successfully used by the future clinicians to master the topic "Food Poisoning". The method of creating educational videos for visual demonstration of laboratory work can be used in distant learning. The digital learning method demonstrates the possibility of using advanced digital devices and internet-based technologies in preventive medicine. It seems necessary to further improve the educational process at all the faculties as educational and professional standards, as well as the academic passport for Hygiene, are updated.

Keywords: hygiene, specialization of faculties, innovative teaching technologies, digitalization

Author contribution: the authors made equal contributions to the manuscript preparation.

Compliance with ethical standards: the study was compliant with the principles of biomedical ethics.

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Received: 21.09.2023 **Accepted:** 23.09.2023 **Published online:** 08.12.2023

DOI: 10.24075/rbh.2023.083

ОСОБЕННОСТИ ПРЕПОДАВАНИЯ ГИГИЕНЫ В МЕДИЦИНСКОМ УНИВЕРСИТЕТЕ С УЧЕТОМ ПРОФИЛЬНОСТИ И ЦИФРОВИЗАЦИИ

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Проблема организации преподавания гигиены с учетом профильности факультетов медицинского университета актуальна в условиях цифровизации. Владение цифровыми навыками определяет конкурентоспособность современного врача-профессионала. В статье проведен анализ использования цифровых технологий для изучения профильных вопросов гигиены. Образовательный процесс на кафедре общей гигиены Воронежского государственного медицинского университета построен по принципу систематичности и последовательности. Профессионально-образовательная траектория, в том числе на цифровых платформах, учитывает преемственность преподавания от фундаментальных теоретических дисциплин к клиническим и профильным. В учебном процессе рассматривают проблемы частной гигиены, такие как специфика устройства и эксплуатации медицинских организаций, особенности профессиональной деятельности врачей различных специальностей. Традиционные методики преподавания гигиены дополнены дифференцированно используемыми инновационными методами обучения. Метод деловой игры успешно применяют для освоения темы «Пищевые отравления» будущие врачи-клиницисты. Метод создания учебных видеофильмов для наглядной демонстрации лабораторных работ может быть применен в случае дистанционного обучения. Метод цифрового обучения показывает возможности использования современных цифровых устройств и интернет-технологий в профилактической медицине. Представляется необходимым дальнейшее совершенствование образовательного процесса на всех факультетах по мере обновления образовательных и профессиональных стандартов, а также паспорта научной специальности «Гигиена».

Ключевые слова: гигиена, профильность факультетов, инновационные технологии обучения, цифровизация

Вклад авторов: все авторы внесли равный вклад в подготовку публикации.

Соблюдение этических стандартов: проведенное исследование соответствует требованиям биомедицинской этики.

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Статья получена: 21.09.2023 **Статья принята к печати:** 23.09.2023 **Опубликована онлайн:** 08.12.2023

DOI: 10.24075/rbh.2023.083

The main preventive discipline, hygiene, plays an important role in forming the worldview of modern physician. Teaching the academic discipline "Hygiene" at the Department of General Hygiene of the Voronezh State Medical University (VSMU) is organized in accordance with the faculty specialization and digital technology. The use of digital environment when studying hygiene is associated not only with the demands of society, but also with the young generation's need for information acquisition and exchange, self-organization and self-development. Information technology in the field of public health and preventive medicine opens up new opportunities for future specialists, minimizes the risk of making mistakes when working. Implementation of advanced developments into educational process via special programs and services makes it possible to improve the students' creative and research abilities, enhance motivation to study.

The study was aimed to characterize the features of organizing the teaching of hygiene at the Department of General Hygiene of VSMU taking into account specialization of the medical university faculties in the context of digitalization.

Theoretical (analysis, comparison, and compilation of data reported in scientific, methodological, and educational literature) and empirical (monitoring certain aspects of teaching and educational technologies used for students at various

medical university faculties during lectures and practical classes on hygiene, as well as during extracurricular activity) methods were used during the study.

Educational process for the academic discipline "Hygiene" is built in accordance with the competencies set out in the Federal State Educational Standards of Higher Education (FSES HE) 3++ and employment functions of Professional Standards for specialties. Improvement of employment functions is inseparably linked with digitalization. Further update of educational standards and the specified universal, general professional and digital competencies, as well as orientation on professional standards for specialties, will make it possible to improve methodological approaches to teaching [1–4].

Digital educational technologies at the Department of General Hygiene of VSMU

The main digital resources used in distance learning at the Department are the Webinar video communication service (Alex Alpern; Russia) and the Moodle digital environment (Martin Dougiamas; Australia). Teaching using the Webinar and Moodle digital platforms constitutes up to 30% of the subject complexity. The Moodle platform enables automatization of a significant number of classes on the subject at various faculties and creation of a common information space for students and teachers combining conventional forms of training and the use of information and computer technologies [5–10].

In Moodle, a training course being a combination of training modules and comprising lectures, practical classes, interactive control elements (tests, situational tasks, forums), interactive links to information resources was developed for each faculty. The benefits of such system are as follows: possibility to study the material in own pace, identification of weaknesses and gaps requiring special attention. Teachers can continuously monitor the process of mastering the educational materials and, therefore, more effectively manage the teaching process.

On the other hand, teaching the academic discipline "Hygiene" using digital technologies at various faculties has some features. Thus, the use of the digital element "Seminar" when studying the module "Hygiene of Medical Institutions" involves different scenarios. The features of engineering dental specialty institutions are studied at the Faculty of Dentistry, pharmacy projects are considered at the Faculty of Pharmacy, while medical institutions for the specialty are studied at the faculties of general medicine and pediatrics. Students are offered to create their own projects, discuss them on the platform, and choose the best one. The system continuously monitors user activity and prepares reports on their participation.

Organizing educational process at the department considering specialization of the medical university faculties

Teaching hygiene is oriented on training of primary care physicians, preventive medicine physicians, and pharmacists. According to FSES HE 3++ and the curriculum, 252 h or seven credit units are allocated per subject at the faculties of general medicine and pediatrics.

Faculties of general medicine and pediatrics

The lecture course on hygiene at the Faculty of General Medicine (12 lectures) includes issues related to hygiene of ambient air, water, water supply, nutrition, labor, children and adolescents, as well as hospital hygiene. The fuller lecture course at the Faculty of Pediatrics consisting of 14 lectures makes it possible to further elaborate the questions concerning hygiene of children and adolescents, in particular, health indicators of children and adolescents, health groups, methods to assess and estimate physical development, hygienic principles of organizing academic work at school. In all lecture courses attention is paid to the regional specifics of the ambient air quality, as well as climate-related factors, natural waters used to ensure water supply of Voronezh and the region. The content of the courses includes using the data from digital platforms of Rospotrebnadzor and practical healthcare structures.

Faculty of Dentistry

Students at the Faculty of Dentistry are taught hygiene for 108 h or three credit units. The curriculum provides for five lectures. Ten lecture hours at the Faculty of Dentistry, in contrast to 24 and 28 h at the faculties of general medicine and pediatrics, do not make it possible to fully describe the hygienic significance of environmental factors. Digital educational materials, in particular, original educational videos provided on the Moodle platform, allow students to fill the gaps. One of the lectures on the subject is dedicated to hygiene of dental specialty institutions and professional hygiene of dentists. Monitoring of the hygienic regulatory documentation is accomplished by using online resources and digital library systems. Digital content makes it possible to consider hygienic requirements for engineering, instrumentation and equipment of dental clinics in the up-to-date format, enables assessment of occupational hazards and diseases typical for modern dentistry. Furthermore, hygienic characteristics of water as the most important environmental factor in terms of its chemical composition are provided during lectures for dental students. It is reported that water can be the cause of endemic fluorosis and caries. Emphasis is placed on the quality of water in the Voronezh region, since water contains elevated levels of hardness salts, as well as iron and manganese, which requires the use of specific methods of water treatment and dispatching.

Faculty of Preventive Medicine

The academic discipline is most complex in the 2nd and 3rd year students of the Faculty of Preventive Medicine: 324 h or nine credit units. The lecture course consists of 12 lectures. The quantitative format of the lecture course at the Faculty of Preventive Medicine is similar to that for students of the Faculty of General Medicine, which, in our opinion, is insufficient. The basics of discipline, propedeutics of hygiene, without which high-quality training of the hygienic physician or epidemiologist is impossible, are taught at the Department of General Hygiene. A preventive medicine physician should be able to identify causal relationships between the changes in sanitary and epidemiological situation and health indicators of the population. Students at the Faculty of Preventive Medicine become familiar with the hygienic assessment methods, characteristics of various environmental factors and fundamentals of social and hygienic monitoring during classes and lectures on hygiene. Teaching the special academic discipline "Social and Hygienic Monitoring and Health Risk Assessment" in the fifth year allows them to master information and internet resources of the social and hygienic monitoring system. Students are taught to find and analyze information, including legislation and regulatory documents, in accordance with the professional task. The students are provided access to electronic databases of the

Rospotrebnadzor institutions, they work with the professional document search engine.

Given the faculty specifics, special attention is paid to preventive medicine methodology and hygienic standardization of chemical and physical factors. The common patterns of hazardous substances behavior in the biosphere, as well as combined and complex effects of chemical and physical factors on the body, are considered within the framework of environmental quality management. As for hygienic diagnosis of public health and environment, information is provided on toxicology of polymeric materials and sanitary hygienic expertise of products made of such materials. Part of the lecture course is devoted to teaching the scientific principles of healthy lifestyle, fundamentals of mental hygiene, hygienic aspects of physical activity and tempering, hygienic requirements for organization of work and rest, diet taking into account the body's biorhythms. The issues of generating the health-preserving educational process are considered, specifically hygienic requirements for using computer and user risk factors.

We consider it expedient to address the today's pressing hygienic issues resulting from scientific and technical progress and included in the existing academic passport for 3.2.1. Hygiene, such as aspects of information and analytical hygiene, hygiene of health preservation, in the lectures for future experts in preventive medicine.

Faculty of Pharmacy

Three lectures at the Faculty of Pharmacy with the overall complexity of the Hygiene academic discipline of 72 h or two credit units involve only a general review of basic hygiene issues given the fact that teaching the subject is aimed to make students familiar with the common patterns of influence of environmental factors, working conditions and schedule of employees of pharmacies and pharmaceutical enterprises on the body. One lecture on the specialty is devoted entirely to the fundamentals of sanitary improvement of pharmacies and occupational hygiene of pharmacists, including occupational hazards, occupational diseases of employees, arranging health promotional activities. Information about the issues included in the curriculum is available from the Moodle digital educational environment.

Thus, mastering the academic discipline "Hygiene" by the students takes place considering the specifics of different faculties. The common trends imply reduction of lecture hours and increasing the time for practical classes and extracurricular work. For example, students learn the issues related to hygiene of soil on their own due to reduction of lecture hours on the discipline. Work continues on updating the lectures considering the issues that are most difficult for students aimed at improving the teaching of academic disciplines.

Innovative methods to teach hygiene within the framework of competence-based approach to teaching

In today's conditions of competence-based approach to teaching working with students involves implementation of modern teaching methods into educational process, including interactive methods [11–24]. The latter are aimed to improve the students' motivation toward educational and professional activities. Conditions have been created at the Department for manifestation of the creative initiative that forms and develops the interest for academic discipline and stimulates self-search for necessary information. We use various pedagogical techniques that contribute to organization of the students' joint action under conditions simulating the real situation. One of the methods to ensure the students' active learning is the method of situational tasks or the case-study method based on assessing and resolving a problematic situation. The students are offered to think about a real situation that not only reflects certain practical issue, but also actualizes some body of knowledge needed to solve the problem.

One more pedagogical technology represents working in small groups allowing the members to improve their educational interest and master business communication. Students develop critical thinking when working in groups (teams), which implies the abilities to acquire data, compare, match the data to the earlier studied phenomena, build the logic of evidence-based solution of the problem under consideration, etc. Small training groups construct new knowledge together, they do not acquire ready-made knowledge. The teacher's task is to involve all students into generating a real work product together. Laboratory work enabling integration of theoretical knowledge and practical skills is an example of such training. Students united in small groups do laboratory work with the teacher's advisory and methodological assistance.

Business (role-playing) games make it possible to involve all students and ensure group cohesion. Educational material is effectively mastered, communicative and social skills and abilities necessary for mastering future profession are formed. A business game for the section "Hygiene of Nutrition" on the topic "Food Poisoning" is an example [25], which is targeting general practitioners and pediatricians. Its essence lies in formulating a preliminary diagnosis by the clinician based on the anamnestic data and the "patient's" complaints. The teacher's task is to distribute functions among students of the group in the business game. The teacher promotes developing the skills of interviewing the affected individual, helps to establish a correct diagnosis by asking additional questions, guides the "physician's" thoughts during differential diagnosis of food poisoning, notes students, who are the most competent when playing their roles in the business game.

Active methods to acquire knowledge also include making movies vividly demonstrating educational content. Videos prepared by teachers and students together are considered to be the best variant. In doing so, high students' commitment to selection and presentation of materials on the issue is formed. Hyperlinks to videos are hosted on the Moodle platform. Discussion of material can be arranged in addition to watching a video. During the discussion the teacher can figure out various viewpoints on the issue and guide students to the right conclusion from the discussed issue in a well-argued manner. Active discussion makes it possible to organize the knowledge and draw conclusions correctly.

The above allows us to draw a conclusion about differentiation of students' training at the Department of General Hygiene of VSMU. The issues of special hygiene (for example, hygiene of dental specialty institutions, hygiene of pharmacies and pharmaceutical enterprises, etc.) are in more detail analyzed for students of appropriate faculties. During practical classes at the faculties of general medicine and pediatrics hygienic requirements for project documentation of medical institution are considered, that of dental clinic are considered at the Faculty of Dentistry, of pharmacy at the Faculty of Pharmacy; standards for the design of various construction objects are considered at the Faculty of Preventive Medicine.

Hygiene teaching update in accordance with the updated standards and legislation

The educational process organization is compliant with the requirements of educational and professional standards for the specialties available at the university, which enables developing a hygienic way of thinking and acquisition of solid knowledge on the academic discipline “Hygiene” by students. The research fields set out in the academic passport for 3.2.1. “Hygiene” are considered.

However, the today’s standards of training physicians do not fully take into account the latest trends in hygiene development, its achievements, new methodological and informational approaches, as well as the technology to provide sanitary and epidemiological well-being of the population. We believe that further update of educational and professional standards for specialties will enable orientation to the relevant issues of medical practice, which, in turn, will improve the quality of educational process in the medical university. The thematic plan should be revised taking into account socio-economic changes in society, changes in the regulatory framework governing the activities of the sanitary and epidemiological service, adoption of new laws and/or amendments related to the living environment.

Compilation of the work programs of academic disciplines for various faculties makes it possible to clearly define the issues taught within the framework of a single discipline considering the knowledge acquired by students when learning the preceding disciplines, thereby outlining the systematic nature and sustainability of teaching. The professional and educational trajectory of future hygienists and epidemiologists takes into account the teaching continuity from fundamental theoretical disciplines to clinical and relevant for the specialty ones [4, 26, 27]. Hygiene arms students with the basic knowledge essential for further formation of qualified specialists in preventive field of medicine. The subsequent teaching of hygiene of nutrition, occupational hygiene, radiation and communal hygiene it built on the basement founded during the study of the discipline at the Department of General Hygiene. The teaching continuity at the Faculty of Preventive Medicine of VSMU is reflected in the handbook for students’ extracurricular work with innovative implementations and abstracts of the lecture courses for various disciplines.

It is necessary to issue differentiated Hygiene tutorials and workshops to improve teaching of hygiene. The use of innovative teaching methods, such as the problem-based exposition of material, increases the interest in the subject and enhances cognitive activity, thereby promoting successful mastering the discipline [4, 21, 25].

Students’ research work as a method to improve their professional qualification

According to the last generation FSES, students’ research work is part of training of physicians in the specialty “Preventive Medicine”. Engaging students in research reinforces motivation for learning hygiene within the framework of educational process. Cooperation of teachers at various departments and the sanitary service specialists in organizing the shared circles and conferences is also aimed at improving the students’ professional qualification level. Such measures expand the future physicians’ understanding of modern hygienic issues and form practical skills of hygienic diagnosis of the environment.

CONCLUSION

Integration of efforts between the academic staff and practical healthcare professionals, complex use of conventional, innovative and digital methods to teach hygiene ensure high-quality training of future physicians of various specialties.

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HYGIENIC ASSESSMENT OF DAILY DIETARY INTAKE OF MEDICAL STUDENTS

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It is difficult to overestimate the relevance of the study of the actual nutrition of students of higher education institutions, as nutrition is the most important component of healthy lifestyle. The aim of the study was to perform hygienic assessment of the medical university students' daily dietary intake. The study involved 1200 students of the 1st, 2nd and 3rd years at the department of general medicine, pediatric department and dental department. The method of studying actual nutrition with the help of an electronic food diary, where the subjects entered information about the foods consumed during the day, was chosen to record actual nutrition facts. Data processing showed that the daily nutritional intake of students at all the studied faculties was characterized by reduced caloric content, reduced intake of nutritional substances, lack of systematization of meals and eating mainly in the evening. Thus, hygienic assessment of the medical students' daily dietary intake revealed shortcomings in the organization of nutrition of this population group, which should be eliminated in order to preserve and improve the health of future specialists. In subsequent studies, one would need to assess the nutrition of different gender groups in order to to trace the emerging nutritional stereotypes in groups of young men and women, taking into account the differences in age and the chosen specialty.

Keywords: student nutrition, actual nutrition, diet analysis, dietary habits, nutritional pathology, preventive measures, healthy nutrition

Author contribution: Makarova IO — conducting experiments and collecting data/evidence, analyzing and interpreting the data obtained; taking responsibility for all aspects of the paper, the integrity of all parts of the paper and its final version; applying statistical, mathematical, computational or other formal methods to analyze and synthesize research data.

Compliance with ethical standards: the study was approved by the Ethics Committee of the Burdenko Voronezh State Medical University (protocol № 7 dated 8 November 2021). All study participants submitted the informed consent to personal data processing.

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Received: 11.11.2023 **Accepted:** 20.12.2023 **Published online:** 27.12.2023

DOI: 10.24075/rbh.2023.084

ГИГИЕНИЧЕСКАЯ ОЦЕНКА СУТОЧНОГО РАЦИОНА ПИТАНИЯ СТУДЕНТОВ МЕДИЦИНСКОГО ВУЗА

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Актуальность исследования фактического питания учащихся высших учебных заведений сложно переоценить, так как питание является наиболее важной составляющей здорового образа жизни. Целью исследования было выполнить гигиеническую оценку суточного рациона питания студентов медицинского университета. В исследовании приняли участие 1200 учащихся 1–3 курсов лечебного, педиатрического и стоматологического факультетов. Для регистрации суточного рациона был выбран метод изучения фактического питания с помощью электронного дневника питания, где испытуемые вносили информацию об употребленных за день продуктах. При обработке данных было установлено, что для суточного рациона обучающихся всех исследуемых факультетов характерны пониженная калорийность, снижение употребления пищевых веществ, отсутствие систематизации приемов пищи и питание преимущественно в вечерние часы. Таким образом, гигиеническая оценка суточного рациона питания студентов медицинского вуза определила недостатки в организации питания исследуемого контингента, которые необходимо устранить в целях сохранения и укрепления здоровья будущих специалистов. В ходе дальнейших исследований необходимо оценить питание различных гендерных групп, чтобы получить возможность проследить формирующиеся стереотипы питания в группах юношей и девушек с учетом разницы в возрасте и выбранной специализации.

Ключевые слова: питание студентов, фактическое питание, анализ рациона, пищевые привычки, алиментарная патология, профилактические мероприятия, здоровое питание

Вклад авторов: И. О. Макарова — проведение экспериментов и сбор данных/доказательств, анализ и интерпретация полученных данных, принятие ответственности за все аспекты работы, целостность всех частей статьи и ее окончательный вариант, применение статистических, математических, вычислительных или других формальных методов для анализа и синтеза данных исследования.

Соблюдение этических стандартов: исследование одобрено этическим комитетом Воронежского государственного медицинского университета имени Н. Н. Бурденко (протокол № 7 от 8 ноября 2021 г.). Все участники исследования подписали согласие на обработку персональных данных.

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Статья получена: 11.11.2023 **Статья принята к печати:** 20.12.2023 **Опубликована онлайн:** 27.12.2023

DOI: 10.24075/rbh.2023.084

Studentship is a social phenomenon that is of great scientific interest due to its patrticularism. This phase is rather important for humans both in social terms and in terms of the body systems' development completion. In this regard, the issue of nutrition during this period becomes especially important, since among other lifestyle factors it is nutrition that has the most significant impact on health. Therefore, nutrition comes to the foreground among other factors of healthy lifestyle, as evidenced by a huge body of scientific literature [1–4].

Today, nutrition is a rather pressing issue, which suggests high public interest in healthy lifestyle. However, this problem is often given very little attention in the student environment [5]. This is largely due to heavy workload at classes, a lot of tutorials to master when preparing for classes, and the lack of time. If we talk about medical students, then, due to the educational process specifics, they have even less free time, which invariably affects their lifestyle and later their health status [6].

In addition, for a number of reasons, certain food groups are unavailable to students, which means that students do not get enough useful nutrients. This leads to a decline in general health, problems in mastering educational material, as well as the increased risk of developing nutrient-dependent pathology, which, according to statistical studies, is a quite common problem in modern society.

Table 1. Number of participants

	Boys	Girls
Department of General Medicine		
Year 1	46	98
Year 2	35	94
Year 3	14	115
Pediatric Department		
Year 1	25	113
Year 2	15	115
Year 3	13	123
Dental Department		
Year 1	34	103
Year 2	41	93
Year 3	26	97

At the moment, there are quite a lot of scientific works focused on the issue of nutrition in the context of the emergence of nutritional diseases or lifestyle in general, including assessment of the higher school students' nutrition [7, 8]. Nevertheless, there are not enough large-scale studies focused on the issues related to student nutrition and their rationale.

The study was aimed to perform hygienic assessment of the daily food intake of medical university students to provide a potential basis for justification of possible non-compliance with the established standards and for completion of the list of most efficient preventive measures to avoid the development of disorders associated with nutrition in students.

METHODS

The study involved 1200 students of VSMU (951 girls and 249 boys) from among the 1st, the 2nd and the 3rd year students. The number of students from each department is shown in Table 1.

The age of the participants was 18-21 years (average age 19.1 ± 0.9 years). To identify possible differences in dietary intake in students of different training profiles, students from three different departments — general medicine, pediatric and dental — were selected. The study was conducted September 2021 to May 2023 on the basis of the VSMU sports and recreational complex. The type of the study was cross-sectional. The method chosen to record actual nutrition was based on an electronic food diary, Diet 5.0 (Istoki Zdorovya; Russia), designed to quantify a person's nutrition based on objective interviews with the client. This software is designed to generate diets corresponding to the individual nutrient norm of the patient. The norm is set automatically taking into account optimization goals, anthropometric data, psychological loads, physical activity, and in some cases, data on the subject's chronic diseases and conditions are also used.

During the study, anthropometric data acquired were recorded in the electronic diary, the main parameters of the participants were identified, and minimum calorie intake required for restoration of energy expenditures was calculated. After that participants had to record all foods consumed during the day for three days in order to create a personal complete diet. Then, considering the data obtained, a profile was created, in which the surveyed individuals entered information about all the meals consumed during the day (breakfast, morning snack, lunch, afternoon snack, dinner, evening snack) and their time (8:30, 11:00, 13:30, 16:00, 19:00, 21:00) using the method of 24 h nutrition recording. Software automatically calculated the calorie intake and the ratio of macronutrients in the consumed foods based on this profile.

The data obtained were statistically processed using the MS Office Excel 2016 software package (Microsoft; USA). Methods of statistical analysis and descriptive statistics were applied including data presented as arithmetic mean (M) and standard deviation (σ), with some data presented as percentages.

RESULTS

When processing the data, the following results were obtained: the average total caloric content of the diet of students of the first three courses at three studied faculties was 1320 kcal, of which breakfast was 267.8 kcal (20.3%), morning snack was 65.3 kcal (5%), lunch was 447 kcal (33.9%), afternoon snack was 69 kcal (5.2%), dinner was 509 kcal (38.6%), and evening snack was 57.8 kcal (4.4%).

When calculating the content of macronutrients in the diet, it was found that the basis of the diet were carbohydrates — 159 g (58%), fat held the second place in the macronutrient composition of the diet — 66 g (24%), while the content of proteins was reduced — 50 g (18%) (Fig. 1, 2).

The study conducted has shown that the energy value and amounts of nutritional substances consumed by students were significantly lower compared to the standard values (Table 2).

When analyzing student diets, the following features were revealed. First, breakfast is the least caloric meal, which is observed in all departments, while dinner, on the contrary, is the most high-calorie meal. Second, there is some heterogeneity

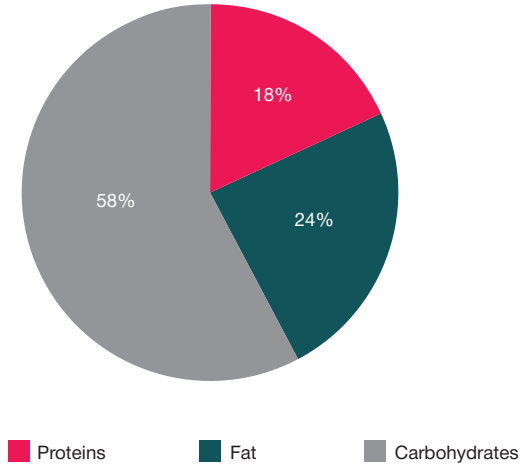

Fig. 1. Macronutrient composition of the diet (%)

Table 2. Students' daily intake of nutritional substances and energy consumption

	Year 1	Year 2	Year 3
Proteins, g/day	46.4 ± 1	51.2 ± 0.9	53 ± 1
Fat, g/day	65.5 ± 2.4	68 ± 1.3	67 ± 2.4
Carbohydrates, g/day	152 ± 2.9	167 ± 4.5	158 ± 4.6
Energy value, kcal	1281 ± 26	1388 ± 23	1294 ± 22

in the results obtained, as a strong variation in the caloric content of the diet was found in students of pediatric and dental departments (Fig. 2–4).

The results obtained can be generally characterized as follows:

– reduced caloric content of the diet;

– insufficient consumption of all groups of nutritional substances by students;

– meals taken at random;

– eating mainly in the evening hours.

DISCUSSION

The study has made it possible to identify some features of the medical university students' nutrition, trace the trends of diet formation and reveal the major shortcomings of actual students' diet on the example of three primary academic years.

According to methodical recommendations MP 2.3.1.0253-21 "Standard rates of physiological demand for energy and food substances in different population groups of the Russian Federation", the indicators of the students' diet macronutrient composition deviate from the established standards for adults.

The findings suggest that medical university students definitely have a calorie deficit, since the daily calorie intake for their age (18–29 years) and 1st labor class is 2150 kcal for males and 1700 kcal for females.

The analysis of the diet caloric content in the studied groups showed that students at the department of general medicine had the lowest total caloric content of the diet. It was 1390 kcal, while the caloric content of the diet of students of pediatric faculty was 1539 kcal and that of dental students was 1432 kcal. Therefore, the caloric content of lunch and dinner consumed by students at the department of general medicine is the lowest among the studied faculty, while the lowest caloric content of breakfast has been revealed in students of the faculty of dentistry (263 kcal).

The maximum calorie intake of students falls on evening hours, while the caloric content of morning meals is reduced, which means that the structure and frequency of meals are impaired. This is a risk factor for many nutritional disorders [9]. Furthermore, this indicates that students do not have enough time to eat in the morning and at lunch because of early rising and heavy workload in classes, which contributes to the development of emotional stress and related consequences, such as emerging disorders associated with the nervous system.

This disruption of meal patterns can affect both students' performance, as low nutrient intake in the morning prevents the body from utilizing its resources and paving the way to cognitive decline throughout the day, poorer general well-being, as morning nutrient intake ensures that metabolic processes are at sufficiently high level throughout the day.

Moreover, insufficient macronutrient consumption by students has been revealed during the study. Thus, analysis of the diets presented has shown that the students' overall fat intake is 66 g, which represents the lower limit of normal fat intake for adults. Fat consumption is related to the nervous system activity, so why we can conclude that the medical university students, who have high cognitive load in classes and experience emotional stress when preparing for exams and tests, leave this system of the body without proper support. This situation adversely affects general health and the students' progress in mastering the profession [10].

Furthermore, insufficient carbohydrate content was revealed in the students' daily diet, since total daily carbohydrate intake is 159 g, which is well below the established standard (250–500 g). However, one should not forget that carbohydrates form the basis of the diet and play the role of energy source in the body [11–13]. Thus, already at the stage of assessing the macronutrient composition of the students' diet, it can be concluded that the diet is unbalanced and correction of the diet requires organization of preventive work in the educational institution.

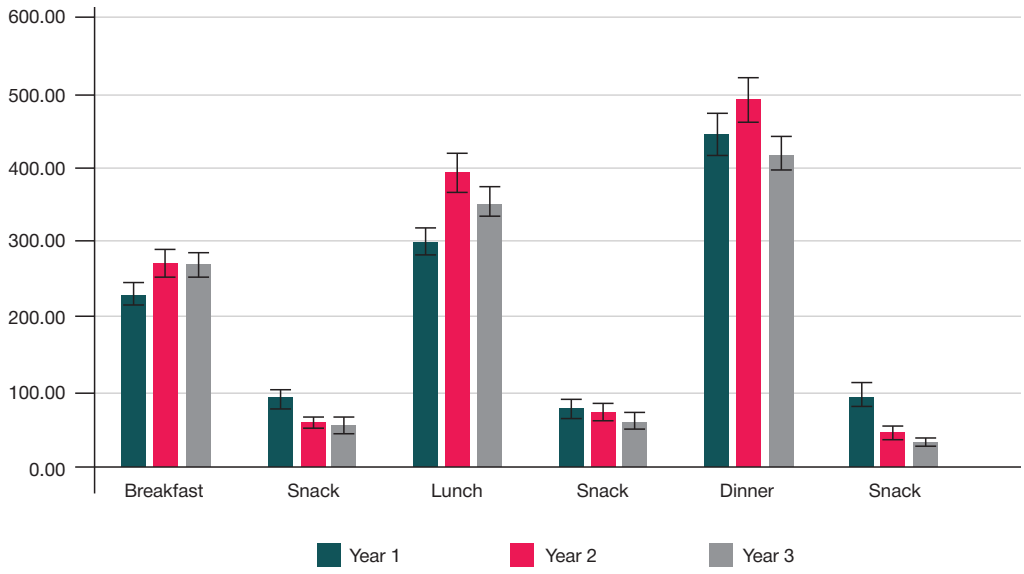

Fig. 2. Caloric content of the main meals of students of the Department of General Medicine (kcal)

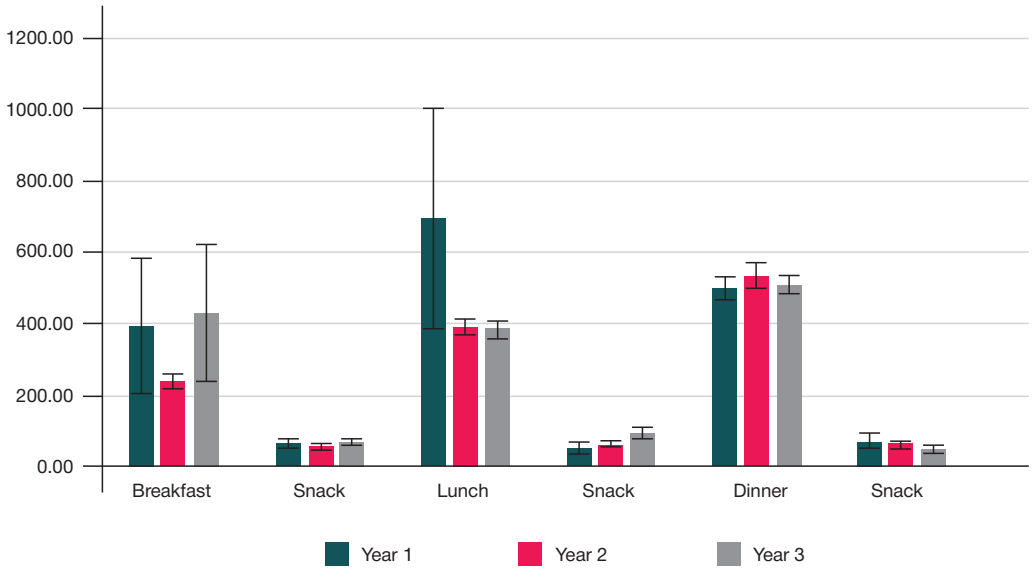

Fig. 3. Caloric content of the main meals of students of Pediatric Department (kcal)

The analysis of the diets also revealed a lack of protein intake by the students. The total daily protein intake is 50 g, which, given that the normal range is 60–100 g, represents a significant deficit. This factor can provoke a number of pathological conditions even with a short duration of exposure. Insufficient protein intake results in anemia, with which a great number of diseases of organs and organ systems are associated. For this reason, insufficient intake of products containing protein is extremely dangerous at any stage of body development, let alone an organism that is at the final stage of development. Insufficient intake of protein with food in students is usually associated with a limited budget, as well as lack of time to prepare meals from protein-containing products [14, 15].

The findings indicate that a comprehensive approach to dealing with the problem of nutrition of students of higher education institutions is needed. Evaluation of the data obtained revealed the main shortcomings of the existing nutrition system. It was found that overcoming this situation requires both work with students themselves to organize nutrition and healthy lifestyle, and certain changes in the structure of the educational institution.

CONCLUSIONS

The study of the medical university students' nutrition revealed some discrepancies between their actual nutrition and the established principles of healthy lifestyle. First, analysis of the diets of the medical university students at all the studied faculties revealed a downward trend in the calorie intake: given the normal caloric content range is 1700–2150 kcal, the total caloric content for three faculties is 1320 kcal. Such situation can, in turn, be the risk factor of disorders associated with heavy workload in classes, emotional stress and accelerated pace of life. Second, frequency of meals is impaired at all faculties. Given high caloric content of dinner, breakfast is the lowest calorie meal, which means that young adults consume food mostly in the evening, which can result in digestive problems and early onset nutritional disorders. Third, assessment of the diet macronutrient composition has shown that nutrition is imbalanced. Thus, hygienic assessment of the medical university students' daily food intake revealed shortcomings in the nutrition setup of this population group, which should be eliminated in order to preserve and improve the health of future professionals through introduction of

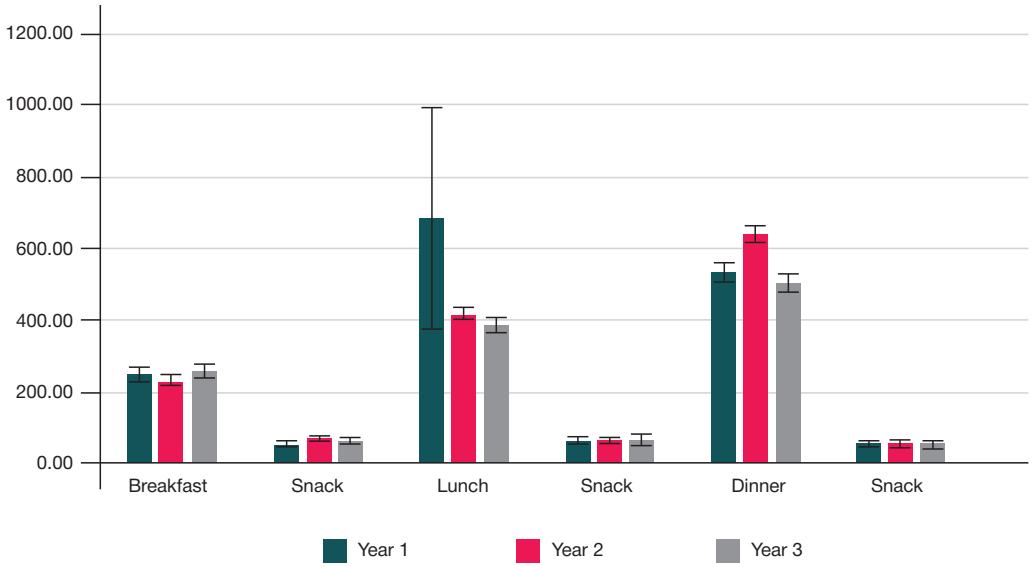

Fig. 4. Caloric content of the main meals of students of Dental Department (kcal)

preventive measures focused on healthy nutrition in the higher education system. In the future studies it is necessary to assess nutrition of different gender groups in order to trace the emerging nutritional stereotypes in groups of young men and women, considering the differences in age and the chosen specialty.

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INFLUENCE OF MODERN EDUCATIONAL ENVIRONMENT ON THE NEURO-MENTAL HEALTH OF SCHOOL-AGE CHILDREN

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The steadily growing prevalence of various psycho-social maladaptation forms among children and adolescents is reported all over the world. The today's tempo of life associated with active introduction and widespread use of information technology results in the dramatic increase in educational workload, thereby provoking a significant increase in the prevalence of borderline mental disorders, primarily neurotic disorders in schoolchildren. Investigation of various forms of neuro-mental health impairment and somatic disorders in school-age children is among research priorities in different countries. The paper provides systematized data of the studies focused on assessing neuro-mental disorders in schoolchildren.

Keywords: children's health, factors of school environment, school-related diseases, school educational environment, children's neuro-mental health

Author contribution: Milushkina OYu, Kozyreva FU, Pivovarov YuP — academic advising; Dubrovina EA, Grigoreva ZA — data acquisition, statistical processing, literature review, manuscript writing.

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Received: 20.10.2023 **Accepted:** 25.12.2023 **Published online:** 30.12.2023

DOI: 10.24075/rbh.2023.085

ВЛИЯНИЕ СОВРЕМЕННОЙ ОБРАЗОВАТЕЛЬНОЙ СРЕДЫ НА НЕРВНО-ПСИХИЧЕСКОЕ ЗДОРОВЬЕ ДЕТЕЙ ШКОЛЬНОГО ВОЗРАСТА

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Во всем мире отмечают неуклонный рост различных форм психосоциальной дезадаптации у лиц детского и подросткового возраста. Современный ритм жизни с активным внедрением и повсеместным использованием информационных технологий приводит к резкому увеличению нагрузки в сфере образования, что провоцирует значительный рост пограничной психической патологии, в первую очередь расстройств невротического характера у школьников. Изучение форм нарушения нервно-психического здоровья и соматических расстройств у детей школьного возраста является одним из приоритетных направлений исследований в разных странах. В статье приведены и систематизированы данные исследований, посвященных изучению нервно-психических расстройств у школьников.

Ключевые слова: здоровье детей, факторы внутришкольной среды, школьно-обусловленные болезни, школьная образовательная среда, нервно-психическое здоровье детей

Вклад авторов: О. Ю. Милушкина, Ф. У. Козырева, Ю. П. Пивоваров — научное руководство; Е. А. Дубровина, З. А. Григорьева — сбор материала, статистическая обработка, анализ литературы, написание статьи.

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Статья получена: 20.10.2022 **Статья принята к печати:** 25.12.2023 **Опубликована онлайн:** 30.12.2023

DOI: 10.24075/rbh.2023.085

According to the state statistics and scientific research results, a negative trend in health indicators of children and adolescents is observed in Russia over almost three decades. Thus, according to the data available, physical education lessons at school are reported to be the main form of physical activity in primary school-age children. Furthermore, there is insufficient outdoor exercise, while high anxiety levels observed in primary school-age children are often associated with fears and worries directly related to school attendance [1–6]. Similar data are provided by researchers from different countries, which suggest steady deterioration of students' health; the growing prevalence of neurological and mental disorders, metabolic disorders (mostly obesity) is reported, along with high rate of childhood and adolescent suicide in a number of countries [7–13]. Since the individual's health formation depends on the combination of endogenous and exogenous factors he/she is exposed to, the currently ongoing research is focused on determining the causes of the neuro-mental and somatic health problems in school-age children. It is necessary to study the features of students' health formation at various stages of school ontogeny for further rational organization of preventive and health improving measures in educational institutions. It has been confirmed that the today's educational process adversely affects students' health. Thus, about 50% of schoolchildren show difficulty and disorders of adaptation to the educational environment factors, which, in turn, often results in significantly increased prevalence of functional nervous system impairment among schoolchildren [1–13]. The prevalence of chronic disorders among school-age children has significantly increased over the past two decades. According to the data of various studies, the prevalence of chronic disorders in high income countries varies between 3.5–35% of children under the age of 17 years [11–13]. Children with various neuro-mental and chronic disorders are at higher risk of psycho-social difficulties and developmental disorders compared to healthy peers. Furthermore, it has been confirmed that students with chronic disorders have a higher rate of stress, difficulty understanding and mastering the curriculum, as well as lower attendance later in life compared to healthy students [11].

At the same time, the major forms and possible causes of the increase in the prevalence of neuro-mental and somatic disorders in school-age children are inadequately disclosed

in the available literature. The study was aimed to review the available data of the studies focused on the position of the disease class "Mental and behavioural disorders" in the structure of incidence in terms of child-care attendance and incidence among school-age children, prevalence, age-related features and structure of this disease class, as well as the impact of educational environment factors on the development of neuro-mental disorders in school-age children.

Methods

A review of papers published in 2010–2022 in scientific and practical periodicals available from Russian and foreign databases (RSCI and PubMed, Cyberleninka) was performed.

Major types and prevalence of neuro-mental and somatic disorders in school-age children

Currently, about 60% of children have certain chronic disorders. Moreover, no more than 13% of pre-school children and 1–2% of adolescents can be considered perfectly healthy. Longitudinal studies have shown that in general in the 1–9 grades there is a negative trend in the health status of schoolchildren, the prevalence of chronic diseases increases, the occupancy rate for health groups III–IV increases due to a decrease in the number of children assigned to health groups I and II (in 2005–2010 the population of healthy schoolchildren (health group I) reduced from 4.3 to 0% in primary school and from 2.5 to 0% in high school) [1–16, 18]. According to the available data, nervous system disorders are reported in 12% of surveyed schoolchildren, while mental disorders are reported in 6% of school students [4]. As for the central nervous system (CNS) disorders, students have neuroses with predominant severe astheno-neurotic syndromes, mononeuroses (tics, enuresis, sluttering), vegetovascular dysfunction, pathocharacterological and psychopatic personality development, borderline intellectual functioning, epilepsy syndromes, remission of endogenous disorders in a large number of cases.

Some authors believe that the schoolchildren's health status is an integral indicator reflecting the effects of environmental and in-school factors, educational activities on the students' bodies that is composed from the levels of physical and intellectual development at different ages. This also depends on the state of neuroendocrine processes, body's functional status, immune defense, and adaptive reactions [14–16]. The combined effects of the educational process adverse factors result in deterioration of adaptive capacity of the nervous, endocrine, immune and other systems of the growing body, as well as in functional disorders and their progression, development of chronic diseases [11, 17, 18]. In recent decades, a steadily growing rate of various forms of psycho-social maladaptation among children and adolescents is reported in Russia, which leads to severe socio-economical consequences. The increase in the number of cases of criminal, addictive and auto-aggressive forms of behavioral deviations, drug abuse and early alcohol abuse, various forms of deviant behavior in adolescent students, borderline mental disorders, primarily neurotic disorders, in schoolchildren, is observed in Russia [1–7]. This is partially due to revolutionary changes in the field of information technology and a dramatic increase in information load, as well as to other changes in educational sphere [10–12]. Thus, the study focused on assessing the students' school experience demonstrates three models of school experience: "negative on all items" (37%), "negative on all items, except school workload" (40%) and "generally positive" (23%) [11].

The overall prevalence of all mental disorders is 10.11%, including 11.48% among boys and 8.68% among girls [12]. The other study was focused on assessing the causes and development conditions of school maladjustment and borderline mental disorders in 155 children/adolescents (108 males, 47 females) treated in the psychiatric day hospital for children and adolescents [14]. In this study, family history of neuro-mental disorders was reported in 50% of patients regardless of their gender; residual organic manifestations were reported in 94.8% of surveyed indivuduals, 61.3% showed somatic asthenization [14].

According to the available data, about 18.3% of surveyed schoolchildren and adolescent students have some neurodevelopmental disorders [19]. The growing rate of somatic disorders capable of causing certain mental disorders, such as depression, is reported. Thus, for example, a number of foreign studies have revealed excess body weight in 19.7%, obesity in 16%, and the combination of excess body weight and obesity in 35.7%. In addition, the trend towards the increase in the prevalence of excess body weight with age is observed [20]. Summarizing the results of domestic studies, we can also note the increase of incidence in terms of child-care attendance to 1779.1‰ among children aged 0–14 years [21]. The worst dynamics of health status is observed in individuals in their late teens (15–17 years). About 50% of students have career restraints due to health problems, 50–70% have health barriers to military service, and every fifth individual has reproductive problems. The study of the children and adolescent health status has shown that there has been a trend towards an increase in the incidence in terms of child-care attendance by 2–4% per year and in the prevalence of chronic disorders in Russia over 20 years; reduction of the number of healthy children in all age and gender groups is observed. According to official statistics, the overall incidence among children aged 0–14 years, including incidence among individuals in their early teens (10–14 years), exceeds 2400‰, while the incidence among individuals in their late teens (15–17 years) is close to 2000‰ [22].

The early research results demonstrate that anxiety (43%), oppositional behavior (30%), antisocial personality disorders (10%), alcohol (27%) and drug (18%) abuse in adolescents can sometimes be associated with persistent attention deficit hyperactivity disorder (ADHD) (in 50–80% of cases) [23]. According to a number of studies, such neuropsychiatric disorders, as anxiety and fear related disorders (30.7 ± 1.6%), somatoform (60.8 ± 2.8%) and hyperkinetic (61.4 ± 1.7%) disorders, are most typical for students attending gymnasiums and innovative schools. Behavioral disorders (53.2 ± 2.9%) are more typical for students attending comprehensive schools [24]. The prevalence rate of different borderline mental disorders of varying severity reaches 55%, where 80% is the share of preclinical forms, which usually remain undetected during the routine check-ups. Severe clinical symptoms of borderline neuro-mental disorders have been reported in 97.5 ± 0.5% of students attending innovative schools and 92.7 ± 1.5% of students attending comprehensive schools in various training periods. Insufficient provision of the educational environment psychological safety results in the emergence of a number of factors adversely affecting the students' mental and physical health and contributing to the educational process disruption [19, 24, 25].

Analysis of the prevalence of severe clinical depression, dysthymia and bipolar disorder among children and adolescents aged 6–16 years has shown that 2.004% of surveyed individuals have severe depression, 0.352% have dysthymia, and 0.856%

have bipolar disorder. The overall prevalence of severe mood disorders is 3.212% [26]. In addition, some authors note the impact of the high rate of psychosomatic complaints and behavioral deviations in adolescents, especially boys [27]. This is confirmed by domestic studies. Thus, it has been noted that the majority of students with mental retardation feel negative when trying to understand the terms related to school attendance: a negative attitude towards school attendance is reported in 57% of students [28]. Today, there are many studies focused on assessing cognitive features and adaptation of children and adolescents at school. However, neuro-mental disorders, social skills, communication, education/professional life and comprehensive studies are less thoroughly discussed [29].

Behavioral disorders associated with the disorders of intellectual development often become the causes of impaired social and psychological adaptation of students of this category later in life. According to the research data, neurosis and neurosis-like conditions prevail among pre-nosological forms of neuro-mental disorders in primary school students, while pathocharacterological reactions prevail in the middle and high school students [14, 24]. According to the research, about 40% of schoolchildren suffer from psychosomatic disorders; somatoform and psychosomatic disorders, long-term response to stress are observed in 77.3% of children having family problems; 22–23% show persistent behavioral deviations with pathocharacterological reactions. The analysis of the assessment results of 155 children and adolescents aged 10–15 revealed residual organic manifestations contributing to the development and decompensation of the disease manifestations in 147 patients (94.8%). Somatic weakness was reported in the majority of children (61.3%). The analysis of the subjects' family background showed that 74 children (47.4%) were brought up in intact families, and supportive parenting was reported in 43.2% of such families; as for single-parent families, the families with altered structure, supportive parenting was reported in 25.9% of cases. Hyperprotection and hypoprotection prevailed in cases of unharmonious parenting [14].

About 46% of schoolchildren have various astheno-neurotic disorders, increased irritability, irrational mood swings, concentration problems. Psychasthenic disorders in the form of various phobias (fear of the dark, being alone, school, bad marks) are also typical for students, some children suffer from repetitive movements (tics) [1–16, 24].

Assessment of academic success has shown that the majority of cases of persistent school failure result from various kinds of intellectual disability, such as mental retardation. Furthermore, certain cognitive disorders of mild severity, associated primarily with attention deficit and difficulty concentrating, are reported in every tenth school-age child [7, 11, 25]. The combination of adverse genetic, perinatal factors, primary residual damage to the brain structures changing their function results in the overall susceptibility to the disorders that can be induced by a wide variety of triggering external factors [23]. Today, the leading place in the structure of functional impairments and chronic disorders is occupied by mental and behavioral disorders [11, 14, 24, 26]. Furthermore, 39.4% of disorders are represented by neurological deficits, 17.4% are represented by residual organic CNS damage, 17.4% are represented by the diagnosed ADHD; specific disorders of the development of school skills are reported in 14.0% of cases [4]. Assessment of neurological disorders showed that complaints of neurological phenomena (sleep disorders, asthenic syndrome and mood swings, headache) prevailed among school students.

According to the available data, mental retardation is a large group of disorders characterized by intellectual and mental disability, generally due to developmental disorder; early developmental disorders of the CNS can be provoked by biological (genetic and intrauterine factors, perinatal disorders, chronic disorders and other conditions) and socio-psychological (emotional and social deprivation, stressful situations, educational neglect) factors [4]. Mental retardation represents a significant brain development slowdown most often detected when the child enters school that manifests itself as the lack of overall knowledge, narrow-mindedness, intellectual immaturity, poor intellectual orientation, predominance of gaming interests, emotional immaturity. Many children with mental retardation show signs of cerebasthenia and hyperdynamic syndrome. When assessing such children, speech and language delay, decreased mental performance due to deficiency and exhaustion of attention and memory are reported [4, 28, 29]. The study of psychosocial maladaptation in children and adolescents of grades 5–9 showed that the students having a negative experience of school attendance (many years of demonstrating a negative attitude to underachieving students and those unable to strictly observe classroom discipline of teachers and classmates) show low or even negative sociometric status index, more severe symptoms of the learning process inadequacy and decreased academic performance, higher severity of personality disorders, low self-esteem, increased motivation to avoid failure [30]. It was also shown that in classes with advanced study of certain disciplines training intensification during classes exceeded optimal (60–80%) and constituted 85–90%, while in the control group it did not exceed 80% [31].

Today, attention deficit hyperactivity disorder (ADHD) is among the most common nosological forms of neuro-mental disorders and represents the most common cause of behavioral disorders and learning difficulties in pre-school and primary school age children. According to the data of foreign and domestic epidemiological studies, the prevalence of ADHD among children of these age groups reaches 4.0–9.5%. Moreover, according to various authors, it varies between 12 and 29% of pediatric population. Physiological status of the child with ADHD is characterized by changes in the cerebral cortex regulatory influences on the subcortical structures, which is reflected in the brain energy state alterations [28]. This is associated with the increased tone of the autonomic nervous system sympathetic and parasympathetic divisions and impaired coordination ability. The major ADHD manifestations include disorders of attention (attention deficit), signs of impulsivity and hyperactivity. The decrease in the hyperactivity symptom severity with age is reported, however, attention problems, distractibility, and impulsivity can persist for a long time, constituting a factor of neurosis, social maladaptation [23, 26–32].

The analysis of data on the prevalence of functional nervous system disorders and chronic neuro-mental disorders in schoolchildren has shown that their rates in intensive schools are three times higher than in conventional schools [33].

At the same time, 40–50% of generally healthy students have some symptoms of functional nervous system disorders [4, 34]. Preclinical forms of functional nervous system disorders found in students include disseminated microsymptoms of organic lesion, dyslalia (cluttering), labyrinthopathy, mental retardation [4]. Psychological trauma finds a fertile soil in students with premorbid background and biological insufficiency (weak type of higher nervous activity, residual microsymptoms of organic lesion), which, in turn, result

in monosymptomatic neuroses (enuresis, sluttering, hyperkinetic and neurotic disorders) [17–34]. Some researchers believe that the nervous system asthenization results from excess load on the CNS followed by impaired cortical neurodynamics, resulting in the fact that negative emotions, feelings of danger, distress, uncertainty, ambiguity predominate in schoolchildren, while the screening tests show predominance of neurological complaints (sleep disorders, tearfulness, headache) [4, 8–34]. Functional nervous system disorders in the form of vascular dysfunction are reported in 19.3% of schoolchildren, asthenic syndrome in 8.3%, closed head injury sequelae in 4.9%, and minimal brain dysfunction in 2.8% of students [4, 34]. It is assumed that the emergence and development of a number of functional disorders and chronic diseases are largely associated with the increased psychoemotional load and the students' low physical activity [11, 34]. Furthermore, some authors assume that delayed formation of connectivity between the leading brain structures underlies many borderline mental disorders in children at early stages [23]. According to the assessment results of 70 primary school-age children, in 50 cases (71.4%) personal characteristics were revealed that made it possible to distinguish five variants of behavior. Predominant types were as follows: irritability (44.5%), adjustment disorders (42.8%), and increased irritability (20.4%) [35].

Thus, of neuro-mental disorders, functional disorders of the CNS, neuroses and astheno-neurotic manifestations, ADHD predominate in school-age children, while pathocharacterological reactions are more typical for older students.

According to domestic studies, a negative dynamics of the incidence of mental disorders in children and adolescents is observed since 2007. In the Russian Federation, the number of reported cases of mental disorders was 703,200 in children aged 0–14 years and 273,500 in adolescents aged 15–17 years, which constituted 16.5 and 6.5% of the total number of patients, respectively [36]. The share of mental disorders in the overall incidence structure is small (about 3%): these rank 10th in children and 11th in adolescents [37]. In 2015, it was found that at least 11–16% of children and adolescents had at least one mental disorder. Furthermore, according to various research data, the global prevalence of mental disorders among children and adolescents is 3.5–38.3% [37].

It is necessary to note the relationship between somatic disorders/impairments and secondary mental disorders in adolescents. The analysis of somatic disorders in school-age children has shown that diseases of the respiratory system occupy the leading place in the structure of incidence in terms of child-care attendance (58.49 and 58.41%), diseases of the digestive system occupy the second place (5.84 and 5.30%), and the third place is occupied by diseases of the eye and adnexa (5.20 and 5.33%). Furthermore, the most prevalent diseases include infectious and parasitic diseases, diseases of the skin, nervous and musculoskeletal systems [38, 39]. The growing rate of injuries (by 10.40%) and diseases of the digestive system (by 2.53%) is reported in children of this age group, which can be indicative of the problem related to shaping good nutritional habits and health preserving behavior [11, 15]. According to some authors, the combined share of the listed above disease classes is 86.2% [21]. The more detailed analysis of the structure of the leading disease classes has shown that diseases of the respiratory system predominate mostly due to seasonal ARI and ARVI (94.4%), influenza, acute sinusitis, acute nasopharyngitis, acute bronchitis. Abnormalities associated with various visual acuity disorders predominate among eye disorders (52.4%): myopia, hyperopia, astigmatism, strabismus, accommodative dysfunction; acute inflammatory disorders of the eye account for 9.7% [38]. The majority of authors note a significant role in pediatric and adolescent morbidity played by school related illnesses [6]. Constant eye strain contributes to progression of vision problems, physical inactivity plays a negative role, since it disturbs normal development of the musculoskeletal system, circulatory and respiratory system organs, which results in disorders of these systems later in life [11]. In the class of disorders of the musculoskeletal system, the first places are occupied by flat feet, spinal instability, scoliosis (98.3%). These disorders are determined and to the great extent dependent on the school environment factors [21]. The share of children with normal body weight has decreased by 16.9% in boys and by 13.9% in girls. Underweight individuals predominate among children with abnormal body weight (80%). The growing share of runt children is reported (1.3%) [22]. The prevalence of various health problems among first-grade students is 1635‰, while the rate of functional impairment is 1100‰ and the rate of chronic disorders is 535‰. Various physical development disorders are found in 19.0% of primary-school students, among them there are many children with physical developmental delays. In early 2000s, functional disorders of the musculoskeletal system, neuro-mental disorders, functional disorders of the digestive and cardiovascular system moved to the leading places in first-grade students, while in individuals in their late teens these places were occupied by neuro-mental disorders, functional disorders of the cardiovascular and musculoskeletal systems, visual problems. The growing share of functional disorders of the circulatory system in the structure of morbidity of schoolchildren of all age groups should be noted. Among functional disorders found in schoolchildren attending institutions of new type, disorders of the endocrine, cardiovascular, musculoskeletal, and nervous systems are the most prevalent [11, 15–18, 22, 33]. It has been confirmed that the growing rate of somatic disorders in children and adolescents often results in the development of secondary mental disorders (anxiety, depression, body dysmorphic disorder, etc.), while the combination of somatic and mental disorders significantly impairs the quality of life and adaptation [40].

Thus, high prevalence of various neuro-mental disorders among children and adolescents should be noted, along with their association with a number of out-of-school and education-related factors. The extraordinary diversity of the disease entities in mental disorders of children and adolescents requires a more thorough investigation of the risk factors of this group of disorders. Some authors note the role played by educational workload and educational process intensification, high psychoemotional stress associated with learning in the development of a wide variety of adolescent mental disorders. Furthermore, excess educational workload can result in somatic disorders being a major risk factor of severe mental illness and formation of the "vicious circle", thereby significantly deteriorating correction of condition in such patients later in life. The complex interplay between biological, socio-economic, environmental, psychological and educational factors, living conditions, lifestyle, quality of medical care is poorly understood. It is reasonable to study the major aspects of the impact of educational process and related school risk factors of neuro-mental disorders in children and adolescents.

Impact of modern educational environment factors on the schoolchildren's neuro-mental health

The data of many studies demonstrate unfavorable changes in the major pediatric health indicators at school, which is largely due to the fact that advanced educational technologies

do not undergo sanitary and hygienic testing aimed at assessing safety for schoolchildren's health. Under exposure to increasing educational workload, training intensification and informatization, mastering the curriculum is achieved through significant strain on the students' body functional capabilities. According to the results of some domestic studies, the most significant determinants of students' health status include the increased intensity and monotony of school work, intellectual workload, reduced duration of breaks and rehabilitation deficit index. Some authors believe that organization of educational process and school meals is a leading risk-inducing factor of neuro-mental and somatic disorders in schoolchildren, regardless of the educational institution type and grade [36]. Today, the issue of the relationship between the microsocial environmental, constitutional biological, exogenous organic and somatogenic factors contributing to the development of borderline mental disorders in children and adolescents showing school maladjustment remains urgent [14]. Some studies show the association of school maladjustment and borderline mental disorders with the family history of neuro-mental disorders [13]. According to the research conducted by pediatricians, current situation is characterized by the presence and growing rate of unfavorable in- and out-of-school factors affecting the students' health. It is also characterized by growing rate of disorders, regardless of the form of training [30]. The most significant psychotrauma-inducing stimuli include excess educational workload and disruption of the educational process (especially in schools of new type). A number of authors believe that it is these factors that cause neurotic disorders with further somatization of neurosis, predominance of visceral symptoms and impaired function of organs and systems, as well as reduced overall resistance of the growing body [33–34, 41].

About 50% of schoolchildren have problems related to adaptation to the educational environment factors due to adverse effects of modern educational environment factors. A significant increase in the prevalence of the nervous system functional disorders among schoolchildren has been reported [4–6]. It has been found that high educational workload, including that experienced when taking extra classes, long time spent on the computer, impaired daily routine, insufficient sleep, conflicts at school and in the family, psychosomatic disorders in teachers and other factors play an important role in the development of neurotic mental disorders (asthenic and neurotic reactions, neuroses) [18, 23, 30, 31].

The growing rate of neuro-mental disorders is largely related to extensive use of digital technology in the educational process [42]. The emergence and development of new digital informational and educational environment has some positive aspects, but is also characterized by a number of additional factors capable of adversely affecting the students' health status. In the modern educational process, the students are exposed to the combined effects of electromagnetic emission and acoustic impact, extra static and psychoemotional stress, educational process intensification and increased visual load associated with introduction of digital tutorials with various font design since the very beginning of training. Today, the impact and possible adverse effects of exposure to these school risk factors on the students' health, child's body functional state and development of education-related disorders are poorly understood [8, 11]. It has been confirmed that the use of advanced information technology and Wi-Fi systems in the educational process results in transformation of training condition, increased effects of electromagnetic waves of various ranges, increased noise levels [43]. Noise exposure degrades the quality of training and sometimes provokes pediatric asthenic and neurological disorders (fatigue, overall exhaustion, headache and vertigo). In addition, the use of gadgets significantly increases visual load and requires specific operating conditions (for example, certain illumination levels in classroom), which, in turn, can further worsen the described symptoms [44]. According to the sanitary and hygienic testing results, about 17% of institutions have increased indoor noise levels [45]. The growing body of research demonstrates adverse effects of digital tutorials on the health status of schoolchildren, which is due to the use of different font designs creating excess visual load and provoking fatigue, its cumulation and exhaustion in children. In this regard, the hygienic control of electromagnetic emission, noise levels, and standardization of the processes of using electronic educational resources becomes relevant.

The today's educational process requires high concentration of attention, ability to constantly promptly switch between the educational tasks. This, in turn, contributes to the cognitive function intensification and neuro-mental overload, often resulting in deterioration of adaptation and children's learning activity [11, 43]. Modern educational system has evolved towards the increasing amount and complexity of academic information, rapid intellectual activity intensification, introduction of new academic disciplines and programs. The educational process organization is among major factors affecting the students' health. It should be noted that educational institutions not always comply with the sanitary legislation requirements for educational process organization [31, 33]. The today's educational system is primarily focused on the training intensification, and, despite wide variety of training programs, the majority of such programs are not focused on preservation and improvement of students' health [31, 43]. It has been found that the majority of reforms introduced into the educational system in combination with the existing extracurricular workload adversely affect the children's somatic and neuro-mental health. The steady increase in the academic workload results in compensation for large amounts of time spent on learning by reducing sleep and physical activity. According to the available data, 75% of schoolchildren are physically inactive, 40–55% of surveyed individuals demonstrate severe fatigue in the end of the school day or week. Furthermore, elevated blood pressure is reported in 60%, and neurosis-like reactions are found in 80% of children. The listed above responses contribute to the disorders of cardiovascular and musculoskeletal systems, autonomic dysfunction and neuro-mental disorders later in life [11]. The studies have shown that when conventional forms of training are used, 50% of schoolchildren are at the average level of neuro-mental development, 35% are at the level below average, 15% show underdevelopment. In the group of students with intense forms of training, 55% of students are at the average level of neuro-mental development, 25% are at the level above average, 20% are at the level below average. When performing psychological testing of students using the Kettle test, the researchers have found that 30% of surveyed individuals in conventional classes are at risk of borderline mental disorders: they demonstrate high levels of anxiety, irritability, low activity and intelligence, high sensitivity [8]. Among adolescents enrolled in intensive training programs, the majority of students demonstrate high neuroticism: their share is 66.6% vs. 21.4% in comprehensive classes. In students of the lyceum classes with normal neuroticism levels, the average score of neuroticism severity is higher than that of schoolchildren attending comprehensive classes (40.8% vs. 36.2%), which indicates approaching the upper limit of normal for this neuroticism level [5].

Thus, a number of medical experts believe that high educational workload currently represents the most negative factor of school environment [1–8, 25, 46].

It should be noted that even compliance of educational institutions with the hygienic requirements does not ensure no of out-of-school risk to the health of schoolchildren, since the risk is most often associated with domestic surroundings, family members' habits and knowledge about healthy lifestyle (rational nutrition, adherence to sleep and wakefulness, work and rest regimes) [4, 8, 9, 11, 47]. Currently, the issue of childhood and adolescent psycho-traumatic factors as the basis for the broad spectrum of psychosomatic and neurotic disorders, high risk of severe depression and suicide remains relevant. Psycho-traumatic factors are a multidisciplinary problem that requires coordination of the in-school and out-of-school activities, since these factors are often associated with not only poor relationships in the class and school community, but also with parents, their communication with the child and with each other [1–16]. It has been proven that poor psychological safety of the educational environment, inadequate school climate, pedagogical violence, didactogeny, bulling and victimization contribute to shaping mental and physical health of individuals involved in educational process [48]. In addition, the emergence and development of mental disorders are influenced by emotional instability, high levels of anxiety, psychovegetative lability, as well as by mistreating victim by the family and teachers, which contributes to prolonged stress followed by the development of neuro-mental disorders resulting in difficulties with social functioning restoration later in life [48]. Psychosomatic and neurotic disorders in schoolchildren are often associated not only with poor relationships between the student and the teacher and peers with each other, but also with the parents' personalities playing an important role in the child's development, his/her response to bulling and pedagogical violence, as well as in the development of didactogeny, post-traumatic and post-didactic stress disorders [48].

CONCLUSION

Thus, when considering modern educational environment factors adversely affecting the students' health, we should distinguish increased educational workload, unregulated use of digital technology in educational process, as well as significant effects of a number of psychosocial traumatic factors (bulling, conflicts at school, pedagogical violence, family problems). The increasing share of school-related health problems in the structure of functional disorders and chronic diseases of schoolchildren dictates the need for optimization of learning conditions, which is an urgent task. Neuro-mental disorders that are most common in students include borderline mental disorders, anxiety disorder, behavioral disorders. Borderline mental disorders in children/adolescents showing school maladjustment are based on complex pathogenetic mechanisms, biological (organic) and psychogenic (neurotic), which determine the choice of treatment/rehabilitation and preventive programs. Such disorders can be prevented only via identification of individual features of schoolchildren's mental development. Such measures should supplement systemic organization of activities aimed at students' health improvement.

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