

RUSSIAN BULLETIN OF HYGIENE

SCIENTIFIC MEDICAL JOURNAL

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ADDRESS Ostrovityanov St. 1, Moscow, 119997, Russia

Indexed in RSCI. IF 2018: 0,5

Open access to archive



Issue DOI: 10.24075/rbh.2026-02

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; address: Ostrovityanov Street 1, Moscow 119997 Russia

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Approved for print 30.06.2026

Circulation: 100 copies. Printed by Print.Formula

www.print-formula.ru

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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.2026-02

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);

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Подписано в печать 30.06.2026

Тираж 100 экз. Отпечатано в типографии Print.Formula

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ASSESSMENT OF HEALTH IMPROVEMENT EFFECTIVENESS IN CHILDREN IN SUMMER CAMPS: MODERN APPROACHES AND INDICATORS

Sonkin VD, Goncharova GA 


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Stationary summer recreation camps provide opportunities for comprehensive health improvement and optimal physical development of children and adolescents. However, the issue of evaluating the effectiveness of health measures during a single session (typically lasting 21 days) remains relevant. The paper is focused on the analysis of modern approaches to physiological and hygienic assessment of the effectiveness of recreation and health improvement in children and adolescents in summer recreation camps, considering the short duration and complex nature of the health interventions. Additionally, it explores prospects for using modern biomedical technologies to enhance the reliability and information value of methods for assessing health-improving effects. Promising methods include those based on bioelectrical impedance and the use of digital health monitoring systems, considering the child's baseline health status and individual characteristics.

Keywords: children's health, summer camps, assessment of health improvement effectiveness, physical development, functional tests, individual approach

Funding: the study was conducted as part of the state task for the Institute of Child Development, Health and Adaptation No. 073-00070-25-02 dated 21 April 2025 on the topic "Updating the Criteria for Assessing the Effectiveness of Children's Health Improvement in Stationary Organizations for Children's Recreation and Health Improvement".

Author contribution: Sonkin VD — concept, search for and analysis of literary sources, manuscript writing and editing; Goncharova GA — search for and analysis of literary sources, manuscript writing, editing, and formatting.

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Received: 21.11.2025 **Accepted:** 11.03.2026 **Published online:** 01.06.2026

DOI: 10.24075/rbh.2026.158

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ОЦЕНКА ЭФФЕКТИВНОСТИ ОЗДОРОВЛЕНИЯ ДЕТЕЙ В ЛЕТНИХ ЛАГЕРЯХ: СОВРЕМЕННЫЕ ПОДХОДЫ И ПОКАЗАТЕЛИ

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Летние стационарные оздоровительные лагеря обеспечивают возможность всестороннего укрепления здоровья и оптимального физического развития детей и подростков, однако актуальным остается вопрос оценки эффективности оздоровления за одну смену (как правило, продолжающуюся 21 день). Целью работы было проанализировать современные подходы к физиолого-гигиенической оценке эффективности отдыха и оздоровления детей и подростков в летних стационарных оздоровительных лагерях с учетом небольшой продолжительности и комплексного характера оздоровительного воздействия, а также перспективы использования современных биомедицинских технологий для повышения надежности и информативности методов оценки оздоровительного эффекта. Перспективными представляются методики на основе биоэлектрического импеданса и использование цифровых систем мониторинга здоровья с учетом исходного состояния и индивидуальных особенностей ребенка.

Ключевые слова: здоровье детей, летние лагеря, оценка эффективности оздоровления, физическое развитие, функциональные пробы, индивидуальный подход

Финансирование: исследование выполнено в рамках государственного задания ФГБНУ «Институт развития, здоровья и адаптации ребенка» № 073-00070-25-02 от 21.04.2025 по теме «Актуализация критериев оценки эффективности оздоровления детей в стационарных организациях отдыха детей и их оздоровления».

Вклад авторов: В. Д. Сонькин — концепция, поиск и анализ литературных источников, написание и редактирование текста; Г. А. Гончарова — поиск и анализ литературных источников, написание, редактирование и оформление текста.

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Статья получена: 21.11.2025 **Статья принята к печати:** 11.03.2026 **Опубликована онлайн:** 01.06.2026

DOI: 10.24075/rbh.2026.158

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Modern research reports negative trends in children's health: decreased physical activity, deterioration in physical development, and the increased incidence of acute and chronic diseases among school-age children, necessitating effective health measures [1].

To assess and improve the effectiveness of health improvement programs, it is necessary to introduce simple, accessible in the context of summer camps, and at the same time informative methods that allow one to estimate the dynamic changes in children's physical development, functional state and general health during the session [2–5].

In the current context of socio-economic changes against the backdrop of deteriorating health of the younger generation, improving the system of summer recreation camps is becoming an important state task aimed at preserving and improving the health of children [1, 6].

The review is focused on evaluating modern approaches to physiological and hygienic assessment of the effectiveness of children's and adolescents' recreation in summer recreation camp considering the short duration and complex nature of the health-improving effect, as well as prospects for using modern digital and biomedical technologies to enhance

the reliability and information value of methods for assessing health-improving effects.

Role of summer recreation camps in development and health improvement of children

Summer recreation camps for school-age children are characterized by systematic organization of a rational motor regimen, diet improvement, implementation of the participants' social activity considering their personal interests, as well as the exposure to natural health-improving factors, i.e. sun, air, and water, having a beneficial effect on the immunity and psycho-emotional state [5, 7].

All the above has a positive effect on the self-realization and socialization of children and adolescents, that is, it forms the socio-pedagogical aspect of health improvement [8]. Furthermore, the children's psycho-emotional and physical state is improved, largely due to the provision of high physical activity in the format of various sports-oriented events [9]. However, the question of how this improvement can be measured and evaluated is still a matter of debate [4, 5, 10].

In summer recreation practice, such an assessment is carried out by medical professionals on the basis of current guidelines approved in 2019 [2]. According to the guidelines, at the beginning and in the end of the session, the summer camp medical staff records the following child's morphofunctional state indicators, which provide the basis for drawing a conclusion about the health improvement program effectiveness:

- height (body length);
- body weight;
- muscle strength (handheld dynamometry);
- vital capacity (VC).

These indicators are evaluated during follow-up throughout the health improvement session (lasting at least 21 days). To ensure the reliability and comparability of the results of assessing the effectiveness of children's health improvement in summer camps, it is important to adhere to the same timing of measurements and requirements for performers. Baseline measurements are performed at the beginning of the session: on days 1–2 after arrival. Measurements are taken in the camp's medical unit to record baseline data. In the end of the session, 1–2 days before departure, final measurements are carried out to evaluate the dynamic changes. In the camp, these are carried out by a staff physician or nurse, who had been trained and use calibrated equipment. It is important that the measurements are carried out by the same specialists using the same methods and instruments, under the same conditions, to ensure data consistency and high assessment quality.

Along with the above quantitative indicators, the following is also recorded:

- physical development (harmonious, disharmonious — underweight; disharmonious — overweight);
- health group — first, second, third;
- group for physical education classes — basic, preparatory; therapeutic exercise group.

It is recommended to express the total dynamics of the indicators in points in accordance with a specially developed scale [2].

A differentiated approach is used to assess the dynamic changes in body weight, depending on the baseline physical development. In contrast to the standards of 50–60s of the last century, when any weight gain was considered as a positive trend, the current guidelines suggest that the weight gain represents a sign of health improvement in cases of harmonious physical development or disharmonious physical development due to underweight, while in overweight

individuals the decrease in this indicator would be a health improvement manifestation.

Recently, it was proposed to take into account the child's body type when analyzing the dynamic changes in physical development indicators, as this has a great effect on the direction of the body's adaptive changes during health improvement [11, 12].

According to the guidelines [2], the total score for each child expressed in health improvement effectiveness indicators should be assessed. When the child's total score (based on the height, body weight, muscle strength, and respiratory function measurements) for the health improvement session is 12–16 points, the health improvement effectiveness is considered to be high; 6–11 points — the health improvement effectiveness is considered to be low; below 6 points — no health-improving effect.

A sufficiently large number of published reports are focused on scrupulous implementation of the guidelines on assessing the effectiveness of organized summer recreation for children and adolescents in various regions of the Russian Federation [13, 14, etc.]. In most cases, the authors note a fairly high efficiency of health improvement (over 80%), but there always remains a part of the child population in whom health improvement is ineffective (usually within 5%). This may be due to both shortcomings in the organizational and technological procedures in a particular health institution and the specific individual characteristics of some participants.

Thus, classical biomedical criteria are basic in terms of assessing the effectiveness of health improvement: dynamic changes in anthropometric indicators (height, body weight, body mass index — BMI); dynamic changes in physiological indicators (blood pressure, heart rate, vital capacity, handheld dynamometry data, body's adaptive-homeostatic responses); functional tests (exercise tests); immunological indicators (incidence rate, rate of complications of chronic disorders, etc.). The effectiveness of these criteria has been confirmed by numerous studies by domestic and foreign researchers [1, 7].

Along with biomedical indicators, social and hygienic criteria are also distinguished: incidence rate by visits, number of sick days per 100 children, rate of infectious and noncommunicable diseases, dynamics of children's health groups, as well as indicators of adaptation to camp conditions and the social environment [8].

Modern research emphasizes the importance of psychological criteria, including assessment of psycho-emotional state, sleep quality, emotional well-being, subjective satisfaction with the time in the institution (surveys of children and parents), assessment of motivation and communication skills (the use of questionnaires, surveys, and digital tools allow us to track these indicators in real time) [4, 8, 10].

Further development of the system of stationary summer recreation camps meets the interests of the younger generation and the expectations of parents [5]. The inclusion of novel, advanced methods and technologies allowing for the more informative assessment of the health status of participants and facilitating the analysis of individual characteristics in a stream of diverse information represents one important direction of such development [10, 11].

Possible aspects of modernizing the methodology for assessing the effectiveness of summer recreation in health improvement institutions are as follows:

- the use of estimated indices, which are often more sensitive in terms of information value, along with absolute anthropometric and physiometric indicators [11, 15];
- consideration of individual anthropometric characteristics and body type when analyzing shifts in physical development and the results of functional tests [11, 12];

- introduction of new research methods into the practice of medical supervision under the conditions of a summer recreation camp — bioelectrical impedance analysis [4, 16], cardiointervalometry [11]; motor activity measurement [10, 17];
- development of software and application of digital technologies for automated calculation of quantitative indicators of health improvement and its effectiveness under the conditions of summer stationary recreation camps [18, 19].

What fresh ideas and innovative methods are being proposed to improve the health improvement assessment accuracy and comprehensiveness?

First, integration of advanced methods, such as variational cardiointervalometry (determination of the body's adaptive capacity and the balance of the autonomic nervous system branches) [11, 20], bioelectrical impedance analysis (quantitative assessment of body composition and metabolism) [21], infrared thermography (identification of vascular dysfunction in the limbs and skin, assessment of the body's temperature status) [22, 23], and accelerometry (quantitative assessment of the amount and intensity of physical activity) [24], allows one to complement the traditional approach with new possibilities. These methods provide more in-depth and accurate monitoring of children's condition, which is especially important in the context of limited time spent in the camp.

Second, assessment digitalization and automation play a key role in improving the efficiency and convenience of camp staff. The integration of digital platforms and mobile applications allows for the collection, processing, and interpretation of large amounts of data, creating a personalized health pattern for each child [4, 25, 26]. Such software is widely used in practice nowadays [18, 19].

The third important aspect is related to personalization of approaches to the formation of environmental conditions contributing to health improvement. Consideration of the children's

constitutional characteristics, which has become widespread in physical education in recent decades [4, 11, 12], in summer camps can help increase confidence in the results and improve the quality of services provided [3, 12, 14, 27].

In addition, gamification and the involvement of children and parents in the health monitoring process are important areas. The game format increases children's interest and motivation, making the process of monitoring their health a fun and enjoyable activity [28, 29].

Training of qualified personnel and regular professional development of camp staff are necessary for successful implementation of new technologies and methods. Only well-trained specialists can effectively use modern tools and provide an individual approach to each child [30, 31].

CONCLUSION

The shortcomings and limitations of existing methods for assessing the health-improving effects of summer camps are associated with two objective factors: the need to use the simplest and most accessible methods to diagnose the functional state and the short-term effect of camp health factors, since 21 days represent the minimum time for adaptive changes in the human body. These circumstances determine the need for the search, development and implementation of more reliable, informative and sensitive diagnostic procedures and indicators, which is the focus of scientific research at the current stage. Cardiointervalometry, bioelectrical impedance analysis, infrared thermography, accelerometry, and other modern approaches can be promising express methods to assess the body's functional state. The development of appropriate approaches is a pressing issue in the physiology of development and adaptation of a child in order to strengthen his/her health.

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THE IMPACT OF THE EDUCATIONAL PROCESS ON THE DIET AND EATING BEHAVIOR OF MEDICAL STUDENTS

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The problem of inadequate nutrition among students is especially significant at medical universities, where the academic workload is high. It is particularly important because the years spent in higher education are when long-term eating habits are formed, and the body undergoes its final stages of development. In this work, we aimed to assess how the intensity of the educational process affects daily diet and eating behavior of students, and suggest substantiated preventive measures. The cross-sectional study involved 199 second-year students (114 women and 85 men; mean age 19.5 ± 1.5 years), who completed a questionnaire; the results were then processed using descriptive statistical methods. We assessed the caloric and macronutrient composition of the diet, dietary regime, and behavioral factors. The mean dietary energy intake was 1597.3 ± 27.1 kcal; the diet was calorie-deficient for 122 participants (61.3%) and adequate for 59 (29.6%) ($p < 0.001$). By nutrient, 122 participants (61.3%) did not consume enough protein, 117 (58.8%) lacked sufficient fat, and 100 (50.3%) had insufficient carbohydrate intake. Young men consumed more energy than young women (1701.6 ± 31.8 vs. 1520.4 ± 25.3 kcal; $p < 0.001$). Only 44.4% of the respondents ate three meals a day, while 24.2% ate two or less. Regular consumption of fast food products was admitted by 157 students (78.9%). The resulting data indicate systemic nutritional deficiencies and the need to implement preventive measures in educational settings.

Keywords: health, nutrition, daily ration, educational process, student

Author contribution: the authors have made equal contributions to this publication.

Compliance with ethical standards: the study was consistent with the principles of biomedical ethics. The survey was anonymous, which ensured confidentiality of the information provided. Each participant submitted a signed informed consent form before the survey.


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Received: 23.03.2026 **Accepted:** 04.04.2026 **Published online:** 02.06.2026

DOI: 10.24075/rbh.2026.159

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ВЛИЯНИЕ УЧЕБНОГО ПРОЦЕССА НА СУТОЧНЫЙ РАЦИОН И ПИЩЕВОЕ ПОВЕДЕНИЕ СТУДЕНТОВ МЕДИЦИНСКОГО ВУЗА

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Проблема нерационального питания студенческой молодежи приобретает особую актуальность в условиях высокой учебной нагрузки медицинского вуза, поскольку в студенческие годы формируются устойчивые пищевые привычки, завершается развитие физиологических систем. Целью исследования было изучить влияние интенсивности образовательного процесса на структуру суточного рациона и пищевое поведение студентов с последующим обоснованием профилактических мер. Проведено поперечное исследование с участием 199 студентов 2-го курса (114 девушек и 85 юношей, средний возраст $19,5 \pm 1,5$ лет), предполагавшее анкетный опрос и применение методов описательной статистики. Оценены калорийность и макроэссенциальный состав рациона, режим питания и поведенческие факторы. Средняя энергетическая ценность рациона составила $1597,3 \pm 27,1$ ккал; дефицит калорийности выявлен у 122 человек (61,3%) против 59 (29,6%) с нормальными показателями ($p < 0,001$). Недостаточное потребление белка отмечено у 122 студентов (61,3%), жиров — у 117 (58,8%), углеводов — у 100 (50,3%). Юноши потребляли больше энергии, чем девушки ($1701,6 \pm 31,8$ против $1520,4 \pm 25,3$ ккал; $p < 0,001$). Лишь 44,4% респондентов придерживались трехразового питания, 24,2% питались два раза в день и реже. Регулярное употребление фастфуда отмечено у 157 обучающихся (78,9%). Полученные данные свидетельствуют о системной нутритивной недостаточности и необходимости организации профилактических мероприятий в образовательной среде.

Ключевые слова: здоровье, питание, суточный рацион, учебный процесс, студент

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

Соблюдение этических стандартов: исследование соответствовало принципам биомедицинской этики. Анкетирование было анонимным, что обеспечивало конфиденциальность предоставленной информации. Каждый участник дал информированное согласие на участие в исследовании до начала опроса.

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Статья получена: 23.03.2026 **Статья принята к печати:** 04.04.2026 **Опубликована онлайн:** 02.06.2026

DOI: 10.24075/rbh.2026.159

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A healthy lifestyle is a key factor in maintaining and improving population health, and proper nutrition is one of its main components. For young people, especially those in higher education, nutrition is particularly important because student years are when physiological systems finish developing and lifelong eating habits form [1, 2].

Numerous studies report pronounced negative trends in eating patterns and behavior among students. An analysis of the actual diet composition confirms that it is inadequate in both quality and energy value [3]. The ration was noted to shift towards excessive fat content and easily digestible carbohydrates, while the amounts of protein, vitamins,

and minerals are insufficient. In addition, this population tends to resort to fast food often [4]. Improper eating patterns caused by heavy academic workloads and limited free time, such as irregular meals, skipping breakfast, and consuming most calories in the evening, remain a serious problem [5].

The cyclical character of the educational process has a significant effect on students' nutritional status. It has been established that their diets deteriorate during the examination period: the share of simple carbohydrates grows, the number of meals a day decreases, there develops a stronger reaction to stress that increases the risk of nutrition-associated disorders [6]. Another important aspect is the educational environment itself. Medical students often exhibit deviant eating behavior, including overeating or excessive dietary restriction, which are associated with severe anxiety and dissatisfaction with their own bodies [7]. International students face additional risks rooted in the need to adapt to new social and climatic conditions [8].

Promising approaches to prevention include expanding hygiene education programs, systematically monitoring students' nutritional status, and improving the organization of university nutrition. The latter, including introduction of the principles of healthy, balanced eating into canteen operations, is a particularly promising approach, because it promotes sustainable healthy eating habits [9, 10]. Furthermore, research indicates that organized and structured nutrition can offset certain deficiencies in an individual's diet, although it demands continuous quality control and diverse menus [11].

This study aimed to assess the influence of educational intensity and the factor of educational environment on the composition of medical students' daily diets and on their eating behavior, and to propose substantiated preventive measures.

METHODS

The study involved 199 second-year VSMU students — 114 women and 85 men — from the general medicine faculty ($n = 138$) and pediatric faculty ($n = 61$). The mean age of the participants was 19.5 ± 1.5 years. The study was conducted between March and April 2025.

The study was cross-sectional and single-stage. To collect the primary data and register the actual nutrition information, we created a survey in Yandex.Forms that asked about demographic characteristics (gender, age, faculty), dietary patterns and meal frequency, meal intervals, and the frequency of consumption of certain foods, including potentially harmful items (fast food, energy drinks). The survey revealed the factors influencing eating behavior (stress, academic workload, financial constraints).

Based on the collected data, we calculated the daily diet, its macronutrient composition (protein, fat, carbohydrate), and its energy content (kcal). The resulting figures were compared with the physiological standards: for caloric content,

the range was 1900–2400 kcal, for protein — 67–84 g, for fat — 63–80 g, for carbohydrates — 266–336 g. Additionally, we evaluated the diet's structure for the inclusion of mandatory components (fruits, vegetables) and the presence of harmful products.

The resulting data were processed in MyOffice 2022 software package (New Cloud Technologies; Russia). We used descriptive statistics: continuous data were presented as mean (M) and standard deviation (σ); qualitative variables were reported as absolute and relative values (percentages).

RESULTS

Analysis of the data ($n = 199$) showed a pronounced imbalance in students' dietary patterns (Table). "Mean energy intake in the daily diet was 1597.3 ± 27.1 kcal, below the recommended dietary minimum for this age group under current mental stress levels. A caloric deficit (consumption of less than 1,900 kcal) was recorded in the majority of respondents — 61.3%. Only 29.6% of participants had the diet aligned with the norm in this respect. The proportion of students not receiving enough calories with their food was significantly higher than the proportion of those with a normal calorie intake ($p < 0.001$).

The analysis of the macronutrient composition confirmed the qualitative deficiency of the diet (Table). It was found that 61.3% of students had inadequate protein intake (mean 54.3 g; normal threshold 60 g), and 58.8% had inadequate fat intake. Carbohydrate intake was lower than normal in half of the respondents (50.3%).

We established that the diets of young men had significantly higher energy values than those of young women (1701.6 ± 31.8 vs. 1520.4 ± 25.3 kcal; $p < 0.001$). A similar trend was observed for protein, fat, and carbohydrates ($p < 0.01$).

The mean ratio of the key nutrients was 13.5% : 33.6% : 55.9% for females, and 13.8% : 34.0% : 57.8% for males. Although all macronutrients showed a deficit (Table), analysis of the participants' dietary patterns indicated a qualitative imbalance and bias toward fat: its content in the boys' diets was 4% above the recommended value, and 3.6% above that value in the girls' diets. This indicates a shift in the balance towards increased fat content with a relative deficiency of protein and carbohydrates in the total amount of food consumed.

The study of medical students' dietary patterns revealed a lack of a clear meal schedule (Fig. 1). Only 44.4% of respondents adhered to the optimal regimen (three meals a day), and a significant portion of the sample (24.2%) ate twice a day or less.

The qualitative features of the students' eating behavior indicate a high prevalence of harmful eating habits. The absolute majority of respondents (78.9%) mentioned regular consumption of fast food products, sugary carbonated and energy drinks. At the same time, the intake of plant fiber and micronutrients was critically low: daily diets of 80.4% of students did not include fresh vegetables and fruits in sufficient quantities.

Table. Mean daily intake of calories and macronutrients (M \pm m)

Indicator	Females ($n = 114$)	Males ($n = 85$)	p
Energy value, kcal	1520.4 ± 25.3	1701.6 ± 31.8	< 0.001
Protein, g	51.2 ± 1.4	58.9 ± 1.7	< 0.01
Fat, g	56.8 ± 1.6	64.3 ± 1.9	< 0.01
Carbohydrates, g	212.5 ± 4.8	245.7 ± 5.3	< 0.01

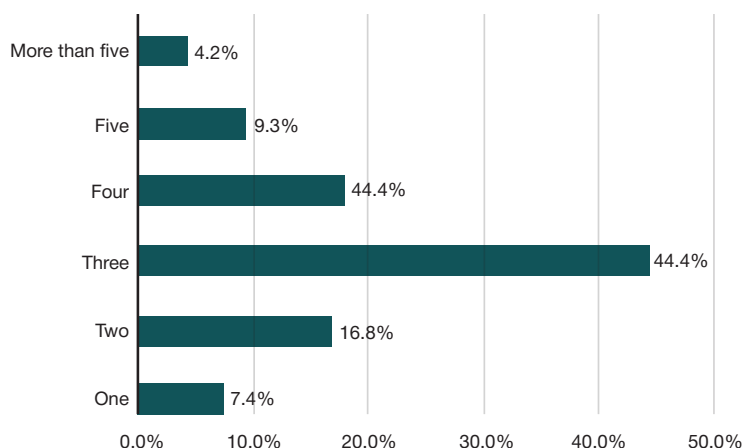


Fig. 1. Frequency of meals, %

The analysis of factors influencing eating patterns in the educational environment identified lack of time and psycho-emotional stress as the main reasons for unhealthy dietary practices (Fig. 2). The former, lack of time, was cited as the main cause of eating disorders in 31.8% of cases, stemming from the density of the academic schedule (daily routine). The latter, stress, was mentioned by more than a quarter of respondents as a factor that alters appetite.

The results generally showed that more than 60% of students chronically consumed fewer calories and less protein than needed, followed irregular eating patterns with infrequent meals, and tended to replace balanced meals with fast food due to stress and time constraints.

DISCUSSION

This study revealed an alarming picture of the nutritional status of second-year medical students: their diets tend to be energy-deficient, irregular in both timing and number of meals per day, and lacking sufficient amounts of essential macronutrients.

The data indicate that the diets of 61.3% fail to deliver the needed amount of calories (mean intake: 1597.3 kcal), which is consistent with findings from a study conducted at Pacific State Medical University, which reported a similar situation for 54.79% of students [12]. However, studies from Samara State Medical University contradict our findings; researchers there reported that students exceeded the recommended dietary energy values by 7–8% [13]. This discrepancy may be explained by differences in the design of the studies or regional specifics of food availability and cost. Regardless, all papers note that the diets of young people in higher education are imbalanced [14].

A critical aspect is the protein deficiency recorded in 61.3% of the respondents. This is consistent with findings from other researchers, who also report that medical students do not consume enough protein (male students, in particular, fall short of the recommended intake by over 20.8%) [13]. Several studies report similar trends that develop over time: from years 1 to 4, students, especially females, tend to consume progressively less protein [15]. Apparently, chronic protein deficiency against a background of high academic workload ultimately impairs the body's adaptive capabilities and promotes morbidity, which is consistent with data showing that by the end of the third year, the number of students assigned to the third health group increases significantly [16].

Analyzing the dietary data, we revealed that less than half of students (44.4%) consume 3–4 meals a day, the optimal number; this is comparable to the results of other studies (38.93%) [12]. At the same time, the figures from our study

appear somewhat more optimistic than data collected at VSMU in previous years, when only 16.5% of boys and 14.2% of girls ate three meals a day [17]. Nevertheless, the continued high prevalence of students who eat one to two meals a day (24.2% of respondents) indicates a persistent problem with disorganized daily routines.

Qualitative deformation of the diet is a matter of special concern: 78.9% of respondents regularly consume fast food, and 80.4% tend to ignore vegetables and fruits. Similar eating behaviors have been described in the literature; some studies report that over 40% of students consume confectionery daily, and 79.25% choose it as a snack [18, 19]. Stress, reported by many respondents as a key factor influencing nutrition, creates a vicious cycle: psycho-emotional stress leads to the choice of comfort food, which, combined with physical inactivity, contributes to metabolic disorders [20].

Thus, the identified violations are systemic in nature and require the development of medical and educational models aimed at promoting healthy lifestyle values within the university environment [21]. Simply informing about the rules of nutrition is not enough. There is a need for structural changes in the university's catering system to address time constraints and ensure access to high-quality food.

CONCLUSIONS

In this study, we performed a comprehensive assessment of the nutritional status and eating behavior of medical students. The study results confirm a systemic crisis in student nutrition, characterized by a chronic deficiency in energy intake and key macronutrients (particularly protein) among most respondents. Our findings indicate that heavy academic workloads and associated psychological stress significantly disrupt dietary patterns and promote the consumption of nutritionally poor fast food.

The specifics of medical education (intense workload, lack of time) were established to directly determine the formation of deviant eating behavior and nutritional deficiencies. The identified imbalance is not episodic, but persistent, which poses risks to the health of future medical doctors.

Further investigation of this subject matter should involve a transition from the identification of violations to the development and implementation of intervention programs. The results of this study can serve as an evidence base for administrative decisions on reorganizing university catering systems (such as introducing subsidized set meals with high protein content or adjusting schedules to ensure adequate breaks). In clinical practice, these data can be used by clinicians in student

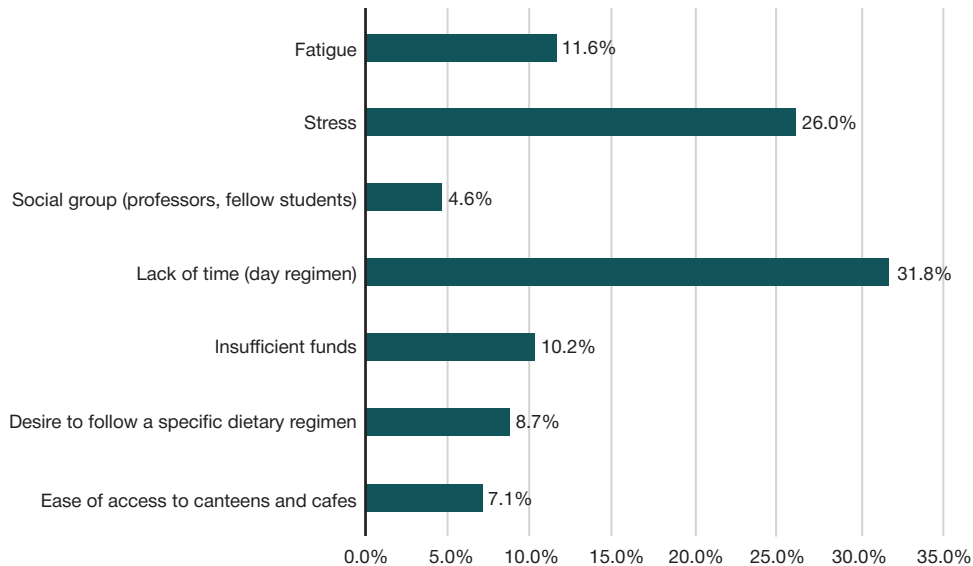


Fig. 2. The influence of various factors on students' eating behavior, %

health clinics to enable early detection of at-risk groups for gastroenterological and metabolic disorders.

A possible hypothesis for future research is that chronic protein deficiency and irregular eating patterns are significant

predictors of declines in cognitive abilities and academic achievement in later years, and that correcting dietary protein intake may improve students' stress tolerance during exam periods.

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PREVALENCE AND KEY FEATURES OF NICOTINE-CONTAINING PRODUCT USE AMONG STUDENTS: THE ANALYSIS

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Despite restrictive measures adopted by many governments worldwide, nicotine addiction remains a serious global health problem. In recent years, adolescents and young people have been strongly encouraged to use nicotine-containing products (NCPs), as the market has seen the emergence of new nicotine delivery vehicles such as electronic cigarettes (e-cigarettes). This study aimed to analyze the patterns of use of NCPs by students. We surveyed 866 young people using standardized questionnaires, including the WHO Global Youth Tobacco Survey (GYTS) and the Fagerström Test. Over the course of their lives, 65.6% of respondents ($n = 568$) had consumed NCPs. E-cigarettes are the most popular product among current users (31.5% of respondents, $n = 273$), ahead of traditional cigarettes and hookahs. A significant portion of users (67.3%, $n = 233$) combine several types of NCPs. The median age at first nicotine use was 16.0 [14.0–18.0] years for boys and 17.0 [15.0–18.0] years for girls; among adolescents who had ever tried nicotine ($n = 256$), 44.4% reported e-cigarettes as their first product. High nicotine addiction was identified in 22.5% of users ($n = 78$). The main reason for the first try is curiosity (63.5%, $n = 366$), and continued (current) consumption is mainly motivated by the desire to relax and get distracted from problems. The results of this study emphasize the need to develop targeted prevention programs that take into account current trends and psychological mechanisms of formation of addiction in adolescents and youth.

Keywords: nicotine-containing products, students, electronic cigarettes, tobacco consumption, nicotine addiction, prevention

Author contribution: Protasova OS, Nasybullina GM — concept and design of the study; Protasova OS, Kishka OV — data collection; Protasova OS, Nasybullina GM — analysis and interpretation of the results; Protasova OS, Kishka OV — literature review; Protasova OS, Nasybullina GM, Kishka OV — preparation of the manuscript. All authors have reviewed the results and approved the final version of the manuscript.

Compliance with ethical standards: the study design was approved by the Ethics Committee of the Ural State Medical University (Minutes No. 7 of October 27, 2023). All participants gave written voluntary informed consent to participate in the study.

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Received: 03.12.2025 **Accepted:** 08.02.2026 **Published online:** 03.06.2026

DOI: 10.24075/rbh.2026.160

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АНАЛИЗ РАСПРОСТРАНЕННОСТИ И ОСНОВНЫХ ОСОБЕННОСТЕЙ ПОТРЕБЛЕНИЯ НИКОТИНСОДЕРЖАЩЕЙ ПРОДУКЦИИ СРЕДИ СТУДЕНЧЕСКОЙ МОЛОДЕЖИ

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Несмотря на принимаемые государствами активные ограничительные меры никотиновая зависимость по сей день остается серьезной проблемой глобального здравоохранения. В последние годы наблюдается интенсивное вовлечение в потребление никотинсодержащей продукции (НСП) подростков и молодежи за счет выхода на рынок новых средств доставки никотина, таких как электронные сигареты. Целью исследования было проанализировать потребление НСП студенческой молодежью. Проведено анкетирование 866 студентов с использованием стандартизированных опросников (GYTS ВОЗ, тест Фагерстрема и др.). Опыт потребления НСП в течение жизни имели 65,6% ($n = 568$) респондентов. Электронные сигареты являются наиболее популярным продуктом среди текущих пользователей (их использовали 31,5% опрошенных, $n = 273$), опережая традиционные сигареты и кальян. Значительная доля потребителей (67,3%, $n = 233$) сочетает несколько видов никотинсодержащей продукции. Медианный возраст первой пробы никотина составил 16,0 [14,0–18,0] лет для юношей и 17,0 [15,0–18,0] лет для девушек, при этом 44,4% подростков, когда-либо пробовавших НСП ($n = 256$), начали знакомство с никотином с электронных сигарет. У 22,5% потребителей ($n = 78$) выявлена высокая степень никотиновой зависимости. Основной причиной первой пробы является любопытство (63,5%, $n = 366$), тогда как текущее потребление в основном мотивировано стремлением к расслаблению и отвлечению от проблем. Полученные результаты подчеркивают необходимость разработки целевых профилактических программ, учитывающих современные тренды и психологические механизмы формирования аддикции у подростков и молодежи.

Ключевые слова: никотинсодержащая продукция, студенческая молодежь, электронные сигареты, потребление табака, никотиновая зависимость, профилактика

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Соблюдение этических стандартов: дизайн исследования одобрен локальным этическим комитетом Уральского государственного медицинского университета (протокол № 7 от 27 октября 2023 г.). Все участники предоставили добровольное информированное согласие на участие в исследовании в письменной форме.

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Статья получена: 03.12.2025 **Статья принята к печати:** 08.02.2026 **Опубликована онлайн:** 03.06.2026

DOI: 10.24075/rbh.2026.160

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The consumption of nicotine-containing products (NCPs) remains one of the most pressing public health problems. According to WHO estimates, tobacco use accounts for about 7 million preventable deaths worldwide each year [1, 2]. On average, smokers lose 10 years of life compared with people who never smoke; in the early 2000s, smoking was the leading cause of adult mortality from non-communicable diseases [3]. It has been found that when heavy smokers quit tobacco, their risk of premature death decreases significantly, and this effect is especially pronounced among those who quit before age 40 [4].

Nicotine consumption is still widespread, including among young people. According to the literature, in 2019, 155 million people aged 15–24 in 204 countries smoked tobacco. The prevalence of smoking in this age group was 20.1% among males and 4.95% among females. In 120 countries, the prevalence of tobacco smoking among men aged 15 to 24 years exceeded 20%, and Russia is one of them (31.6%) [5].

The restrictive and other measures adopted by states have achieved certain successes in the fight against smoking; however, the tobacco market has been undergoing transformation in recent years. We observe that new forms of consumption, such as electronic nicotine delivery systems (ENDS), are becoming increasingly widespread [6]. The popularity of these products is increasing rapidly, with e-cigarettes emerging as the most commonly used NCPs among adolescents and young people [1, 7, 8].

Due to their age and socio-psychological characteristics, young people are at increased risk of nicotine use. They are highly open to new experiences, seek social acceptance through peer imitation, experience high stress, and tend to engage in risky behavior. These factors make them especially vulnerable to marketing and environmental influences that promote e-cigarettes [9–11].

Existing anti-tobacco measures and prevention programs are more effective for older individuals; they do not fully account for youth as a target audience or for the potential risks of new nicotine-containing products, so these programs have clear limitations. School and short-term programs are not effective in the long run, especially in the absence of integrated digital components and involvement of family and community [12–15]. Taken together, these factors underscore the urgency of targeted research to identify the characteristics of nicotine use among young people.

This study aimed to analyze the patterns of use of NCPs by students.

METHODS

This single-stage cross-sectional study was conducted from November 2023 to June 2025 at Ural State Medical University. The study included 866 students in years 1–5 (532 females, 334 males); median age 20.2 years (19.7–21.3). We explored young people's use of NCPs, including prevalence, age at first use, frequency and intensity of use of different types of NCPs, reasons for using NCPs, and the prevalence of nicotine addiction symptoms among smoking students.

The study used an online questionnaire to collect data. The questionnaire was based on Tobacco Questions for Youth Surveys (TQS-Youth), a subset of the WHO Global Youth Tobacco Survey, and included the Fagerström Test, which assesses the degree of nicotine addiction.

The data were analyzed in jamovi 2.3 (<https://www.jamovi.org>) [16]. The Shapiro–Wilk test was used to assess the conformity of quantitative indicators to a normal distribution. Categorical

data were described with percentages, quantitative data — with medians and interquartile ranges. Proportions across fields in the multifield conjugacy tables were compared with Pearson's chi-square test (χ^2). The differences were considered significant at $p < 0.05$.

RESULTS

It was found that at the time of the survey, 65.6% of respondents ($n = 568$) had smoking experience (70.1% males ($n = 234$) and 62.8% females ($n = 334$), $\chi^2 = 4.82$, $p = 0.028$). The median age at the first try of NCPs was 16.0 [14.0–18.0] years for boys and 17.0 [15.0–18.0] years for girls.

Almost half of the smokers in the sample — 44.4% ($n = 256$) — tried e-cigarettes and vaporizers before other NCPs; the choice of product type did not depend on gender. Regular cigarettes were used for the first try by 47.5% ($n = 115$) of male and 39.3% ($n = 133$) of female participants. Hookah was first smoking experience for 9.1% ($n = 22$) of boys and 10.9% ($n = 37$) of girls. Only a small percentage of students were introduced to NCPs through tobacco heating systems (1.9%, $n = 11$) and smokeless tobacco products (0.5%, $n = 3$).

The current consumption of NCPs among young people can be described as follows: occasional use — 18.6% of students ($n = 161$), 20.7% of boys ($n = 69$) and 17.3% of girls ($n = 92$), $\chi^2 = 23.0$, $p < 0.001$; regular daily use of some type of NCP — 17.1% ($n = 148$), 24.0% of boys ($n = 80$) and 12.8% of girls ($n = 68$), $p < 0.001$.

During the 30 days preceding the survey, 17.6% of respondents ($n = 152$) smoked regular cigarettes or cigars: 29.0% of boys ($n = 97$) and 10.3% of girls ($n = 55$), $\chi^2 = 23$, $p < 0.001$. Daily cigarette smoking is more typical for boys than for girls: 7.8% of all respondents ($n = 26$) versus 1.7% ($n = 9$), $\chi^2 = 57.5$, $p < 0.001$. The most common daily dose, irrespective of gender, was 1–4 cigarettes. Only 3.0% ($n = 10$) of male and 0.2% ($n = 1$) of female participants smoked more than half a pack per day, and two boys — 0.6% of the sample — reported smoking more than one pack per day ($\chi^2 = 59.2$, $p < 0.001$).

During the month preceding the study, 20.9% of the respondents ($n = 181$) smoked hookah or pipe with tobacco: 24.3% ($n = 81$) of boys and 18.8% ($n = 100$) of girls ($\chi^2 = 3.69$, $p = 0.055$). Smokeless tobacco was used by 2.8% ($n = 24$) of students, with males preferring it more often than girls: 5.4% ($n = 18$) versus 1.1% ($n = 6$), respectively ($\chi^2 = 13.9$, $p < 0.001$). Tobacco heating systems were used by 7.2% of respondents ($n = 62$): 6.9% ($n = 23$) of boys and 7.3% ($n = 39$) of girls; the gender differences were insignificant.

As for e-cigarettes, in the 30 days preceding the survey they were used by 31.5% ($n = 273$) of the sample, including 38.9% ($n = 130$) of boys and 26.9% ($n = 143$) of girls ($\chi^2 = 26.1$, $p < 0.001$). Daily use was reported by 11.9% of the participants ($n = 103$), including 16.5% of boys ($n = 55$) and 9.0% of girls ($n = 48$). Among the respondents, 7.0% (8.1% of males and 6.4% of females) reported using e-cigarettes once or twice daily. Additionally, 4.4% of participants (5.7% of males and 3.6% of females) used e-cigarettes 10–14 times per day, and 7.6% (11.7% of males and 5.1% of females) reported using such NCPs 30 or more times per day. In a single use of an electronic cigarette or vaporizer, 24.4% of respondents (30.2% of boys and 20.7% of girls) take 1–9 puffs on average, and 2.8% of students (3.3% of boys and 2.4% of girls) take more than 30 puffs. In general, young men tend to resort to such NCPs more frequently and more intensively than young women (Table).

Only 32.7% of current smokers ($n = 113$) had limited themselves to one type of NCPs during the 30 days preceding

Table. Frequency of use of regular cigarettes, tobacco heating systems, and electronic cigarettes in the 30 days preceding the survey

NCP type	Gender		Haven't used	1–2 days	3–5 days	6–9 days	10–19 days	20–29 days	Between 30 days
Regular cigarettes, cigars	Males	abs.	237	30	9	15	10	7	26
		%	71	9	2.7	4.5	3	2.1	7.8
	Females	abs.	477	21	10	4	9	2	9
		%	89.7	3.9	1.9	0.8	1.7	0.4	1.7
	Both genders	abs.	714	51	19	19	19	9	35
		%	82.4	5.9	2.2	2.2	2.2	1	4
Tobacco heating systems	Males	abs.	313	9	5	1	2	2	2
		%	93.7	2.7	1.5	0.3	0.6	0.6	0.6
	Females	abs.	490	13	6	4	4	3	12
		%	92.1	2.4	1.1	0.8	0.8	0.6	2.3
	Both genders	abs.	803	22	11	5	6	5	14
		%	92.7	2.5	1.3	0.6	0.7	0.6	1.6
E-cigarettes	Males	abs.	204	22	13	11	10	19	55
		%	61.1	6.6	3.9	3.3	3	5.7	16.5
	Females	abs.	390	23	14	10	17	30	48
		%	73.3	4.3	2.6	1.9	3.2	5.6	9
	Both genders	abs.	594	45	27	21	27	49	103
		%	68.6	5.2	3.1	2.4	3.1	5.7	11.9

the survey. The remaining 67.3% ($n = 233$) used several different types of NCPs during this period (66.5% ($n = 111$) of boys and 68.2% ($n = 122$) of girls) (Figure).

The majority of smokers in the sample — 72.8% ($n = 252$), 69.5% ($n = 116$) of boys and 76.0% ($n = 136$) of girls — exhibited mild or very mild nicotine addiction. High and extremely high levels of nicotine addiction were identified in 22.5% ($n = 78$) of nicotine users: 26.9% ($n = 45$) of boys and 18.4% ($n = 38$) of girls. Medium level of addiction was typical for 4.6% ($n = 16$) of the surveyed NCP consumers, 3.6% ($n = 6$) of boys and 5.6% ($n = 10$) of girls. A behavioral marker of addiction strength may be the inability to abstain from smoking in prohibited areas; 24.5% ($n = 39$) of boys and 18.8% ($n = 31$) of girls reported engaging in such behavior.

At the time of the survey, 53.5% of NCP users expressed a desire to quit smoking ($n = 185$; no significant gender differences). Over the past year, 51.5% ($n = 86$) of male smokers and 63.1% ($n = 113$) of female smokers — 57.5% ($n = 199$) overall — attempted to quit using NCPs (significant differences, $\chi^2 = 4.905$, $p = 0.27$). The question 'Do you think you could quit smoking/using NCPs if you wanted to?' received an affirmative answer from 73.7% ($n = 123$) of male smokers and 81.0% ($n = 145$) of female smokers, for a combined 77.5% ($n = 199$) of the sample ($\chi^2 = 6.619$, $p = 0.011$).

When asked why they first tried NCPs, the vast majority of students — 63.5% ($n = 366$), 60.1% ($n = 143$) of boys and 66.0% ($n = 223$) of girls — noted that they were interested in experiencing new sensations. The second most common reason is stress; it was reported by 18.8% ($n = 108$) overall, including 18.5% ($n = 44$) of boys and 18.9% ($n = 64$) of girls. Companionship and desire not to offend friends was mentioned as the reason for the first try of an NCP by 4.9% ($n = 28$) of the respondents, 7.1% ($n = 17$) of boys and 3.3% ($n = 11$) of girls. For 3.7% ($n = 21$) of respondents — 2.5% ($n = 6$) of boys and 4.4% ($n = 15$) of girls — the reason was peer pressure, for 2.4% ($n = 14$) — 3.4% ($n = 8$) of boys and 1.8% ($n = 6$) of girls — it was self-affirmation.

Currently, 28.4% of nicotine users ($n = 98$) indicated that nicotine helps them relax and unwind (26.5% ($n = 44$) of boys

and 30.2% ($n = 54$) of girls); 24.9% ($n = 86$) use nicotine to distract from problems (19.3% ($n = 32$) of boys and 30.2% ($n = 54$) of girls); 16.5% ($n = 57$) answered that nicotine use gives them pleasure (20.5% ($n = 34$) of boys and 12.8% ($n = 23$) of girls); 11.9% ($n = 41$) continue to use NCPs because they have grown addicted cannot quit (13.9% ($n = 23$) of boys and 10.1% ($n = 18$) of girls); 1.2% ($n = 4$) use NCPs for company (1.8% ($n = 3$) of boys and 0.6% ($n = 1$) of girls); 0.9% of respondents ($n = 3$) use NCPs to cope with stress — 1.7% of girls ($n = 3$).

DISCUSSION

The study revealed a number of aspects of student behavior related to the use of NCPs that are significant for the public health system. Among youth, the current prevalence of NCP use matches international findings (204 countries) for men and is nearly threefold higher than previously reported for women. [5]. Comparison of the data with findings from domestic studies revealed similar results regarding both the overall prevalence of nicotine use and the magnitude of gender differences in consumption frequency, with young men exhibiting higher rates of use than young women [5, 17–21].

An important result is the identification of complex, multi-product consumption model [22]. The fact that most smokers use several types of NCPs simultaneously indicates the transformation of nicotine addiction. It ceases to be tied to one specific product (cigarettes) and becomes universal, as different nicotine delivery devices and forms are used situationally. This creates a serious challenge to the prevention system, which has historically focused on traditional tobacco smoking. Moreover, the transformation requires additional research on the risk associated with the consequences of using several types of NCPs.

Another significant finding is the dominant position of ENDS in current smoking patterns among young people. They are highly popular, used daily and intensively, which indicates that they are perceived not as temporary fun, but as a full-fledged alternative to traditional cigarettes or even the main method

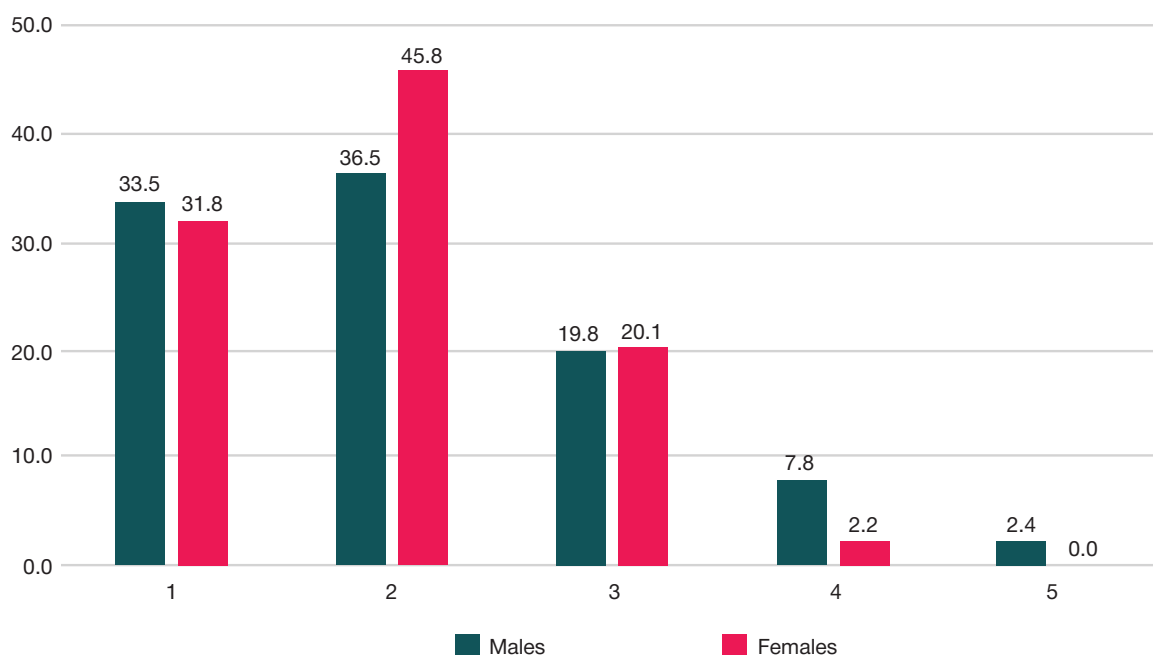


Fig. Number of types of NCPs used by a single person, % of the total number of NCP users (any frequency)

of nicotine consumption, as confirmed by data from similar studies [1, 7, 22–23].

Nearly one-third (29.9%) of young people start nicotine use with ENDS, confirming these devices' major role in recruiting new users, which is particularly concerning. The presented data strongly support applying comprehensive regulatory measures to all NCPs, including e-cigarettes, tobacco-heating systems, and hookahs; the updated Federal Law incorporates such provisions [24].

The analysis of motivation revealed an important shift in the causes of use: the first try of NCPs is commonly driven by curiosity, and their continued use is largely determined by the need for psychoemotional regulation. Nicotine is often seen as a tool for relaxation, distraction from problems, and stress management [25–28]. Therefore, high rates of consumption can be considered an indicator of weak adaptive coping skills among students and their inability to allocate effort properly and organize meaningful leisure activities. Thus, the problem goes beyond the purely medical framework and requires an interdisciplinary approach.

More than half of the respondents (53.5%) expressed a desire to quit using NCPs, which means that young people are aware of the problem and recognize the need for change. That said, 57.5% of participants attempted to quit over the past year, with girls doing so significantly more often (63.1%) than boys (51.5%), which may reflect their higher propensity for health-conscious behavior. However, the fact that a significant proportion of young people who are already motivated to quit continue to use NCPs indicates that the path to withdrawal contains obstacles. This clearly indicates that young people need targeted, scientifically based help and support to overcome nicotine addiction.

Another noteworthy finding is the discrepancy between smokers' history of quit attempts and their self-confidence in their ability to quit smoking. The overwhelming majority of respondents (77.5%) were confident they could stop using NCPs if they wanted to, with girls exhibiting this confidence significantly more often than boys (81.0% versus 73.7%). Against the background of the previously mentioned high percentage of unsuccessful attempts per year, this fact illustrates an important problem: young people tend to overestimate their

ability to give up a bad habit. This cognitive error, possibly stemming from the perception of nicotine addiction as weak or controllable by willpower, poses a serious risk. It can lead to a postponement of decisive action, an underestimation of the complexity of the nicotine withdrawal process, and, as a result, to disappointment and a consolidation of the habit after unsuccessful quit attempts.

Despite the popularity of NCPs, particularly e-cigarettes, among young people, prevention measures designed and tested for this age group remain insufficient. Educational campaigns in the mass media can be one of the measures aimed at prevention of use of NCPs. A randomized trial found that informational messages about the dangers of vaping and its addictive potential were effective. Participants found information about the hazards of smoking more convincing, reported reduced curiosity about vaping, and showed an increased desire to quit e-cigarettes or smoke less frequently [29].

The results of this study show that NCP use among students is a complex issue that extends beyond the medical domain and affects their psychological, behavioral, and social well-being. An effective control strategy should combine awareness of the dangers of NCPs, systematic identification of users, targeted assistance in quitting nicotine, and creation of conditions for a healthy and eventful student life. This will enable a comprehensive approach to the problem, addressing not only addiction but also the need to improve young people's health and quality of life.

CONCLUSIONS

The study revealed the following specifics of use of nicotine-containing products (NCPs) among students.

1. The use of NCPs is common in this population: two thirds of respondents have experience with such products. Young men have higher rates of episodic and daily use, as well as greater smoking intensity, for both traditional and electronic cigarettes.

2. For almost every third young individual, e-cigarettes are the first NCP tried, which puts them in second place after traditional cigarettes. This may indicate a shift in consumer preferences toward alternative nicotine products at the earliest

and most vulnerable stage of habit formation. The median age at first try (16 years for boys and 17 years for girls) confirms that adolescence is a critically important age from the perspective of preventive interventions.

3. The majority of users combine several types of NCPs, which indicates the formation of a complex nicotine addiction that is not tied to a single product.

4. E-cigarettes are the most popular product among current users, significantly outpacing traditional cigarettes and hookah.

5. Although most users were found to have mild nicotine

dependence, one in five students who use NCPs has a high or very high level of nicotine addiction.

6. The main reason for the first try of NCPs is curiosity, which indicates the importance of preventive measures that form an adequate perception of risks. Later on, the main motive for continued use becomes psychoemotional regulation — relaxation and distraction from problems. This allows considering the use of NCPs by young people not only as an addiction, but also as a maladaptive strategy for coping with stress and psychological load.

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ANALYSIS OF PUBLICATION TRENDS IN RESEARCH ON PHYSICAL DEVELOPMENT OF CHILDREN AND ADOLESCENTS

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The large body of accumulated scientific material requires not only literature reviews, but also an analysis of authors' current publication activity and a search for possible research priority areas. This study aimed to analyze publications addressing the physical development of children and adolescents during the past ten years. We searched for papers in <https://elibrary.ru/>, narrowing the selection only to sources belonging to the core of the RSCI. The search spanned the period from the beginning of 2014 to the first quarter of 2025. The keywords were "physical development," "children and adolescents." We found that more than 500 studies on the topic have been published in 33 journals over the past decade. This study highlights the most cited publications, outlines the range of current research topics, and discusses the prospects of future investigations. The analysis of publication activity related to the studies considering physical development of children, adolescents and youth has demonstrated continued relevance of research in this area. However, it should rely on big data, cross-discipline approach involving leading schools of thought, monitoring of previously published papers to avoid duplication, fundamental research as basis of the efforts, and domestic scholar traditions. Other prerequisites of efficient studies in this field include exchange of scientific experience and cross-citation of papers that supports comparisons of the results.

Keywords: publications, physical development, children, teenagers

Funding: the study was part of an R&D effort, registration number AAAAA-A19-119021890068-7, of February 18, 2019.

Author contribution: all authors contributed equally to the preparation and publication of the article.

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Received: 26.09.2025 **Accepted:** 21.04.2026 **Published online:** 06.06.2026

DOI: 10.24075/rbh.2026.161

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АНАЛИЗ ПУБЛИКАЦИОННОЙ АКТИВНОСТИ ПО ПРОБЛЕМЕ ИЗУЧЕНИЯ ФИЗИЧЕСКОГО РАЗВИТИЯ ДЕТЕЙ И ПОДРОСТКОВ

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Учитывая обширный накопленный научный материал, возникла необходимость не только обзора литературы, но и анализа современного состояния публикационной активности авторов и поиска возможных приоритетных направлений исследований. Целью работы было проанализировать публикационную активность по проблеме изучения физического развития детей и подростков за последние 10 лет. Для анализа использовали ресурс <https://elibrary.ru/>. Поиск источников осуществлялся среди источников, входящих в ядро РИНЦ. Глубина поиска включала публикации за период с начала 2014 г. по первый квартал 2025 г. Поиск осуществлялся по ключевым словам «физическое развитие», «дети и подростки». Установлено, что за последние 10 лет опубликовано более 500 исследований по теме в 33 журналах. Показаны наиболее цитируемые публикации, очерчен круг современной тематики исследований, обсуждены перспективы исследований. Анализ публикационной активности по проблеме изучения физического развития детей, подростков и молодежи продемонстрировал, что исследования в этом направлении не теряют своей актуальности. Однако они требуют решения на современном уровне на основе использования облачной платформы *big data* и предполагают интеграцию специалистов различных специальностей, представляющих ведущие научные школы, детальное изучение уже опубликованных исследований для исключения дублирования, базирование вновь планируемых научных работ на фундаментальных исследованиях, учет отечественных традиций. Помимо этого, необходимы обмен научным опытом, перекрестное цитирование научных материалов, подтверждающее сравнительный анализ полученных результатов с другими.

Ключевые слова: публикации, физическое развитие, дети, подростки

Финансирование: исследование выполнено в рамках НИР (номер государственного учета НИОКТР AAAAA-A19-119021890068-7 от 18 февраля 2019 г.).

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

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Статья получена: 26.09.2025 **Статья принята к печати:** 21.04.2026 **Опубликована онлайн:** 06.06.2026

DOI: 10.24075/rbh.2026.161

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In Russia, physical development of children has been a subject of research for historically long time. Ferdinand Friedrich Erisman, the founder of the Russian hygiene school, laid the foundation for analyzing the physical development of children and adolescents in long-term dynamics [1].

Physical development indicators are used to characterize public health, and they reflect the socio-hygienic and economic well-being of a region, which, as suggested by several researchers, necessitates timely collection of the younger generation's physical development data and their comparison over time [2].

Given the large body of accumulated scientific material, it is necessary to not only review the literature, but also to analyze the authors' current publication activity, search for possible research priority areas, and substantiate the relevance of scientific investigations in this field.

This study aimed to analyze publications addressing the physical development of children and adolescents during the past ten years.

METHODS

We used the Russian Science Citation Index (RSCI, <https://elibrary.ru/>) (cited 28.01.2025) to analyze the publication activity related to research in physical development of children and adolescents. The search for papers was limited to the sources included in the core of the RSCI; the publication time span — from the beginning of 2014 to the first quarter of 2025. There were three stages to the search. At the first stage, we entered "physical development" in the "Search for" field of the RSCI's advanced search tool, and applied the following modifiers: keyword presence in titles and keywords; type of paper — journal articles; publication date from 2014 to 2025. The search returned 5054 works. At the second stage, we used the "Continue searching among the found results" tool and added "children OR teenagers" to the query. This attempt yielded 945 publications by 762 authors (mostly Russian) with a total of 7055 citations. At the third stage, we selected papers published in the media part of the RSCI core. Ultimately, the number of works included in the analysis was 566. They covered the processes of growth and development of the country's child population taking into account the impact of climatic, geographical, ethnic, socio-economic, medical, social and other factors. We discarded publications investigating the specifics of physical development of children and adolescents with somatic diseases or practicing certain sports.

At the data processing stage, GigaChat 2.0 (<https://giga.chat>) was used as an auxiliary tool to build the word cloud, cluster the selected papers, and calculate the frequency of occurrence of authors. The results were verified and edited by the authors in accordance with modern approaches to data processing [3]. The data was visualized using the Word Cloud service (<https://diaclass.ru/cloud/>).

RESULTS

We analyzed the journals that published the studies investigating aspects of physical development of the child population (Table).

The journals that published the articles reflect the research directions the authors work in. There were more than 33 such journals; Table above gives the main of them. The most popular journals among the authors were "Hygiene and Sanitation" (3.2.1 Hygiene) — 16 articles; "Bulletin of Moscow University. Series 23: Anthropology" (3.3.1 Anatomy and anthropology) — 16; "Theory and Practice of Physical Culture" (5.8.4 Physical

culture and professional physical training) — 16; "Public Health and Habitat" (3.2.1 Hygiene) — 15; "Russian Pediatric Journal" (3.1.21 Pediatrics) — 10 articles. There were also publications in other journals that publish materials on preventive medicine, pediatrics, and physical education.

We have identified articles with the maximum number of citations by year. This angle reflects current trends in the study of the physical development of the child population. In 2014, an article with 33 citations was published in "Theory and Practice of Physical Culture"; it covered the impact of sports on the physical development of students [4].

An article with 52 citations published in 2015 in the "Kazan Medical Journal" considered the problem of assessing the physical development of children and adolescents [5].

In 2016, the same journal published an article on the study of the physical development of schoolchildren in a modern metropolis, which was cited 38 times [6].

An article about the use of bioimpedance to assess the component composition of the human body and the potential of this method in the study of physical development was published in 2017 in "Bulletin of St. Petersburg University. Medicine"; it gathered 143 citations [7].

An article by a team of pediatricians that discussed assessment of the physical development of children of middle and senior school age based on the results of a one-stage study was published in 2018 in "Pediatric Pharmacology." It was cited 63 times [8].

In 2019, the next installment of a discussion on methods of assessing the physical development of the child population factoring in the specifics of the region — St. Petersburg, in that case — was published in "Pediatrician," and cited 38 times [9].

The same team of authors continued to elaborate on the topic in 2020: they published an article in "Issues of Practical Pediatrics" that covered screening assessment of the nutritional status of schoolchildren living in various regions of the Russian Federation. This work amassed 27 citations [10].

The results of a large-scale study of the state of health and physical development of children and adolescents in school ontogenesis were published in "Healthcare of the Russian Federation" in 2021, and cited 84 times [11].

The long-term study of physical development of children in various regions of Russia retains its relevancy, as it allows characterizing the current acceleration and deceleration processes. An article on this topic was published in "Human Ecology" in 2022. It was cited 39 times [12].

In 2023, "Theory and practice of physical culture" published an article demonstrating the functional capabilities of detrained adolescents, which was cited seven times; in 2025, the same journal delivered a piece analyzing the physical capabilities of asthenized young men during regular training, which amassed 16 citations [13, 14].

Among the authors of the above articles are well-known pediatricians: L.S. Namazova-Baranova, Academician of the Russian Academy of Sciences, et al; V.L. Gritsinskaya, professor, et al; hygienists — V.R. Kuchma, corresponding member of the Russian Academy of Sciences, I.B. Ushakov, academician of the Russian Academy of Sciences, O.Yu. Milushkina, corresponding member of the Russian Academy of Sciences, V.I. Popov, corresponding member of the Russian Academy of Sciences, N.A. Skoblina, professor, I.K. Rapoport, professor; renowned anthropologists, specialists in physical culture and sports. The word cloud below reflects the contribution of the authors.

Professor V.L. Gritsinskaya, representing the St. Petersburg pediatric school of thought, is the most prolific author with 10 articles

Table. Analysis of journals containing studies investigating aspects of physical development of the child population

Journal title	Number of published articles
Hygiene and Sanitation	16
Bulletin of the Moscow University. Series 23: Anthropology	16
Theory and Practice of Physical Culture	16
Public Health and Habitat	15
Russian Pediatric Journal	10
Questions of Children's Dietetics	5
Human ecology	5
Problems of Social Hygiene, Public Health and the History of Medicine	5
Human. Sport. Medicine	4
Yakut Medical Journal	4
Bulletin of Novosibirsk State Pedagogical University	4
Questions of Practical Pediatrics	4
Physical Education of Students	4
Preventive Medicine	4
Acta Biomedica Scientifica	3
Science for Education Today	3
Pedagogics, Psychology, Medical-Biological Problems of Physical Training and Sports	3
Questions of Nutrition	3
Bulletin of St. Petersburg University. Medicine	2
News of the Russian Military Medical Academy	2
Kazan Medical Journal	1
Health Risk Analysis	1
Siberian Psychological Journal	1
Siberian Scientific Medical Journal	1
Human and Their Health	1
Questions of Balneology, Physiotherapy, and Remedial Gymnastics	1
Doctor.ru	1
World of Medicine and Biology	1
Medical Advice	1
Medical and Social Expertise and Rehabilitation	1
Russian Medical Journal. Mother and Child	1
Medical Studies and Practice	1
Acta Biologica Sibirica	1

mentioning her as part of the team of researchers. She has students in various regions of Russia.

We can also mention the scientific school of hygienists, which was formed on the basis of the "East-European" scientific and educational medical cluster in the Central Federal District; scholars from this cluster were cited as article co-authors 27 times. The related schools are those of Samara State Medical University (associate professor M.Yu. Gavryushin — 7 times and professor O.V. Sazonova — 5 times) and Northern State Medical University (associate professor D.M. Fedotov — 6 times). The research was carried out in close cooperation with physical culture specialists (professor S.P. Levushkin — 5 times). Indicators of physical development and factors affecting the health of children, adolescents and youth are also studied by hygiene scientists at the F.F. Erisman Federal Scientific Center for Hygiene, Burdenko Voronezh State Medical University, and Volgograd State Medical University.

Scholars specializing in public health, organization and sociology of healthcare, medical and social expertise also participate

in research on the problems of physical development of the child population (professor E.N. Mingazova — 5 times).

Fundamental research in this field is conducted by the Russian school of anthropologists (professor T.K. Fedotova — 7 times, professor E.Z. Godina — 4 times, candidate of biological sciences A.K. Gorbacheva — 6 times).

DISCUSSION

There is a sufficient amount of fundamental studies of the Russian children's physical development that suggest methodology, approaches to statistical processing, analysis of patterns of growth and development, etc. [15, 16].

However, at the present stage, it is possible to use big data (both current state and historical records) to further study the biological patterns of growth and development and the mechanisms of acceleration-deceleration. The data arrays can be processed with the involvement of specialists from related medical fields as well as economists, demographers,



Fig. Contribution of authors to the bulk of articles covering research on the physical development of Russian children and adolescents

statisticians, programmers, etc., and the body of historical data can be analyzed with the help of AI-driven cutting-edge tools.

Research in this area is relevant for world science, which has been reflected in a number of publications over the past decades [17–19].

For many years, there has been a discussion in the scientific literature about methods for assessing the physical development of the Russian child population and what standards should be applied to this task. Most researchers highlighted the informative value of comprehensive methodology, and pointed to regional age-sex standards [9, 20, 21].

The problem of formulation of regional age-sex standards to support morphofunctional status and biological development assessments has been successfully solved. Alongside the published collections, standards-management software and computer programs enabling assessment of children's physical development have been developed and are freely available [22, 23].

In September 2025, the Order of the Ministry of Health of the Russian Federation of April 14, 2025 No. 211n "On approval of the preventive medical examination procedure for minors, registration form No. 030-PO/u "Card of preventive medical examination of a minor," its record-keeping procedure, and the form of sectoral statistical observation No. 030-PO/o "Information on preventive medical examinations of minors" became effective. This order includes assessment of body mass index, which necessitates development of Russian standards for assessing the body mass index of Russian children. The first

attempts to create such standards have already been made [24, 25].

Longitudinal studies of physical development across different regions remain important for identifying regional determinants of growth and development, particularly factors related to enhancing the health and fitness of children, adolescents, and young people through physical education and sport [26–35].

The emergence of new methods and instrumentation (for example, bioimpedance measurement) expands the possibilities of studying the physical development of children, adolescents and youth, which, in turn, enables extension of the standard anthropometric methodology [36].

CONCLUSIONS

The analysis of publication activity related to the studies considering physical development of children, adolescents and youth shows continued relevance of research in this area. However, it should rely on big data and cross-discipline approach involving leading schools of thought. It is also necessary to carefully examine the already published studies to avoid duplication. Newly planned research should be based on fundamental research, with national scientific traditions taken into account. Other prerequisites of efficient studies in this field include exchange of scientific experience and cross-citation of papers that supports comparisons of the results.

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SANITARY AND HYGIENIC APPROACHES TO FUNGAL CONTAMINATION ASSESSMENT IN LIVESTOCK PRODUCTION FACILITIES

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Intensification of livestock farming creates conditions for the accumulation and circulation of pathogenic and opportunistic fungi with the development of antifungal resistance. The study aimed to perform comprehensive assessment of fungal contamination of production environment in various areas of livestock farms and determine sensitivity of the extracted isolates to common antifungal agent. The presence of fungal contamination in the air of all working areas of the studied production facility was established. Predominance of *Aspergillus niger* and *Candida albicans* was revealed. In 50% of cases, mixed contamination with different types of mold fungi was observed. The highest contamination levels were reported for the bedding material. Resistance of microorganisms to several antifungal drugs with different mechanisms of action at once has been revealed. The study confirmed systemic contamination of the livestock complex production environment with potentially pathogenic fungi forming stable communities in feed and bedding. The reported sanitary and microbiological approaches to assessing fungal contamination at livestock production facilities have a pronounced comprehensive preventive focus, which makes it possible to improve the farm employees' working conditions, as well as provide measures to improve the livestock complex production environment.

Keywords: livestock production, production environment, antifungals, yeast-like fungi isolates, sensitivity, working area

Author contribution: Masyagutova LM — review of papers on the topic, literature analysis, data synthesis; Gizatullina LG — sampling for bacteriological analysis, testing, analysis of the results; Bakirov AB — data synthesis, editing; Kalimullina SN — testing, data acquisition and processing; Kabirova EF — data processing; all authors — approval of the final version of the article, responsibility for the integrity of all parts of the article.

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Received: 28.01.2026 **Accepted:** 18.04.2026 **Published online:** 22.06.2026

DOI: 10.24075/rbh.2026.162

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САНИТАРНО-ГИГИЕНИЧЕСКИЕ ПОДХОДЫ К ОЦЕНКЕ ГРИБКОВОЙ КОНТАМИНАЦИИ НА ПРОИЗВОДСТВЕННЫХ ОБЪЕКТАХ ЖИВОТНОВОДСТВА

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Интенсификация животноводства создает условия для накопления и циркуляции патогенных и условно-патогенных грибов с формированием антимикотической резистентности. Целью исследования было выполнить комплексную оценку уровня грибковой контаминации производственной среды в различных зонах животноводческих предприятий с определением чувствительности выделенных изолятов к распространенным антимикотикам. Установлено наличие грибковой обсемененности в воздухе всех рабочих зон изученного предприятия. Выявлено доминирование *Aspergillus niger* и *Candida albicans*. В 50% случаев отмечена смешанная контаминация разными видами плесневых грибов. Наибольший уровень загрязнения выявлен в подстилочном материале. Выявлена устойчивость микроорганизмов одновременно к нескольким антимикотическим препаратам, имеющим различные механизмы действия. Исследование подтвердило системное загрязнение производственной среды животноводческих комплексов потенциально-патогенными грибами с формированием устойчивых сообществ в кормах и подстилке. Представленные в работе санитарно-микробиологические подходы оценки грибковой контаминации на производственных объектах животноводства имеют выраженную комплексную профилактическую направленность, позволяющую улучшить условия труда работников ферм, а также организовать мероприятия по оздоровлению производственной среды животноводческого комплекса.

Ключевые слова: животноводство, производственная среда, антимикотики, изоляты дрожжеподобных грибов, чувствительность, рабочая зона

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Статья получена: 28.01.2026 **Статья принята к печати:** 18.04.2026 **Опубликована онлайн:** 22.06.2026

DOI: 10.24075/rbh.2026.162

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Intensification of livestock farming characterized by a high concentration of livestock in a limited space creates specific environmental conditions that promote the accumulation and circulation of various microorganisms [1, 2]. Among these fungi of are particular importance, which can not only

cause mycoses in animals, reducing productivity and leading to economic losses, but also act as sources of allergens and mycotoxins, thereby creating occupational and environmental risk for personnel [3, 4]. Contamination of livestock environments with molds and yeast-like fungi sets the stage for deterioration

of product sanitary and hygienic indicators and stable circulation of opportunistic species in the closed system of the production facility [5].

Air in the working area, surfaces of equipment and constructs, feed and bedding material represent the key reservoirs and vectors of mycobiota transmission in livestock complexes. The air environment is the main route of spore dissemination, while contaminated feed and bedding provide direct entry of micromycetes into the gastrointestinal tract and constant animal skin contamination [6, 7]. The difficulty of controlling fungal contamination is compounded by the formation of disinfectant-resistant biofilms on surfaces and the widespread use of antifungal drugs, which contribute to the resistant strain selection [8, 9].

Despite the relevance of the issue, comprehensive studies that simultaneously assess the contamination of various ecological niches (air, surfaces, feed, bedding) in livestock production facilities and provide phenotypic characteristics of the extracted fungal isolates remain underrepresented in the scientific literature. Such a systematic approach is necessary for the development of effective sanitary and preventive measures, as well as guidelines on mycological safety monitoring.

The study aimed to perform comprehensive assessment of fungal contamination of the air and surfaces in various production areas of livestock farms and to characterize the isolated yeast-like fungi based on sensitivity to common antifungal agents.

METHODS

The study was conducted at several typical livestock farms in the Republic of Bashkortostan, specializing in dairy and beef cattle breeding.

Samples were collected in the main technological zones: premises for fattening cattle, calf houses, sections for keeping young animals, heifers and bulls, as well as in milking parlors and settling tanks. To monitor the indicators, administrative premises and the canteen were inspected.

The entire research cycle, from the procedures for collecting, transporting and storing samples to the laboratory stages of sowing, culturing, identifying fungal isolates and determining their sensitivity to antifungal drugs, was carried out in accordance with the current legislation.

Monitoring was carried out in a wide range of production areas, differing in key technological parameters: livestock density, age and sex groups of animals, diet specifics, and production purposes. Collection of samples for analysis was synchronized with the key technological cycles (distribution of feed, manure removal, loading and unloading of feed, etc.) to estimate actual operational contamination.

Air contamination was assessed by the open sedimentation method (Petri dishes with growth media: meat peptone agar, Endo agar, egg-yolk agar, blood agar, Enterococci agar, and Sabouraud agar (SRCAMB; Russia)) and aspiration methods involving the use of the microbiological sampler. Sampling was carried out at a height of 1.5 m from the floor in the central part of the room and in high-risk areas (at feed tables, manure aisles) with exposure time between 10 and 30 min.

Swab and swab blots were collected from the standard area (100 cm²) from the technological equipment (drinkers, feeders), fence elements, walls, floors and ventilation grilles using sterile tampons soaked in saline or peptone solution.

The "envelope" method was used to obtain a representative average sample of bulky and silage feeds. Single samples (8–10 units) were collected from different points within the test volume, including peripheral and central areas, as well as from

the upper, middle, and lower horizons. During sampling the 30–50 cm thick surface layer was previously removed from the silage and haylage to exclude the degraded mass. All single samples were combined in a sterile container, thoroughly homogenized to form an average laboratory sample. The number of feed samples ($n = 9$) was determined by the number of production zones allocated at the production facility in accordance with the technological regulations. Such a sample size ensured the coverage of all the main technological groups of animals and made it possible to conduct comparative assessment of contamination levels in different zones.

The bedding material (bedding) samples were collected in sterile hermetic containers using sterile instruments. The sampling scheme provided for sampling along the diagonal of the room from six points. At each point, material was collected after removing the top layer from the working depth of 5–10 cm characterized by maximum microbiological activity. A portion weighing about 100–200 g was taken from each point, after which all portions were combined into one common sterile container to form a combined sample. The number of bedding samples ($n = 7$) was determined by the number of sections in the production building that met all the inclusion criteria at once (identical maintenance conditions, operation term, physiological group of animals). The collection was carried out within one technological cycle of keeping, which excluded the time factor as an additional variable. Such a sample size enabled statistical analysis of the bedding mycobiota variability within homogeneous production environment. Exclusion criteria: areas with visible areas of moisture, mold or local disinfection (within less than 24 h).

Containers with samples were placed in a refrigerator bag; the time of delivery to the laboratory did not exceed 6 h from the time of sample collection.

To isolate and identify yeasts of the genus *Candida*, inoculation of the following microbiological media with the test material was performed: Sabouraud agar (SRCAMB; Russia), Sabouraud agar with glucose and chloramphenicol (HiMedia; India), Sabouraud agar with maltose (SRCAMB; Russia), and chromogenic agar (HiMedia; India) for yeast and mold. The yeast enzyme activity was determined in the media with the 1% peptone water and an indicator (Andrade, bromothymol blue (SRCAMB; Russia)) by the generally accepted methods. Culturing complied with the required conditions: dishes with cultures of yeast-like fungi was incubated at a temperature of 28 ± 2 °C for 48–72 h. Microbiological testing of mold fungi was performed using the growth medium No. 2 FPH (Sabouraud) (SRCAMB; Russia), chromogenic agar (HiMedia; India) for yeast and mold fungi at 25 °C. Culturing was performed for 5–7 years with the daily monitoring. The incubation time for slow-growing fungi was extended to 10 days. Identification was performed using identification guides for microscopic fungi by assessing morphology, shape, size, and the presence of characteristic structures.

To control the correctness of the yeast-like fungi (genus *Candida*) and mold fungi (genus *Aspergillus*) identification, reference strains from the State Collection of Pathogenic Microorganisms (SCPM) were used: *Candida albicans* ATCC 10231 и *Aspergillus niger* ATCC 16404. The proportion of confirmed isolates was at least 10% of the total number of isolated cultures.

To estimate the potential pathogen significance, the test results with a titer of at least 10^5 CFU/swab were considered.

Antifungal sensitivity testing was performed for all isolated yeast-like fungi of the genus *Candida* of the family *Saccharomycetaceae* from the air and production environment

Table 1. Number of strains of yeast-like fungi of the genus *Candida* isolated from the air and production environment samples at the livestock production facility in the studied period

Family	Genus	Species	Number of <i>Candida</i> strains				
			Air (n = 50)	Swabs (n = 100)	Feed (n = 9)	Bedding (n = 7)	Total (n = 166)
<i>Cryptococcaceae</i>	<i>Candida</i>	<i>C. albicans</i>	10	19	6	5	40
		<i>C. krusei</i>	0	13	3	0	16
		<i>C. glabrata</i>	1	4	2	2	9
Total			11	36	11	7	65

samples. A total of 65 isolates were tested, distributed as shown in Table 1.

To assess yeast sensitivity, the Mueller–Hinton agar (MHA) was used (HiMedia; India): modified, for antifungal sensitivity determination in accordance with the CLSI standard, recommended for diffusion of antifungal agents the paper discs are impregnated with in agar gel, as described in the CLSI standard. The antifungal activity criteria were determined by the disk diffusion method using commercial disks with antifungal agents for *in vitro* sensitivity testing (HiMedia; India). We used an extended panel of disks containing different concentrations of six antifungal drugs (fluconazole, clotrimazole, ketoconazole, nystatin, amphotericin B, itraconazole) measured in µg/disc or U. The results were assessed based on the diameter of the delayed (no) growth of microorganisms around the disks in accordance with the Instructions for Using Discs with Antifungal Drugs (Table 2) and tables from the IACMAC guidelines “Determination of the Sensitivity of Microorganisms to Antimicrobial Drugs” (version 2025-01, section 2: “Disc Diffusion Method to Assess Yeast Sensitivity to Antifungal Drugs”).

The 24-h culture (24 h at 35 ± 2 °C) for used to prepare the inoculum with the turbidity corresponding to the 0.5 McFarland standard for each strain, which corresponded to the cell content (1 × 10⁶–5 × 10⁶ CFU). A total of 1 mL of the resulting suspension was applied to the surface of the growth medium in Petri dishes in three directions. Discs with antifungals were placed onto the agar 15 min after inoculation.

The dishes were incubated at 35 ± 2 °C in the usual atmosphere for *C. albicans* and in the 5% CO₂ atmosphere for *C. krusei* and *C. glabrata*. The results were considered reliable with the almost flush growth of the culture and uniformly round zones of growth inhibition in the cups. If this was not observed after 20–24 h of growing, the results after 48 h were considered. A ruler was used to measure the zones of inhibition. The Petri dishes with the closed lids were placed upside down on a dark matte surface so that the light fell on it at an angle of 45° (counting using reflected light).

The testing quality control at all stages was accomplished in accordance with the IACMAC guidelines “Determination of the Sensitivity of Microorganisms to Antimicrobial Drugs” (version 2025-01). The yeast antifungal sensitivity testing quality

control involved the use of specific reference strains obtain from commercial sources (SRCAMB) that were recommended in accordance with the CLSI standard: *C. albicans* ATCC 10231, *C. albicans* ATCC 24433. Reference strains were included in each testing series. Inoculation and reference cultures and test isolates was performed under the same condition using the same batches of growth media. The series of tests was considered valid, when the diameters of the zones of inhibition for reference strains corresponded to the ranges determined by the disc manufacturer (Table 3). When the values were beyond the reference range limits, the series results were not taken into account, and the analysis was repeated.

When using the disc diffusion method for the *C. albicans* ATCC 10231 culture, the diameter of the zone of inhibition was as follows: amphotericin B — 15.9 ± 1.7 mm, nystatin — 19.6 ± 2.6 mm, clotrimazole — 15.5 ± 1.7 mm, ketoconazole — 19.6 ± 1.3 mm, itraconazole — 19.6 ± 1.2 mm, fluconazole — 32.7 ± 3.7 mm. As for the *C. albicans* ATCC 24433 culture, the zones of inhibition were as follows: amphotericin B — 14.8 ± 1.6 mm, nystatin — 20.9 ± 1.4 mm, clotrimazole — 22.2 ± 3.3 mm, ketoconazole — 24.4 ± 3.8 mm, itraconazole — 18.9 ± 0.9 mm, fluconazole — 32.1 ± 3.3 mm. The values obtained correspond to reference ranges for the reference strain, thereby confirming the experiment validity.

Statistical data processing was performed using the Statistica 10.0 software package (StatSoft; USA) and Microsoft Excel (Microsoft; USA). Significance of the associations between categorical variables (fungal species, object type, resistance level) was assessed using the Pearson’s chi-squared test (χ²) for contingency tables. The two-tailed Fischer’s exact test was used in cases of violation of the assumption of sufficient expected frequencies (when more than 20% of the cells had the expected frequency < 5, or at least one cell had E < 1).

RESULTS

The microbiota of the air in the working area of the premises is represented by two major groups: yeast-like and mold fungi (Fig. 1).

Microbiological testing of the samples collected from different premises of the working area showed that the mycobiota

Table 2. Zones of inhibition of the growth of yeast-like fungi cultures by antifungal drugs

Antifungal agents in the disk	Content in the disk	Diameter of the zones of inhibition, mm		
		resistant	intermediate (sensitivity depends on the dose)	sensitive
Amphotericin B	100 U	< 18	–	≥ 18
Nystatin	100 U	< 25	–	≥ 25
Clotrimazole	10 µg	< 18	–	≥ 18
Ketoconazole	10 µg	< 22	–	≥ 22
Itraconazole	10 µg	< 22	–	≥ 22
Fluconazole	25 µg	≤ 30	15–18	≥ 30

Table 3. Zones of inhibition (mm) by antifungals for reference strains

Antifungal	Symbol	Содержание в диске	Zone diameter (mm)			Control strains	
			R or less	S-DD*	S or more	<i>C.albicans</i> ATCC 10231	<i>C.albicans</i> ATCC 24433
Amphotericin B	AP	100 U	–	–	–	10–18	10–17
Nystatin	NS	100 U	–	–	–	15–23	19–23
Clotrimazole	CC	10 µg	–	–	–	12–18	18–32
Ketoconazole	KT	10 µg	–	–	–	18–22	20–32
Itraconazole	IT	10 µg	–	–	–	18–22	16–20
Fluconazole	FU	25 µg	14	15–18	19	28–39	28–39

Note: the reference ranges are provided in accordance with the instructions of the disk manufacturer (HiMedia; India) and confirmed during the method validation in laboratory settings; * — sensitive dose-dependent.

generic and species composition was almost the same, but the percentage varied depending on the department. The typical representatives of pathogenic and opportunistic mycobiota often detected during screening were as follows: *Aspergillus flavus*, *Aspergillus fumigatus*, *A. niger*, *C. albicans*, *C. krusei*, *C. grabrata*, *Candida tropicalis*. The distribution of the specified microorganisms based the frequency of their detection in the samples, as well as the share in the opportunistic microflora structure were similar in the premises with similar environmental conditions and similar indicators of agrobiocenosis contamination (Fig. 2).

Assessment of the working area swabs showed that mold and fungi represented mainly by *A. niger* and *C. albicans* were present in all working areas of the complex. *A. niger* was most often isolated in the calf house premises (35.7% of cases) and in the section for keeping bulls (24.3%); *C. albicans* was most often isolated in the section for keeping young animals (42.81% of cases) and in the settling tank (45.39% of cases).

In terms of species, among mold fungi together with *A. niger* such mold fungi, as *A. flavus*, *A. fumigatus*, were identified, and *C. krusei*, *C. grabrata*, *C. tropicalis* were isolated together with *C. albicans*. Furthermore, all these fungal species were found in all premises of the working environment, but the percentage was different. Other representatives of fungal microbiota, *Mucor spp.*, *Penicillium spp.*, *Fusarium*, were detected in less than 1% of samples.

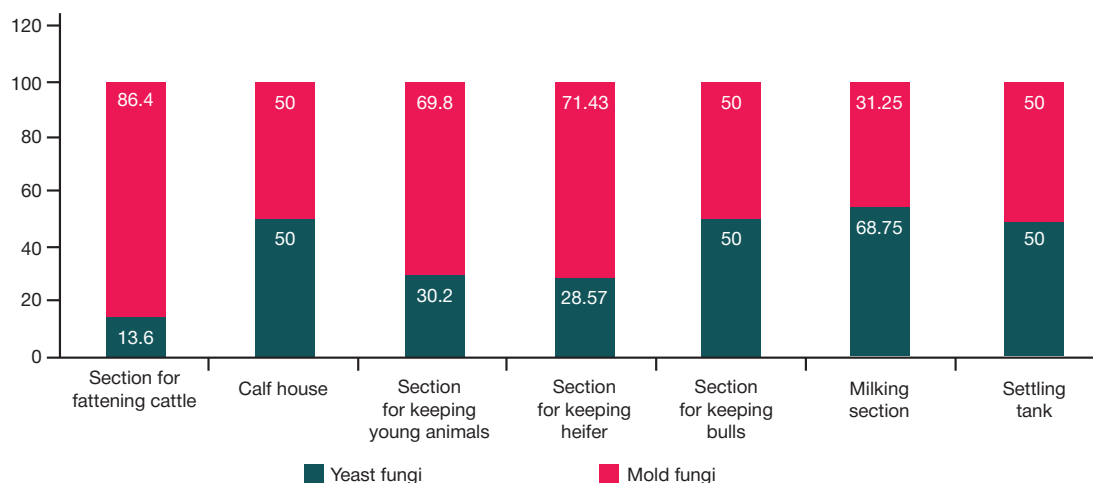
The analysis conducted suggests that all the tested feed samples are contaminated with mold and yeast-like fungi. *A. niger* was identified in 90% of samples, while *A. flavus* and *A. fumigatus* were found in 10%. In a half of cases (50% of samples), mixed contamination represented by two species of mold fungi at once was reported.

The most complex microbial cenosis represented by two- and three-component associated was reported for feed samples collected from the premises for keeping young animals, bulls, and the settling tank. Associations of *Pseudomonas aeruginosa*, *Citrobacter freundii*, and *Enterobacter aerogenes* were identified in the samples from the section for keeping young animals. *Escherichia coli*, *Proteus vulgaris*, and *Enterobacter aerogenes* were isolated from feeds from the premises for keeping bulls; *E. coli* and *Citrobacter freundii* were isolated from samples from the settling tank. *E. aerogenes* was also identified in the structure of microorganisms isolated: 20% of samples.

Among all isolated opportunistic microorganisms, mold and yeast-like fungi have the highest relative importance, which may indicate unsatisfactory feed storage and insufficient sanitary processing of the production environment working areas (Fig. 3).

The bedding material fungal microflora is represented by mold fungi: *A. flavus*, *A. fumigatus*, and *A. niger* were isolated from 100% of samples. As for yeast fungi, *C. albicans* was isolated from 100% of samples. *C. krusei* and *C. grabrata* were detected less often. *C. tropicalis* was not detected in any of the bedding material samples (Fig. 4).

The analysis of the rate of the *Candida* yeast-like fungi isolation revealed considerable differences depending on the studied object. The maximum contamination (100%) was reported for feed and bedding material samples. In swabs, the rate was 36%, which was higher compared to air samples, in which the isolation rate was minimal and reached 22%. The determined dependence of the *Candida spp.* Detection rate from the substrate type is significant ($p < 0.001$), which suggests the significantly higher likelihood of detecting fungi in the feed and bedding compared to the air and swabs. All the microorganisms isolated

**Fig. 1.** Mycobiota of the air in the working area of the livestock complex premises (% of isolated samples)

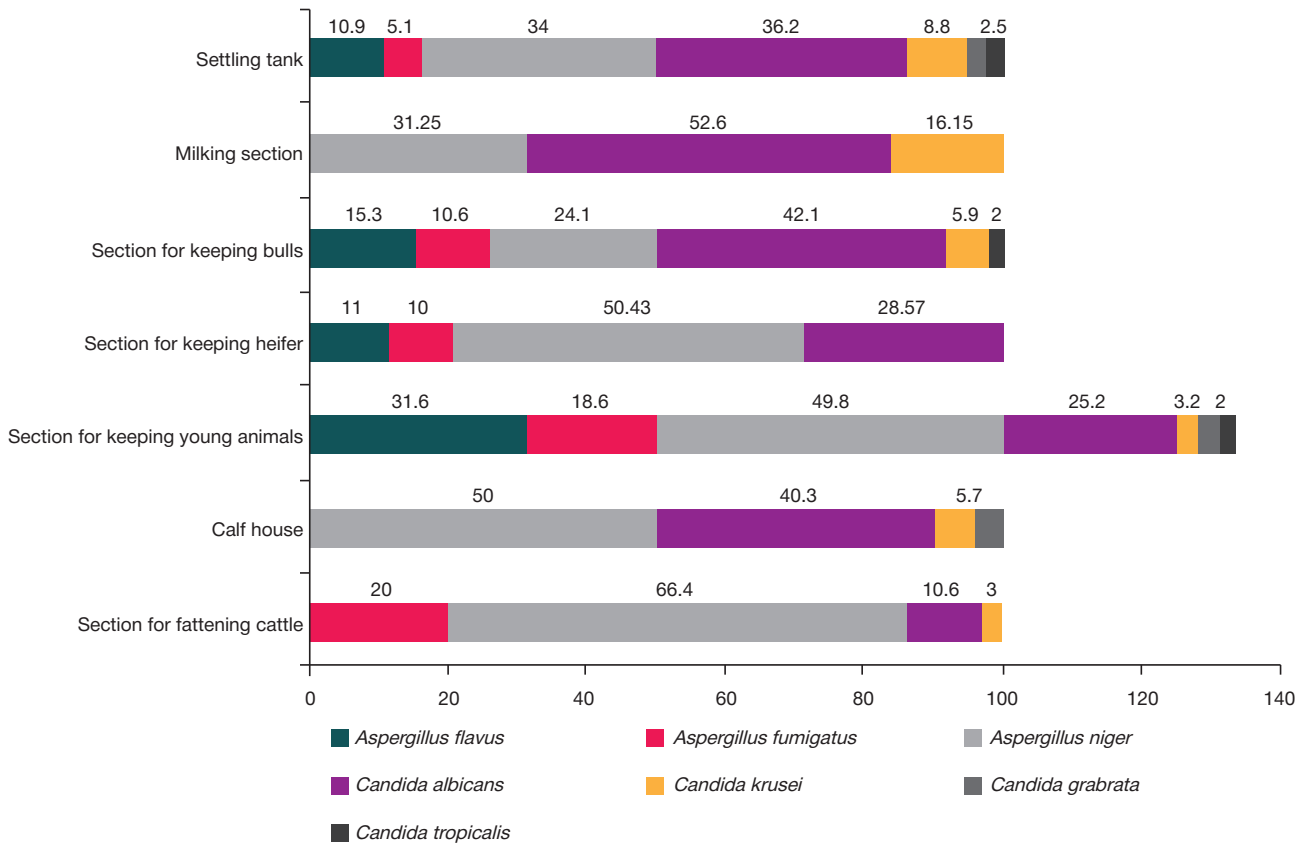


Fig. 2. Content of fungal flora in swabs from the working area (% of isolated samples)

were found in the form of multicomponent associations with other bacterial species.

The analysis of the resistance of 65 isolated strains of *Candida fungi* to six antifungal drugs revealed significant interspecies variability. No significant differences were found when comparing sensitivity of different *Candida* species (A vs. G and K vs. G) (Table 4; $p > 0.05$ in all cases).

The highest *in vitro* efficacy was reported for nystatin and clotrimazole. The share of *C. albicans* sensitive to nystatin was 92.5% (95% CI: 80.1–97.4), to clotrimazole — 87.5%

(95% CI: 73.9–94.5). As for *C. Krusei*, the maximum activity was reported for ketoconazole (93.8%; 95% CI: 71.7–98.9) and nystatin (93.8%; 95% CI: 71.7–98.9).

Fluconazole showed the lowest efficacy: the share of resistant *C. albicans* strains reached 70.0% (sensitivity was only 30.0%; 95% CI: 18.1–45.4). Sensitivity of non-albicans species (*C. krusei* and *C. glabrata*) to fluconazole was also low (56.3 and 55.6%, respectively). High *C. krusei* sensitivity to ketoconazole (93.8%) attracts attention; the value reported for *C. albicans* is 77.5%.

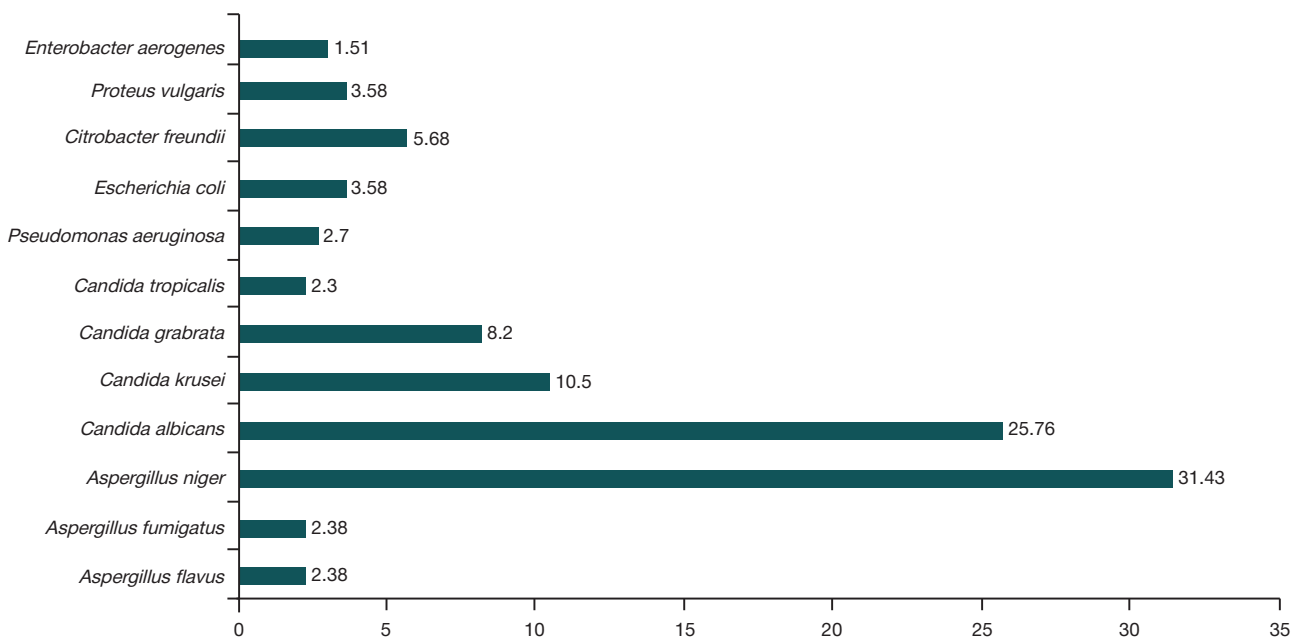


Fig. 3. Typical composition of microbial communities of feeds collected in the livestock complex working areas (% of samples)

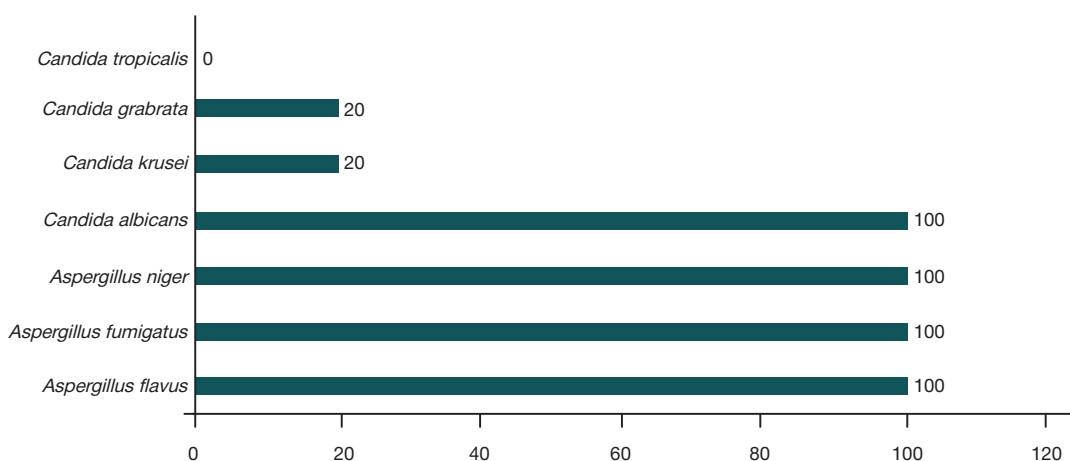


Fig. 4. Species composition of fungal microorganisms isolated from the bedding material in the livestock complex working areas (% of the total number of isolates)

DISCUSSION

Microbiological testing of swabs from the production environment surfaces confirmed fungal contamination of all the complex working areas.

Feeds represent a significant reservoir and vector of microorganism transmission. All the tested feed samples were contaminated with mold and yeast-like fungi. In addition to mycobiota, bacteria *P. aeruginosa*, *C. freundii*, and *E. aerogenes* were identified in feed samples, *E. coli*, *P. vulgaris* were also isolated.

The highest microbial contamination levels are reported for the bedding material, in which the communities are represented by both micromycetes and various Gram-negative bacteria. Among yeast fungi, *C. albicans* was isolated from all samples (100%).

Comparative assessment of the *Candida* yeast-like fungi isolation rate revealed considerable intergroup differences. The feed and bedding material samples were characterized by the 100% contamination. Fungi were more often found in swabs (36%), than in air samples (22%). The differences obtained are highly significant ($p < 0.001$), which suggests the priority role of feeds and the bedding material as a reservoir of *Candida* spp. compared to the air environment objects and swabs.

The findings confirm natural resistance of *C. krusei* to fluconazole (sensitivity is 56.3%, that is considered a relatively high indicator for this species against the background of the literature data) and low sensitivity of *C. albicans* to this azole (30.0%), which can indicate selection of resistant strains in the population. The lack of significant differences between species ($p > 0.05$) is likely to result from the small size of the *C. glabrata* ($n = 9$) and *C. krusei* ($n = 16$) samples.

Table 4. Sensitivity of *Candida* spp. clinical isolates to antifungal drugs, % (abs.) [95% CI]

Drug	<i>C. albicans</i> ($n = 40$)	<i>C. krusei</i> ($n = 16$)	<i>C. glabrata</i> ($n = 9$)	p (A vs. G)	p (K vs. G)
Amphotericin B (AP)	75.0 (30) [59.8–85.8]	68.8 (11) [44.4–85.8]	77.8 (7) [45.3–93.7]	1.000*	0.683*
Nystatin (NS)	92.5 (37) [80.1–97.4]	93.8 (15) [71.7–98.9]	77.8 (7) [45.3–93.7]	0.199*	0.245*
Clotrimazole (CC)	87.5 (35) [73.9–94.5]	81.3 (13) [56.9–93.4]	77.8 (7) [45.3–93.7]	0.598*	1.000*
Ketoconazole (KT)	77.5 (31) [62.5–87.7]	93.8 (15) [71.7–98.9]	77.8 (7) [45.3–93.7]	1.000*	0.267*
Itraconazole (IT)	60.0 (24) [44.6–73.7]	37.5 (6) [18.5–61.4]	55.6 (5) [26.7–81.1]	1.000*	0.433*
Fluconazole (FU)	30.0 (12) [18.1–45.4]	56.3 (9) [33.2–76.9]	55.6 (5) [26.7–81.1]	0.242*	1.000*

Note: n — number of strains tested; the percentage of sensitive strains is specified in the cells, absolute numbers are specified in parenthesis, 95% confidence intervals are specified in square brackets; p (A vs. G) — comparison of *C. albicans* and *C. glabrata*; p (K vs. G) — comparison of *C. krusei* and *C. glabrata*; * — non-significant differences ($p > 0.05$).

The literature data in the *C. krusei* itraconazole sensitivity are controversial and demonstrate significant inter-strain variability: from the high *in vitro* activity to the complete resistance. This suggests that there is no species-specific susceptibility [10–12].

The *C. glabrata* fluconazole resistance is multifactorial, it is realized through overexpression of efflux pumps (resulting from the PDR1 mutations) and mutation on the *ERG11* target gene. Active elimination of the drug from the cell is the leading mechanism, and the *ERG11* alteration increases resistance. This determines the frequent lack of clinical response to fluconazole and requires prescription of echinocandins [13–15].

CONCLUSIONS

The results obtained demonstrate systemic contamination of the livestock complex production environment with potentially pathogenic fungi with the formation of stable microbial communities in key facilities (feeds, bedding). The determined multi-resistance of the circulating strains of yeast-like fungi to common antifungals (resistance to more than four drugs) suggests the need to develop specialized control measures.

The yeast antifungal sensitivity in the context of CLSI standards is the ability of microorganisms to inhibit visible growth under certain test conditions *in vitro*. The determined resistance to the azole class of drugs necessitates exclusion of those from preventive regimens for livestock farming in order to avoid the decrease in antifungal measure efficacy. Polyene group drugs and echinocandins can be offered as alternative antifungal drugs.

Considering the potentially reversible nature of the yeast resistance to antifungals and the positive experience of rotation of agents in adjacent areas, strategy of sequential change

of antifungal drugs so overcome the resistance of *Candida spp.* in candidiasis seems justified.

The reported sanitary and microbiological approaches to assessment of fungal contamination in livestock production

facilities have a pronounced complex preventive orientation, allowing one to improve the working conditions of farm workers, as well as organize measures to improve the livestock complex production environment.

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SLEEP QUALITY OF MEDICAL STUDENTS DURING UNIVERSITY YEARS

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Studying at medical universities involves a high academic workload, frequent movement between clinics, and, in some cases, employment in medical institutions. These factors may impair cognitive function and contribute to the development of anxiety, sleep disturbances, and daytime sleepiness. This study aimed to assess the prevalence and severity of sleep disorders among medical university students in a megalopolis. We used the Epworth Sleepiness Scale (ESS) and the Spiegel Morningness–Eveningness Questionnaire (MOS-SS) to anonymously survey 1,627 students (1,329 females and 298 males) from all years and faculties at St. Petersburg Pediatric Medical University. It was found that 86.7% of students feel daytime sleepiness of varying severity, and it is much more common in females (96.0%) than in males (45.2%; $p = 0.0000$). Various sleep-quality disturbances were identified in 94.5% of students; girls had them more often (99.6%) than boys (71.9%; $p < 0.0000$). We found a moderate positive correlation between daytime sleepiness and sleep disorder severity ($r = 0.45$; $p < 0.05$). The study findings substantiate the need for preventive measures aimed at improving sleep quality and adjusting academic workload, as well as for specialist consultations in cases of severe sleep disorders.

Keywords: sleep, sleep disorders, drowsiness, students, healthcare workers

Author contribution: Lisovskii OV — study concept and design; Moiseeva KE — selection of materials and methods, text editing; Gritsinskaya VL — article authoring; Lisitsa IA — study coordination, collection of literature data; Valiakmetova DG — data analysis and interpretation; Uskova SYu — statistical processing of the material; Shchekaleva PD — preparation of questionnaires, data collection; Stanchu AD — compilation of the database; all authors — approval of the final version of the article, ensuring the integrity of all of its parts.

Compliance with ethical standards: the study was approved by the Ethics Committee at St. Petersburg State Pediatric Medical University (Minutes No. 60/16 of October 24, 2025). Participation in the survey was voluntary and confidential.

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Received: 30.01.2026 **Accepted:** 08.05.2026 **Published online:** 23.06.2026

DOI: 10.24075/rbh.2026.163

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КАЧЕСТВО СНА ОБУЧАЮЩЕЙСЯ МОЛОДЕЖИ В ПЕРИОД ОСВОЕНИЯ МЕДИЦИНСКОЙ СПЕЦИАЛЬНОСТИ

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Обучение в медицинских вузах сопряжено с высокой интенсивностью академической нагрузки, территориальным перемещением между клиническими базами, в ряде случаев — работой в медицинских учреждениях, что может снижать когнитивные способности, потенцировать развитие тревожности, нарушения ночного сна и дневной сонливости. Целью исследования было оценить распространенность и выраженность нарушений сна у обучающихся медицинского вуза в мегаполисе. С помощью опросников Эпворта (ESS) и Шпигеля (MOS-SS) проведено анонимное тестирование 1627 студентов (1329 девушек и 298 юношей), обучающихся на всех курсах и факультетах Санкт-Петербургского педиатрического медицинского университета. Установлено, что у 86,7% студентов имеет место дневная сонливость различной степени выраженности, причем у девушек она встречается значительно чаще (96,0%), чем у лиц мужского пола (45,2%; $p = 0,0000$). Различные нарушения качества ночного сна отмечены у 94,5% студентов, при этом снижение качества сна у девушек регистрировали чаще (99,6%), чем у юношей (71,9%; $p = 0,0000$). Выявлена умеренная прямая корреляционная связь между уровнем дневной сонливости и выраженностью нарушений сна ($r = 0,45$; $p < 0,05$). Результаты исследования обосновывают необходимость проведения направленных на улучшение качества сна, корректировку режима учебной нагрузки профилактических мероприятий и консультации специалистов при выраженных нарушениях сна.

Ключевые слова: сон, нарушения сна, сонливость, студенты, медицинские работники

Вклад авторов: О. В. Лисовский — концепция и дизайн исследования; К. Е. Моисеева — подбор материалов и методов, редактирование текста; В. Л. Грицинская — написание текста статьи; И. А. Лисица — координация исследования, сбор данных литературы; Д. Г. Валиахметова — анализ и интерпретация данных; С. Ю. Ускова — статистическая обработка материала; П. Д. Щечкалева — подготовка анкет, сбор данных; А. Д. Станчу — создание базы данных; все авторы — утверждение окончательного варианта статьи, ответственность за целостность всех частей статьи.

Соблюдение этических стандартов: исследование одобрено локальным этическим комитетом при Санкт-Петербургском государственном педиатрическом медицинском университете (протокол № 60/16 от 24 октября 2025 г.). Участие в опросе было добровольным и предполагало соблюдение конфиденциальности.

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Статья получена: 30.01.2026 **Статья принята к печати:** 08.05.2026 **Опубликована онлайн:** 23.06.2026

DOI: 10.24075/rbh.2026.163

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Sleep is a fundamental physiological process that enables the recovery of cognitive capabilities, supports memory consolidation, and promotes emotional stability and the regulation of bodily systems [1]. In recent years, many researchers in Russia and internationally have investigated the impact of sleep quality

on young people's ability to learn professional skills. It has been established that the persistent misalignment of an individual's chronotype and the externally imposed wakefulness schedules with chronic sleep deprivation lead to social desynchronization and an increased risk of health disorders [2, 3]. It has also been

found that sleep problems are more common among women, heavy smokers and consumers of large doses of caffeinated beverages, people intensively using digital gadgets before bedtime and in the evening, and persons exhibiting symptoms of anxiety and depression [4–6].

Medical students are at increased risk of developing sleep disorders. That said, quality sleep is especially important for them because of the inherently high academic workload, clinical practice tasks, and night shifts, which potentiate chronic sleep deficiency and cause drowsiness during the day. Sleep disorders directly affect learning effectiveness by hindering attention, slowing information processing and decision-making, and generally impairing quality of life [7, 8]. Between 40.6% and 77% of clinical students in Southeast Asia and Latin America have been found to have poor Pittsburgh Sleep Quality Index (PSQI) scores, and 90% reported daytime sleepiness [9–12]. In Kyrgyzstan, 72% of medical students had sleep problems that reduced concentration and memory capacity [13]. Sleep problems were experienced by 60% of medical students in Egypt [14]. Russian researchers have also identified difficulties with falling asleep, frequent night awakenings, and daytime sleepiness in a significant part of medical students [15–19].

Given the relevance of the above, we conducted a study to assess the prevalence and severity of sleep disorders among medical university students in a megalopolis.

METHODS

This cross-sectional sociological study involved 1,627 students (1,329 females and 298 males) and was conducted by researchers from the Department of General Medical Practice at St. Petersburg State Pediatric Medical University. The study took place in the middle of the semester; it had no relation to exams and tests. The researchers enrolled students from all faculties, years 1 through 6; the mean age of participants was 20.3 ± 1.3 years. They were invited to confidentially complete a survey created using Yandex Forms that incorporated the Epworth Sleepiness Scale (ESS) and the Spiegel Medical Outcomes Study Sleep Scale (MOS-SS)

[1]. ESS is a diagnostic tool enabling subjective assessment of excessive daytime sleepiness, which can be non-existent (0–8 points), mild (9–12 points), moderate (13–17 points), and severe (≥ 18 points). MOS-SS covers the time of falling asleep, the duration of sleep, the frequency of awakenings and condition after them, and overall satisfaction with sleep. A score of 22 points or less indicated a sleep disorder, mild (12–22 points) or severe (≤ 11 points).

After discarding incorrectly filled out surveys we exported the data to an MS Office Excel spreadsheet (Microsoft; USA). SPSS Statistics 23.0 (IBM; USA) was used for the main stage of processing. The Kolmogorov–Smirnov test was applied to assess normality of distribution of quantitative data. Categorical variables are reported as percentages with corresponding 95% confidence intervals (95% CI) Pearson's chi-square (χ^2) test was used for intergroup comparison. The direction and strength of the relationship between quantitative variables were assessed using Spearman's rank correlation coefficient (applied for not normally distributed data). The differences were considered statistically significant at $p < 0.05$.

RESULTS

According to the ESS, most participants — 86.7 [85.9–87.5]% — experienced daytime sleepiness of varying intensity: mild in 21.9 [20.8–22.7]% of respondents, moderate in 28.5 [27.4–29.6]%, and severe in 36.3 [35.1–37.5]%. Only one in seven study participants got enough sleep at night. More than half of the young men did not feel drowsy during the day (54.8 [51.9–57.7] %); one in three reported mild sleepiness (30.1 [27.7–32.5]%). Significant drowsiness was established in 13.0 [11.1–14.9] % of male participants. The condition was severe in 2.1 [1.3–2.9] % of male students, and it significantly impaired their performance. Among the girls, only 4.0 [3.6–4.5] % did not experience daytime sleepiness, which is significantly less than in the male part of the sample ($p < 0.001$; $\chi^2 = 546.5$). Female respondents were less likely to feel mildly sleepy during the day (20.0 [18.9–21.1]%; $p < 0.001$; $\chi^2 = 14.5$), but more prone to moderate (31.9% [30.6–33.2]%; $p < 0.001$; $\chi^2 = 56.5$)

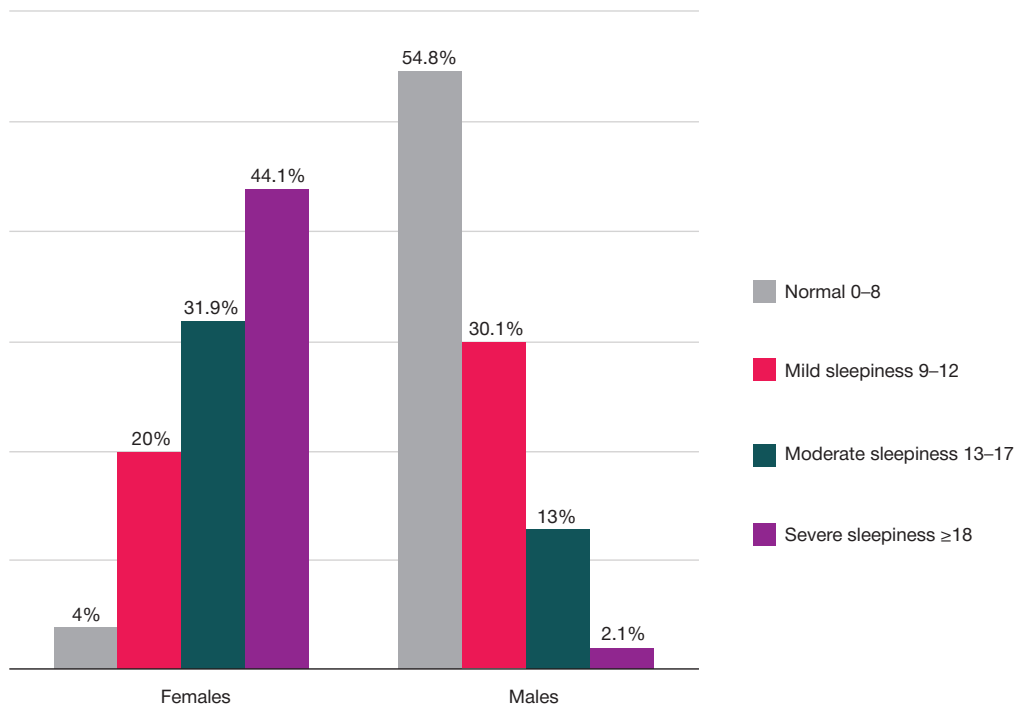


Fig. 1. Daytime sleepiness registered with ESS

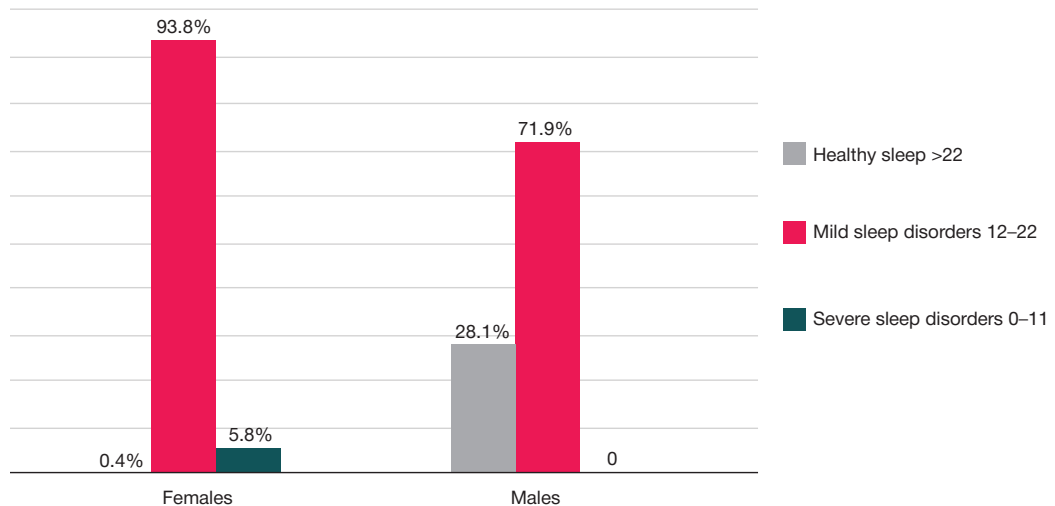


Fig. 2. Sleep quality registered with Spiegel MOS-SS

and severe drowsiness (44.1 [42.7–45.6] %; $p < 0.001$; $\chi^2 = 312.1$) (Fig. 1).

Spiegel MOS-SS revealed that only 5.5 [4.9–6.1]% of students enjoyed healthy sleep, while 89.7 [89.0–90.4]% of them suffered from moderate, and 4.8 [4.2–5.4]% — from severe sleep disorders. Healthy sleep was more common among boys than girls: 28.1 [25.5–30.7]% versus 0.4 [0.2–0.6]% ($p = 0.001$; $\chi^2 = 10.2$). Female respondents mentioned moderate sleep disorders more often (93.8 [93.2–94.5]%) than male ones (71.9 [69.3–74.5]%, $p < 0.001$; $\chi^2 = 128.5$). Severe sleep disturbances were recorded only in girls — their share in the sample was 5.8 [5.2–6.4]% (Fig. 2).

Correlation analysis showed a moderate positive relationship between daytime sleepiness and the severity of sleep disorders ($r = 0.45$; $p < 0.05$). This indicates that students' daytime sleepiness increases as their sleep quality deteriorates.

DISCUSSION

There are numerous studies that investigate sleep duration and quality among medical students [2, 4, 8]. In this work, we found high rates of moderate and severe drowsiness (up to 31.9% and 44.1%, respectively), with an overall sleepiness level of 86.7% (all components).

Our findings are consistent with the opinions of several researchers who note increased drowsiness in up to 90% of students, which allows considering it as a significant factor affecting academic performance and health [3, 10, 11, 20]. Medical students often have to balance study, work, and personal life, which can lead to insufficient sleep [21–23]. Most authors highlight increased daytime sleepiness and decreased nighttime sleep duration among students [5, 13, 24].

Sleep disorders were established in 94.5% of the respondents, predominantly females [25]. Both the general patterns of daytime sleepiness formation and the constitutional features of students with sleep disorders have been identified [7, 26]. It has been

shown that individuals with an evening chronotype are more susceptible to sleep disorders because they are less well adapted to attending morning classes [2].

We conducted this study during the semester, before the exams, which suggests that the identified changes are not related to acute stress, but reflect chronic fatigue, sleep and rest disorders, as well as an imbalanced academic load. Students with higher academic performance are more likely to sacrifice sleep, experiencing significant discomfort and drowsiness during the day [4, 17].

Impaired sleep quality and increased daytime sleepiness may entail reduced attention and worsened cognitive functions as well as an increased risk of emotional burnout [27, 28]. This is especially important for medical students, as it can negatively affect not only academic performance, but also future professional activities. Without remedial measures, chronic sleep disorders and persistent daytime sleepiness are an increased risk factor for psychosomatic diseases [3].

CONCLUSIONS

The Epworth Sleepiness Scale and the Spiegel Morningness–Eveningness Questionnaire are reliable tools for detecting sleep disorders and excessive daytime sleepiness among medical students across all years.

The established relationship between deteriorating sleep quality and increasing daytime sleepiness indicates the development of chronic fatigue and a decline in students' adaptive capacity.

Sleep disorders affect more than 86% of students, highlighting the need for regular monitoring of sleep and psycho-emotional well-being, along with programs to prevent overwork and improve daily routines.

Measures to improve sleep hygiene and establish a well-structured academic schedule will enhance students' mastery of the core curriculum, preserve their quality of life, and support the health of future healthcare professionals.

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MODERN HYGIENIC APPROACHES TO ASSESSING THE COMPLIANCE OF SPECIALIZED FOOD PRODUCTS

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One way to meet the body's physiological nutrient needs is to normalize the population's diet through specialized food products (SFP), including biologically active supplements (BAS). At the same time, the content of bioactive substances in these products requires confirmation of compliance with the mandatory requirements of the Eurasian Economic Union (EAEU) legislation. Sanitary and epidemiological examination is key to obtaining a positive or negative decision on the SFP's compliance with established requirements and declared properties. Based on the results of the sanitary and epidemiological examination, Rosпотребнадзор or another authorized body decides to issue a state registration certificate (SRC), which serves as a document allowing the manufacturer to produce and sell SFPs within the EAEU. This article presents an assessment of modern hygienic approaches to the sanitary and epidemiological examination of SFPs and provides explanations of the procedure for preparing the required documentation for examination. The provisions of the publication will be useful to specialists performing sanitary and epidemiological examination of SFPs, as well as to manufacturers and applicants planning to obtain a SRC.

Keywords: specialized food products, list of documents for examination of specialized food products, sanitary and epidemiological examination, quality and safety requirements

Author contribution: Setko AG — editing, material acquisition, analysis, and processing; Novokshanova AL — editing, concept and design of the analytical review, material acquisition and analysis; Yuskina ON — editing, material collection, literature data processing; all authors — approval of the final version of the article, responsibility for integrity of all parts of the article.

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Received: 20.01.2026 **Accepted:** 13.05.2026 **Published online:** 24.06.2026

DOI: 10.24075/rbh.2026.164

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СОВРЕМЕННЫЕ ГИГИЕНИЧЕСКИЕ ПОДХОДЫ К ОЦЕНКЕ СООТВЕТСТВИЯ СПЕЦИАЛИЗИРОВАННОЙ ПИЩЕВОЙ ПРОДУКЦИИ

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Один из путей обеспечения физиологических потребностей организма в нутриентах лежит в нормализации рациона питания населения с помощью специализированной пищевой продукции (СПП), в том числе биологически активных добавок к пище (БАД). Вместе с этим, содержание биологически активных веществ в данном виде продукции требует подтверждения соответствия обязательным требованиям законодательства Евразийского экономического союза (ЕАЭС). При этом санитарно-эпидемиологическая экспертиза является ключевой для получения положительного или отрицательного решения о соответствии СПП установленным требованиям и заявленным свойствам. Именно по результатам санитарно-эпидемиологической экспертизы Роспотребнадзор или другой уполномоченный орган принимает решение о выдаче свидетельства о государственной регистрации (СГР), который служит документом, позволяющим производителю производить и реализовывать СПП на территории ЕАЭС. В статье представлена оценка современных гигиенических подходов к санитарно-эпидемиологической экспертизе СПП, даны пояснения к процедуре подготовки пакета документов, необходимого для предоставления на экспертизу. Рассматриваемые положения будут полезны специалистам, выполняющим санитарно-эпидемиологическую экспертизу СПП, а также производителям и заявителям, планирующим получить СГР.

Ключевые слова: специализированная пищевая продукция, перечень документов для проведения экспертизы специализированной пищевой продукции, санитарно-эпидемиологическая экспертиза, требования к качеству и безопасности

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Статья получена: 20.01.2026 **Статья принята к печати:** 13.05.2026 **Опубликована онлайн:** 24.06.2026

DOI: 10.24075/rbh.2026.164

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Measures aimed at improving and optimizing the population's diet and combating the constant increase in the incidence of non-communicable diseases of a nutritional nature, such as obesity, type 2 diabetes mellitus, diseases of the digestive and cardiovascular systems, and cancer, are being taken throughout the world. The Russian Federation (RF) adheres to the same policy.

Monitoring the health status of the Russian population has shown that lifestyle factors have become the most significant factors influencing the health of citizens in 2023.

According to Rosпотребнадзор, in 50 regions of Russia, more than half of citizens (53.1%, which in absolute terms accounted for 77.7 million people) had significant health consequences from the exposure to factors such as smoking,

alcohol consumption, and the unbalanced diet [1]. Furthermore, more than half of deaths in the Russian Federation occur as a result of foodborne diseases associated with the consumption of low-quality food products and poor nutrition. Chronic non-communicable diseases are the leading cause of death all over the world. Thus, in 2019 these caused 71% of deaths registered worldwide [2].

One of the ways to normalize the population's diet involves the development and production of innovative products, which include fortified and specialized food products (SFPs), including biologically active supplements (BAS), the use of which allows for a balanced diet, leveling out macro- and micronutrient imbalances. The use of SFPs reduces labor losses, medical expenses, etc., associated with foodborne diseases. As a result, a better quality of life is achieved and the life expectancy of the population increases in general [2]. Rospotrebnadzor is responsible for controlling the production and release of such products for sale to the population.

Modern diets of the population in developed economies are characterized by the increased consumption of processed foods. Furthermore, manufacturers are constantly developing new types of food products to adapt to consumer preferences and demand. Compared to traditional food products, SFPs with the modified macro- and micronutrient composition, the effectiveness of which has been proven during the conformity assessment, have a competitive advantage. The production of such products is associated with specific preparation of the main raw materials and/or further introduction of functional food ingredients, and the technological process involves the use of auxiliary techniques: mixing, grinding, refining, heat treatment, extending storage periods, using additives that improve the organoleptic properties and shelf life of products, etc. Meanwhile, when trying to reduce the cost of production, there is risk of the SFP counterfeiting. In this regard, control over the production and release of such products, including sanitary and epidemiological examination, is extremely important to ensure the safety and health of the population. At the same time, in the course of their professional activities, the authors have become convinced that at the present time, in order to confirm the SFP compliance with the established requirements, objective hygienic criteria are required for conducting the sanitary and epidemiological examination.

The SFP hygienic assessment is the subject of research by many authors, but there are not enough relevant papers at the moment. Thus, the researchers [3] describe some of the features of the state registration procedure, including the procedure for its implementation. There are papers describing the market for baby food in the RF and abroad; the procedure for state registration of food products for children over the age of 3 years is provided [4]. The experience of implementing technical regulations of the Customs Union into the activities of regional bodies and organizations of Rospotrebnadzor is reported [5]. A number of papers provide the data on the market of SFPs in other countries of the Eurasian Economic Union (EAEU) [6]. The paper [7] provides information about the implementation of the draft "Guidelines for Conducting Sanitary-Epidemiological and Hygienic Assessment (Expertise) of Biologically Active Food Supplements" at the Eurasian Economic Commission with the participation of representatives of authorized bodies of the EAEU member states in the field of sanitary and epidemiological welfare.

Based on the above, hygienic assessment of the SFP compliance with mandatory requirements is a pressing issue. The provisions of the paper will be useful to specialists performing sanitary and epidemiological examination of SFPs,

as well as to manufacturers and applicants planning to obtain a state registration certificate.

The aim was to develop modern hygienic approaches to assessment of the SFP quality, safety, and efficacy.

Methods

We performed the analysis, systematization, and synthesis of the legal, regulatory, and scientific information concerning the SFP hygienic standardization. The research objects were full-text documents of the legislative and regulatory acts of the Russian Federation, the EAEU and other countries, scientific publications from the electronic databases (eLIBRARY, PubMed, Scopus, Web of Science) on the issue of SFP manufacture and conformity assessment, as well as our own research data [8].

Analysis of the current situation

The analysis of the data of food quality and safety monitoring conducted by Rospotrebnadzor since 2019 has revealed an increase in the number of products that do not meet mandatory requirements [1], including SFPs, which suggests either insufficient registration control, or product falsification by manufacturers. However, both require careful analysis and corrective measures.

An example is the detection of the substances not declared by the manufacturers in food products (Fig. 1). According to Rospotrebnadzor, in 2023, undeclared ingredients or potentially hazardous substances were found in most categories of food products widely consumed by both adults and children in all regions of the RF [1].

Of particular concern is the fact that all of these are mass-market products present in the diet of a wide range of consumers. The diagram clearly demonstrates that SFPs, including baby food and dietary supplements, constitute a large share of products, in which the undeclared substances were found, which suggests the relevance of the issue under consideration.

At the same time, the exceeding of permissible levels of contaminants in food products is a serious concern, which once again highlights the importance of the SFP quality and safety control (Fig. 2).

The sanitary and hygienic studies conducted by Rospotrebnadzor in 2023 revealed the presence of hazardous and unacceptable substances in food products. Preservatives were found in 17.66% of the tested food samples, toxic elements in 7.83%, glycidol and glycidyl esters in 3.41%, microbial transglutaminase in 3.03%, sweeteners in 2.78%, pesticides in 2.03%, antimicrobial agents in 1.36%, nitrosamines in 1.29%, GMO ingredients in 0.66%, mycotoxins in 0.31%, β -adrenergic agonists in 0.25%, colorants in 0.16% [1].

The presence of the above substances in food products indirectly affects the total number of disease cases in the population. It is estimated that the share of diseases caused by the presence of toxic and other hazardous substances in food products throughout the Russian Federation in 2023 in absolute terms was 958.4 cases per 100,000 population.

Improving the quality and life expectancy of the population of the RF is undoubtedly possible with the use of SFP, but this category of food products is not an exception in terms of the possible presence of contaminants. The SFP quality and safety are monitored by Rospotrebnadzor, and the state registration system has been functioning since 1997. Some food products in this category are sold through the Chestny Znak (Honest Sign) state labeling and tracking system

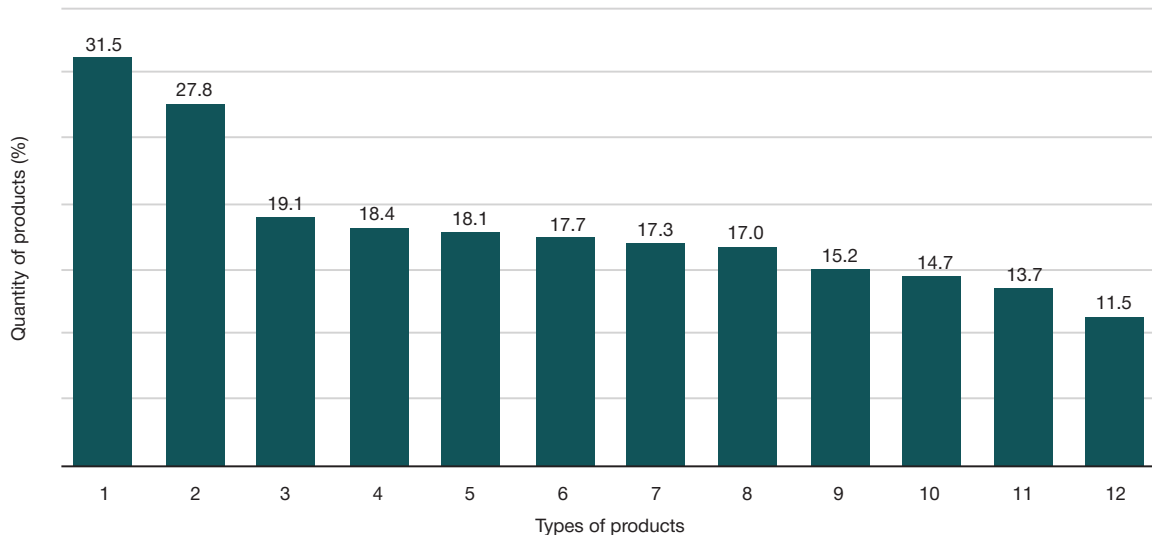


Fig. 1. The number of contaminated samples with the detection of undeclared substances by product group in the RF in 2023, % [1]: 1 — SFPs, including baby food and dietary supplements; 2 — fish, non-fish fisheries and products derived from them; 3 — meat and meat products; 4 — poultry, eggs and products of their processing; 5 — honey and bee products; 6 — sugar and confectionery; 7 — grain (seeds); 8 — fruit and vegetable products; 9 — packaged drinking water; 10 — fat and oil products; 11 — beverages; 12 — milk and dairy products

in the form of dietary supplements. Despite this fact, more than 30% of SFPs do not meet hygienic quality and safety standards, and the percentage of dietary supplements containing prohibited substances is high.

Methodology for preparing a package of documents for examination

Information about the SFP state registration is contained in the Unified Registry of Registered Food Products "Unified Regulatory and Reference Information of the Eurasian Economic Union" [1]. In the RF, the national part of the Unified Registry of Specialized Food Products is in effect: the "Register of State Registration Certificates (within the Eurasian Economic Community Customs Union, Russian part)" [9]. The SFP state registration is indefinite, but it can be terminated or suspended by the authorized body for registration of SFPs. Such a forced measure is resorted to in cases of the SFP non-compliance with the requirements of technical regulations established as a result of state control (supervision) and/or by decision

of the judicial authorities of a member state of the Customs Union, due to the fact that providing the population with high-quality and safe food products is one of the priority areas of the countries' development.

The procedure for implementing state registration [10] is based on the results of the sanitary and hygienic examination aimed primarily at assessing the compliance with the following hygienic criteria:

- production safety;
- quality and safety of raw materials and final products;
- SFP efficacy.

The SFP sanitary and hygienic examination represents a the process of reviewing documents, analyzing and evaluating the information contained therein, including information on the label (label layout) and information on the presence of food, biologically active and auxiliary substances, the results of laboratory testing, efficacy assessment, based on which the conclusions about the possibility of registering the product are drawn.

When analyzing the raw components used in SFP, it is necessary to evaluate not only the food components,

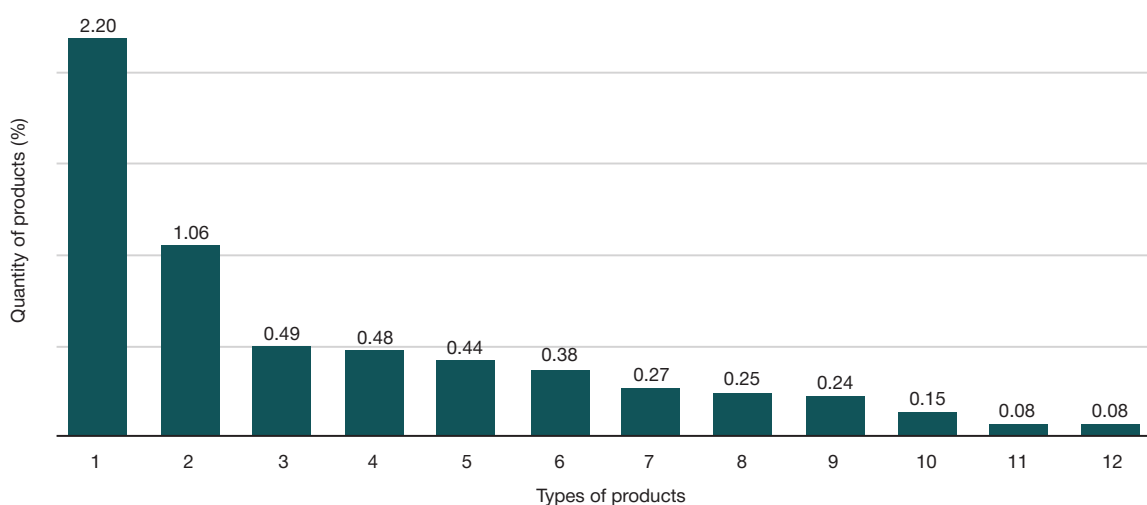


Fig. 2. The number of samples exceeding acceptable levels of contaminants by product group in the RF in 2023, % [1]: 1 — grain (seeds); 2 — SFPs, including baby food and dietary supplements; 3 — meat and meat products; 4 — fruit and vegetable products; 5 — fish, non-fish fisheries and products derived from them; 6 — packaged drinking water; 7 — milk and dairy products; 8 — poultry, eggs and products of their processing; 9 — honey and bee products; 10 — sugar and confectionery; 11 — fat and oil products; 12 — beverages

but also the biologically active substances characteristic of these types of raw materials. The documents, in accordance with which the products have been manufactured, are the sources of such information: technical conditions, technological instructions, specifications, recipes and/or information on the composition of products, and other documents. If the SFP contains components of animal origin, it is necessary to confirm their safety by providing documents, including veterinary certificates. If the SFP contains components of plant origin, the documents required must contain information on the part of the plant, as well as the binary name (genus and species of plant) in Latin and Russian. If the SFP contains auxiliary food components, including food additives and flavorings, a document containing information on the source and method of obtaining them has to be provided.

The documents provided for examination include the manufacturer's declaration indicating that the SFP manufactured is compliant with the requirements of the regulatory documentation according to which it is produced, such as copies of quality certificates or safety (quality) data sheets for products, or quality certificates certified by the manufacturer, or an information letter from the manufacturer.

Before starting selling the SFP, the manufacturer develops a draft label inscription (information indicated in the marking), including so that consumers are informed about the product features, and information about the product distinctive features is presented objectively and does not mislead the consumer. In this regard, copies of labels or their layouts must be submitted for expert evaluation, containing not only information on the product composition, nutritional and energy value, but also recommendations for use, restrictions on intake. The requirements for the labeling design are set out in TR CU 022/2011 "Food Products in Terms of Their Labeling" [11].

The SFP test samples are the object of conformity assessment [12]. The product samples selected must be identical to the products intended for sale to the consumer in all parameters, composition, and manufacturing technology образцы. The product samples selected must be isolated from other products, packed, sealed or stamped at the selection site., A selection report is produced in accordance with GOST R 58972—2020 based on the results of the SFP sample selection [13].

Laboratory testing of the indicators characterizing the quality and safety of food products must be carried out in the testing laboratories (centers) accredited in the established manner and included in the "Unified Registry of Conformity Assessment Bodies of the Eurasian Economic Union" [14]. When establishing the SFP compliance with the safety and quality requirements, the test methods certified in accordance with the established procedure must be used. The product testing and measurement results are applicable to all the products, among which the specified product samples were selected [15].

The SFP production conditions are also the subject of expert evaluation. For substantiation the documents confirming the implementation of the management system and/or a copy of the certificate of production compliance with the principles of good manufacturing practice (GMP) are provided. Furthermore, a copy of the certificate of implementation of a food safety management system based on the ISO 22000 international standard and/or documents confirming that the manufacturer has developed, implemented and maintains procedures based on the principles of hazard analysis and critical control points (HACCP) can be provided [16].

When performing the SFP examination, the absence (presence) of psychotropic, narcotic, toxic, potent substances, doping substances as defined by the current WADA list,

nanomaterials, hormones, pesticides, genetically modified (transgenic) organisms and microorganisms, as well as synthetic drugs in the products is determined [17, 18]. A declaration of absence of the listed substances and a declaration confirming the product compliance with the requirements of the applicable Customs Union technical regulations are provided [15, 17, 18].

To ensure objective assessment of the SFP quality and safety, as well as authenticity, the conformity assessment documents completed in accordance with the established procedure must be available for raw material ingredient. Such documents may include certificates of state registration, declarations of conformity, specifications, certificates of analysis, quality certificates and other documents that contain information on the SFP ingredients in accordance with the recipe, and research results. In addition, the documents confirming the product packaging material safety are provided.

If the SFP is manufactured in the country located outside the customs territory of the Customs Union of the Eurasian Economic Union, justification for the supplied product quality and safety is also required. The justification is documents issued by state authorized bodies of the country in which the SFP is manufactured. These may be health authorities, food regulatory authorities or other competent authorities that confirm the product safety and permit the SFP sale in the country of manufacture and other countries. The document is certified in accordance with the established procedure.

Furthermore, an agreement between the applicant and the foreign manufacturer, which provides for the product compliance with the requirements of technical regulations, must be submitted for examination. Such an agreement serves as a guarantee that in the case of the product non-compliance with the declared characteristics or harm to the environment and consumer health, the person authorized by the manufacturer is liable in accordance with the Customs Union legislation [12].

In addition to the above documents, the applicant may provide other information and materials of his/her choice, substantiating confirmation of the product conformity with mandatory requirements. In the SFP efficacy is declared, specifically the product therapeutic and/or prophylactic properties, it is necessary to provide evidence in the form of a report and conduct a clinical trial focused on the efficacy assessment in authorized medical institutions equipped with the essential equipment and qualified personnel, with the provision of a report completed in accordance with the established procedure. According to the Methodological Guidelines [19] the following guidelines represent the evidence of the SFP efficacy: the bioactive ingredient introduced into the product must be permitted for use in the food industry and registered in accordance with the established procedure; the inclusion of a bioactive ingredient in the SFP composition a must be justified; each bioactive component introduced into the SFP composition must have precise physical and chemical characteristics that can be reliably determined in accordance with the approved regulatory documentation in the laboratories accredited in the established manner. It should be noted that when developing a SFP, not only information on the effectiveness of bioactive ingredients and substances must be taken into account, but also possible interactions with other product ingredients, and the bioactive ingredient amount in the food product must be physiologically adequate and effective, but, in accordance with Appendix No. 5 "Daily Food Intake and Bioactive Substances for Adults in the Composition of Specialized Food Products (SFPs) and Dietary Supplements" [20], not exceeding the upper permissible consumption

level. Furthermore, the bioactive component introduction into a product should not worsen the product organoleptic characteristics and presentation. The effectiveness of a specialized dietary therapeutic and/or dietary preventive product means the presence of a significant positive result and the absence of a negative impact on the functions of human organs and systems in relation to the declared disease entities. The efficacy evaluation trial is conducted in accordance with the principles of good clinical practice in authorized medical institutions.

On September 1, 2025 the Federal Law No. 150-FZ of 07.06.2025 "On Amendments to Certain Legislative Acts of the Russian Federation" [21] came into force in the RF, in accordance with which the specifics of regulating the appointment and use of dietary supplements are provided. In August 2025, the Russian Government has submitted a draft Resolution "On the Approval of Quality Criteria for Bioactive Food Supplements and Their Effectiveness Depending on the Degree of Impact on Human Health" [22]. The Federal Law provides for the creation of a dietary supplement registry, from which medical professionals will prescribe dietary supplements to patients, if indicated. The registry will include

dietary supplements that are registered and have been tested for quality and safety indicators in accordance with the established procedure in accredited testing laboratories of the RF, and also have evidence of effectiveness.

CONCLUSION

Modern industrial production of food products, including specialized food products (SFP), is characterized by combining numerous different ingredients and many technological methods. In this context, the risk of contamination of final products with foreign compounds that have a negative effect on public health increases.

To reduce the risk of obtaining low-quality SFPs, manufacturers are advised to strictly comply with mandatory requirements for the manufacture, transportation, storage, and sale of products. The quality and safety of food products remain a pressing issue, the solution to which requires control at every stage of the food product's delivery to the consumer: from the beginning of manufacture to the "shelf". In this context, an important role is given to the SFP hygienic assessment with subsequent state registration.

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CONSUMER MOTIVATION WHEN CHOOSING DRINKS POSITIONED AS HEALTHY

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Given the growing prevalence of nutrition-related diseases (obesity, type 2 diabetes mellitus) in the Russian Federation, medical community and producers of functional and specialized products have been increasingly focused on the category of soft drinks positioned as healthy. This study aimed to identify the key drivers of consumers' choices of soft drinks marketed as healthy. The sample consisted of urban residents (Moscow) aged 18 and above. In June–July 2025, we invited 144 respondents to fill out an online survey and analyzed relevant regulatory documents published in 2023–2025. Five leading drivers of choice were identified: taste (80%), ingredients and naturalness (71%), price (53%), functional effect (51%), and purchase convenience (38%). It was found that the gravity of the price factor is inversely correlated with the respondents' income level ($\chi^2 = 15.3$; $p = 0.0047$). The results of this study confirm that beverage choices are largely driven by hedonic motivations and subsequently rationalized through health-related justifications. Successful integration of functional beverages into consumer practices requires adaptation to the system of consumer rituals and taste expectations.

Keywords: functional beverages; consumer choice; healthy diet; sweeteners; purchase drivers; soft drinks; beverage market

Funding: the study was supported within the framework of the state budget assignment, topic No. FGMF-2025-0014.

Author contribution: Oganesyants EL — data collection and analysis, manuscript authoring; Kochetkova AA — research concept and design, manuscript editing.

Compliance with ethical standards: the study was conducted in accordance with the ethical standards of the Declaration of Helsinki (Fortaleza, 2013). All participants provided voluntary informed consent to participate anonymously in the online survey.

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Received: 07.05.2026 **Accepted:** 16.05.2026 **Published online:** 25.06.2026

DOI: 10.24075/rbh.2026.165

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МОТИВЫ ПОТРЕБИТЕЛЬСКОГО ВЫБОРА НАПИТКОВ, ПОЗИЦИОНИРУЕМЫХ КАК ПОЛЕЗНЫЕ ДЛЯ ЗДОРОВЬЯ

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В условиях роста распространенности алиментарно-зависимых заболеваний (ожирение, сахарный диабет 2-го типа) в Российской Федерации внимание врачей и производителей функциональных и специализированных продуктов все чаще бывает сосредоточено на категории безалкогольных напитков, позиционируемых как полезные для здоровья. Целью исследования было выявить ключевые детерминанты потребительского выбора безалкогольных напитков, позиционируемых как полезные для здоровья среди городских жителей. В июне–июле 2025 г. методом онлайн-опроса 144 респондентов в сочетании с анализом нормативных документов за 2023–2025 гг. изучены предпочтения и мотивы покупки жителей г. Москвы в возрасте 18 лет и старше. Выявлены пять ведущих мотивов: вкус (80%), состав/натуральность (71%), цена (53%), функциональный эффект (51%), удобство покупки (38%). Установлено, что значимость ценового фактора обратно коррелирует с уровнем дохода респондентов ($\chi^2 = 15.3$; $p = 0.0047$). Результаты исследования подтверждают преобладание гедонистического фактора, рационализируемого здоровьесберегающей риторикой, при выборе напитков. Успешная интеграция функциональных напитков в потребительские практики требует адаптации к системе потребительских ритуалов и вкусовых ожиданий.

Ключевые слова: функциональные напитки, потребительский выбор, здоровое питание, сахарозаменители, мотивы покупки, безалкогольные напитки, рынок напитков

Финансирование: работа выполнена в рамках государственного бюджетного задания, тема № FGMF-2025-0014.

Вклад авторов: Е. Л. Оганесянц — сбор и анализ данных, написание рукописи; А. А. Кочеткова — концепция и дизайн исследования, редактирование рукописи.

Соблюдение этических стандартов: исследование проведено в соответствии с этическими стандартами Хельсинкской декларации 2013 г. Все участники предоставили добровольное информированное согласие на анонимное участие в онлайн-опросе.

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Статья получена: 07.05.2026 **Статья принята к печати:** 16.05.2026 **Опубликована онлайн:** 25.06.2026

DOI: 10.24075/rbh.2026.165

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Current dietary trends in Russia show high consumption of foods with added sugars and fats, along with a deficiency in dietary fiber, vitamins, and minerals [1–4]. In response to public health challenges, including the growing prevalence of obesity, type 2 diabetes mellitus, and metabolic syndrome, the government has tightened nutrition-related legislation: there have been introduced excise taxes on beverages with high added sugar content and strict labeling and advertising rules

[5–7]. Against this background, a new market for functional beverages is emerging. In this category, competitive advantage is determined not only by taste but also by consumers' perception of health benefits.

According to epidemiological studies, a significant proportion of the population of the Russian Federation (RF) exceeds the daily sugar intake recommended by the WHO: no more than 10% of total caloric intake, with an optimal target of no more

than 5% [8]. The recommendations of the Ministry of Health of RF suggest a threshold of about 24 kg/year/person (\approx 65 g/day) [9], while the actual mean per capita sugar consumption is estimated at 30–40 kg/year. According to the Ministry of Health, the prevalence of obesity among adults is 24.6%, with higher rates among women, highlighting the urgency of addressing nutrition-related issues.

A diet high in calories but low in nutritional value leads to more overweight and obese individuals, a higher prevalence of cardiovascular diseases, and a shift in dietary patterns toward "fast energy" from simple carbohydrates. The key problem is the lack of a long-term dietary strategy in the population: people prefer to focus on short-term effects (such as weight loss, perceived improvements in health, and enhanced performance, focus, and concentration) rather than on systemic lifestyle changes.

Trends in sugar content reduction and growth of the sugar substitute market

Starting from July 1, 2023, the RF introduced an excise tax on sugar-containing soft drinks: 7 rubles/liter for products with a sugar content of more than 5 g/100 ml (with some category-level exemptions). The tax is enshrined in Chapter 22 of the Tax Code of the Russian Federation; in 2025, the rate was increased to 10 rubles/l. This policy stimulated manufacturers to switch to sweeteners (sucralose, stevia, erythritol, and aspartame) [5, 6, 10]. However, sugar substitutes have a dual effect: on the one hand, they reduce calorific value of drinks and help to avoid blood glucose spikes, and on the other hand, such products support the preference for sweet foods, which prevents long-term changes in dietary patterns [11–13].

The global trend of reducing the consumption of free sugars has transformed the soft drinks market. In 2024, the sugar-free segment in Russia grew by 22.7% in volume and 49% in monetary value (according to Nielsen). Consumer reports show a growing readiness to pay about 15% more for natural composition and absence of artificial sweeteners [14, 15]. People are increasingly concerned about their health and therefore show interest in healthy drinks that align well with their health improvement goals [14, 16–19].

Socio-demographic factors influencing the purchase of healthy food products

According to various studies, age and gender are the main characteristics that determine the choice of healthy food and drinks. Women are more likely to prefer healthy products; they buy them regularly, and report a more positive attitude towards such food [2, 20]. Older consumers tend to choose healthy foods and beverages more often than their younger counterparts; they are especially interested in those products that, according to manufacturers, reduce the risk of diseases [21, 22]. Young people are less likely to overpay for healthier food options.

Some studies report a positive relationship between the level of education and willingness to buy foods and beverages with a high content of biologically active substances [16, 23–25]. Another factor directly related to the consumption of functional foods and beverages is income [23, 26].

Psychological factors influencing the choice of healthy food products

Research suggests that beyond demographic factors, the desire to "feel good" is a strong motivator in choosing

healthy foods [14]. The perceived value of personal health is a strong predictor of purchasing behavior, especially in the context of eating out [27, 28]. Health-conscious consumers — for example, those who exercise regularly — are much more likely to purchase healthy drinks, even at the expense of taste.

The key drivers for consumers when choosing healthy drinks are health benefits (low sugar content, added vitamins, natural ingredients), taste (87% of consumers worldwide consider taste to be a decisive factor — FMCG Gurus, 2025), safety and trust in the product, and product attributes and marketing — brand reputation, packaging design, labeling, price sensitivity [26, 29, 30].

This study aimed to identify the key drivers of consumers' choices of soft drinks marketed as healthy among urban residents in Moscow.

METHODS

Database compilation

The online survey was conducted among Moscow residents from June to July 2025 via social media. The participants, 18 years of age or older, provided voluntary informed consent to fill out the questionnaire anonymously in Russian. The study included 144 respondents. Inclusion criteria: age 18 and over, residence in Moscow, voluntary consent. Exclusion criteria: age under 18, refusal to participate in the study.

The questionnaire consisted of four sections. Section 1 — socio-demographic characteristics of the respondents, employment and nature of work. Section 2 — information about the participants' dietary habits (preferred drinks in the morning, afternoon, and evening), key outlets where they buy beverages. Section 3 — questions about new functional drinks, the desired effect, as well as the key drivers for their purchase. Section 4 — functional drinks consumed during physical activity, types of drinks, frequency of consumption, and places of purchase.

Statistical analysis

Statistical data processing was done in IBM SPSS Statistics v. 26 (IBM Corp.; USA). Pearson's chi-squared (χ^2) test was used to compare frequencies in groups with different income levels. The differences were considered significant at $p < 0.05$. The data are presented as absolute and relative frequencies.

RESULTS

Socio-demographic characteristics of the sample

The sample comprised 144 people, 92 of whom were women (64%). Most of the participants were 18–24 years old (48% of the sample), the second largest age group — 25–34 years old (40%). By type of employment, the majority of respondents were students (27%), full-time office workers (25%) and employees on a hybrid schedule (23%). Up to 57% of respondents were employed in finance, law, and analytics, 13% in information technology, digital, and design, and 9% in retail and marketing. By income, the respondents were distributed relatively evenly: 11–12% in subgroups "up to 30 thousand rubles/month," "60–100 thousand rubles/month," "100–150 thousand rubles/month," "150–250 thousand rubles/month"; the subgroup with an income of more than 250 thousand rubles/month was 20% of the sample.

Table 1. Beverage consumption through the day ($n = 144$)

Beverage	Morning (before 10:00)	Daytime (10:00–16:00)	Evening (16:00–21:00)	Night (after 21:00)
Water	121 (84%)	118 (82%)	115 (80%)	123 (85%)
Coffee	81 (56%)	81 (56%)	19 (13%)	4 (3%)
Tea	54 (38%)	80 (56%)	91 (63%)	49 (34%)
Herbal tea/herbal beverages	19 (13%)	28 (19%)	61 (42%)	41 (28%)
Soda/sugary drinks	4 (3%)	41 (28%)	40 (28%)	19 (13%)
Juices/smoothies	17 (12%)	28 (19%)	21 (15%)	6 (4%)
Milk/vegetable milk	13 (9%)	13 (9%)	8 (6%)	5 (3%)
Functional drinks (for focus, sleep, energy)	2 (1%)	6 (4%)	2 (1%)	0
Energy drinks	3 (2%)	13 (9%)	6 (4%)	4 (3%)
Alcohol	3 (2%)	5 (3%)	32 (22%)	22 (15%)
Protein/sports drinks	6 (4%)	4 (3%)	11 (8%)	2 (1%)
Fermented drinks (kombucha, kefir, ayran)	5 (3%)	6 (4%)	10 (7%)	5 (3%)
Other	2 (1%)	1 (< 1%)	1 (< 1%)	5 (3%)

Most participants — 74% — bought beverages in mid-tier supermarkets (Lenta, Magnit, Pyaterochka, Perekrestok). The second preferred outlet were delivery services Yandex Lavka and Samokat (59%), the third option — VkusVill (46%).

Table 1 summarizes the information on the drinks most frequently consumed during the day. Water is the preferred drink at any time of the day; coffee and tea consumption peaks in the morning and afternoon; carbonated sugary drinks and juices rise up in the afternoon and evening; alcohol is mainly consumed in the evening and at night.

Analysis of functional drinks

The majority of the respondents categorized protein shakes (69%), isotonic and sports drinks (60%), and herbal teas (60%) as functional beverages. Only 26% of the participants regarded kombucha, fermented drinks, and enhanced soda with vitamins as functional. The most sought-after effects of functional drinks were reinforcement of concentration and attention (52.6%), sleep improvement (44.1%), "a quick boost" (43.4%), digestive support (42.8%), "something light and healthy" (41.4%).

As for the drivers of choice of functional drinks, taste comes first (80%), followed by composition (71%), and price (53%) (Table 2).

Price-wise, the respondents were ready to spend up to 300 rubles (24%), up to 150 rubles (20%), and up to 200 rubles (15%) on a beverage. The gravity of the price factor is significantly lower in the group with an income of more than 250 thousand rubles/month (20.7%) compared with groups with an income of 100–250 thousand rubles/month (66.7%) and less than 60 thousand rubles/month (53.8%) ($\chi^2 = 17.8$; $p = 0.0016$).

Table 2. Drivers of choice of functional drinks ($n = 144$)

Driver	Number of positive responses
Tastiness	115 (80%)
Composition (natural, proven effect)	102 (71%)
Price	76 (53%)
Effect	73 (51%)
Sold at a convenient location	55 (38%)
Brand confidence	48 (33%)
Form factor (can, shot, powder)	23 (16%)
Packaging	22 (15%)

The main negative factors when choosing a drink are unpleasant taste (68%), excessive promises of the manufacturer (46%), and price (45%). The price factor was most often noted by respondents with an income of less than 60 thousand rubles/month (74.4%) and much less often by those with an income of more than 250 thousand rubles/month (31.0%) ($\chi^2 = 15.3$; $p = 0.0047$).

DISCUSSION

This study revealed not only the current consumption patterns, but also deep contradictions that condition the functional beverages market in Russia. Data analysis paints a portrait of a modern urban consumer whose choice is shaped by desire to lead a healthy lifestyle, a high pace of life, and hedonistic needs.

The core of the sample (88%) consisted of respondents aged 18–34 years — the generation of millennials and zoomers, for whom being health-conscious is not a trendy affair but a part of life. Female participants formed the majority of the sample (64%), which aligns with global trends: women are the main driving force behind the demand for health and self-care products [2, 20]. These data are consistent with findings from foreign studies that report women being highly knowledgeable about healthy nutrition [20].

More than 50% of respondents work in highly skilled, well-paid professions, which produces two behavioural patterns: high awareness and scepticism (this audience scrutinizes ingredients, seeks evidence, and distrusts marketing claims) and value-oriented consumption (they prefer paying for proven quality, convenience and benefits rather than prioritizing low price). This explains why "price" (53% of respondents), despite its importance, is inferior to "taste" (80% of respondents)

and "composition" (71% of respondents). Similar patterns have been described in foreign studies on samples with a high level of education [16, 23–25].

An analysis of consumption by time of day demonstrates a pattern of rational energy management: morning and afternoon drinks (water, coffee, tea) are aimed at hydration and stimulation of cognitive function, while evening and night drinks (herbal teas, alcohol) are taken to recover and relax. Functional drinks (for concentration, energy, sleep) occupy a narrow niche, which indicates a deep gap between the supply and real consumer habits.

The difference in how consumers perceive the functionality of different categories of drinks deserves special attention. Protein mixes and isotonic drinks are organically integrated into the sports routine: their benefits are understandable to consumers, linked to a specific action, and do not require explanation. The situation with kombucha, probiotic, and vitamin-enhanced beverages is completely different: despite these products being actively promoted in the media, the majority of respondents perceive them as something "useful in general," without associations with specific effects. The lack of clarity about the function deprives such drinks of value in the eyes of the buyer [17, 19].

Clearly describing the beverage's properties on the label is not enough to guarantee it a place in the customer's daily basket. It is necessary to offer the consumer a clear logic of use — when, why and in what situation to drink it. A product can take root if it starts to integrate into existing consumer habits or forms a new, socially accepted practice in which its benefits become obvious and tangible.

Our findings confirm that it is the taste that determines the initial purchase decision; dislike or lack thereof becomes the main reason for refusal. The composition of the product plays a different role: it does not encourage buying, but removes doubts; the consumer must make sure that the product is "not harmful" before choosing it. As for the distribution channels, most respondents mentioned chain stores and delivery services, which suggests that consumers value convenience:

a functional drink should be easily accessible like any everyday product.

The increasing prevalence of alimentary-dependent diseases, along with the introduction of excise taxes on sugar-containing beverages, create a steady demand for expansion of the range of functional and low-calorie alternatives. The development of the healthy drinks market is no longer a job reserved exclusively for commercial companies — it becomes a task for the public healthcare system. In this context, understanding the drivers of consumer choice becomes a necessary basis for developing both product strategies and preventive measures.

The study's main limitation is the sample's lack of representativeness: it is dominated by young, highly educated residents of Moscow recruited through social networks, which biases the results toward an active online audience. In addition, consumption data are self-reported by the respondents and not verified by objective methods. For further research, it is planned to expand the sample.

CONCLUSIONS

This study allows formulating the following conclusions.

1. The dominant driver for buying functional drinks is taste (80%). The naturalness and composition of the beverage are important for 71% of respondents, but this factor eliminates consumer doubts rather than prompts a choice.

2. The role of price decreases as the respondents' income increases ($p < 0.05$) — this should be taken into account when segmenting the target audience.

3. Kombucha, probiotic lemonades with dietary fiber, and vitamin-enhanced sodas are inferior to sports drinks and isotonics in terms of consumer confidence. The reason is that the buyer does not have a clear idea of when and why to consume them.

4. The consolidation of functional drinks into consumer behavior is possible only if the product, besides having the claimed benefits, naturally fits the habits, values, and taste preferences of the target audience.

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THE RESULTS OF APPLYING THE HEALTH DIAGNOSIS PROGRAM IN MEDICAL UNIVERSITY STUDENTS

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The introduction of a system for monitoring the body's functional state and nutritional characteristics into the medical university educational process seems to be a relevant solution to the problem of maintaining the health of student youth. The study aimed to test the use of the Valeoscan program for monitoring the health and diet features in the 1st-year, 4th-year, and 6th-year students of the Medical Institute of the Tula State University ($n = 3676$). A significant ($p < 0.05$) increase in the time it took to complete psychophysiological tests was reported in the first-years, who studied in 2016–2023: the time to complete the correction test increased from 200.59 ± 4.21 s to 231.83 ± 5.71 s in females; from 202.40 ± 6.02 s to 229.00 ± 7.34 s in males. In the dynamics of the years of study (from the 1st to 6th year), a significant ($p < 0.05$) increase in body mass index (BMI) was revealed: from 20.81 ± 0.30 kg/m² to 22.45 ± 0.41 kg/m² in females; from 22.71 ± 0.65 kg/m² to 24.24 ± 0.54 kg/m² in males, respectively. Furthermore, an increase in the proportion of students with overweight in the BMI range ≥ 29 kg/m² was revealed. In the 6th year, the proportion decreased of the students with excess fat in their diet (from 13.72 ± 0.09 to $8.32 \pm 0.04\%$ in females, $p < 0.05$; from 46.94 ± 0.28 to $6.72 \pm 0.05\%$ in males, $p = 0.00039$) and water deficit (from 72.41 ± 0.12 to $66.73 \pm 0.21\%$ in females, $p < 0.05$; from 71.85 ± 0.13 to $66.72 \pm 0.21\%$ in males, $p < 0.05$); the proportion of students, who followed healthy eating principles, increased (from 73.26 ± 0.64 to $81.39 \pm 0.73\%$ in females, $p < 0.05$; from 62.86 ± 0.52 to $65.71 \pm 0.54\%$ in males, $p < 0.05$). The Valeoscan program introduction into the educational process has made it possible to monitor the functional health indicators and nutritional characteristics of medical university students, which can be used to evaluate the effectiveness of the health-preserving technology being introduced.

Keywords: students, health preservation, software package, psychological health, diet

Author contribution: Markelova SV — academic advising, developing the research concept, manuscript writing; Prokhorov PYu — material collection, literature review, manuscript writing.

Compliance with ethical standards: the study complied with the principles of biomedical ethics and did not pose a risk to the participants.

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Received: 13.02.2026 **Accepted:** 11.05.2026 **Published online:** 28.06.2026

DOI: 10.24075/rbh.2026.166

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РЕЗУЛЬТАТЫ ПРИМЕНЕНИЯ ПРОГРАММЫ ДИАГНОСТИКИ ЗДОРОВЬЯ ОБУЧАЮЩИХСЯ МЕДИЦИНСКОГО ВУЗА

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Внедрение в образовательный процесс медицинского вуза системы мониторинга показателей функционального состояния организма и особенностей питания представляется актуальным решением проблемы сохранения здоровья обучающейся молодежи. Целью работы было апробировать применение программы «Валеоскан» для мониторинга здоровья и особенностей питания студентов 1-го, 4-го и 6-го курсов Медицинского института ТулГУ ($n = 3676$). У первокурсников, обучавшихся в 2016–2023 гг., отмечено значимое ($p < 0,05$) увеличение времени выполнения психофизиологических тестов: время корректурной пробы выросло с $200,59 \pm 4,21$ с до $231,83 \pm 5,71$ с у девушек; с $202,40 \pm 6,02$ с до $229,00 \pm 7,34$ с у юношей. В динамике лет обучения (с 1-го по 6-й курс) выявлено значимое ($p < 0,05$) увеличение индекса массы тела (ИМТ): у девушек с $20,81 \pm 0,30$ кг/м² до $22,45 \pm 0,41$ кг/м²; у юношей с $22,71 \pm 0,65$ кг/м² до $24,24 \pm 0,54$ кг/м² соответственно. Помимо этого выявлено увеличение доли студентов с избыточной массой тела в диапазоне ИМТ ≥ 29 кг/м². На 6-м курсе сократилась доля студентов с избытком жиров в рационе питания (у девушек с $13,72 \pm 0,09$ до $8,32 \pm 0,04\%$, $p < 0,05$; у юношей с $46,94 \pm 0,28$ до $6,72 \pm 0,05\%$, $p = 0,00039$) и дефицитом жидкости (у девушек с $72,41 \pm 0,12$ до $66,73 \pm 0,21\%$, $p < 0,05$; у юношей с $71,85 \pm 0,13$ до $66,72 \pm 0,21\%$, $p < 0,05$); увеличилась доля студентов, соблюдавших принципы здорового питания (у девушек с $73,26 \pm 0,64$ до $81,39 \pm 0,73\%$, $p < 0,05$; у юношей с $62,86 \pm 0,52$ до $65,71 \pm 0,54\%$, $p < 0,05$). Внедрение программы «Валеоскан» в учебный процесс позволило обеспечить мониторинг показателей функционального состояния здоровья и особенностей питания обучающихся медицинского вуза, что может быть использовано для оценки эффективности внедряемых здоровьесберегающих технологий.

Ключевые слова: студенты, здоровьесбережение, программный комплекс, психологическое здоровье, рацион питания

Вклад авторов: С. В. Маркелова — научное руководство, разработка концепции исследования, написание статьи; П. Ю. Прохоров — сбор материалов, анализ литературы, написание статьи.

Соблюдение этических стандартов: исследование соответствовало требованиям биомедицинской этики и не подвергало опасности участников.

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Статья получена: 13.02.2026 **Статья принята к печати:** 11.05.2026 **Опубликована онлайн:** 28.06.2026

DOI: 10.24075/rbh.2026.166

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The steady deterioration of health indicators among student youth is a pressing issue of modern higher education. Numerous studies point to the complex nature of the causes of this phenomenon. The leading negative factors include high academic workload, the spread of digital educational technologies, including distance learning, a sedentary lifestyle, and an unbalanced diet among students [1, 2].

The population health preservation is one of the main tasks faced by the Government of the Russian Federation (RF). In the context of the state's national policy, the student youth health preservation becomes one of the primary tasks of preventive medicine [3].

The hardware and software systems for studying health and lifestyle indicators, environmental factors are widely used in various fields. The list of indicators monitored and the frequency of their testing are determined in accordance with the objectives of the study. Software packages may contain specific diagnostic algorithms that can be applied to specific population groups or professional groups.

Such software packages, as Helzy, SberHealth, SberMed AI, Symptom Checker, Medical Diagnostics, LetsGetChecked, etc., are examples of the use of free online services for the diagnosis of disorders [4].

Automated systems are used to diagnose the mental state of workers in a number of professions associated with the risk of emergency situations, high psycho-emotional stress, and irregular working hours [5].

The Health Test program is used for preclinical diagnosis of psychophysiological adaptation and health status under industrial conditions [6].

By using the Sveto-Test device when studying the functional state of the body, the critical frequency of light flickering fusion is assessed in various modes of using electronic devices [7].

The NS-PsychoTest hardware and software system is used to evaluate the psychophysiological properties and body's functions when using an interactive whiteboard in preschool education institutions [8].

The use of KPFK-99 "Psychomat" for scientific research purposes allowed scientists to evaluate a simple sensorimotor response and the critical frequency of light flickering when studying the influence of the quality of visual materials presented by electronic learning tools on the development of functional disorders by the body [9].

The use of the domestically produced Varicard 2.51 software package was tested in a higher education institution in 2022. Researchers studied the functional health status based on heart rate indicators. Data on the cardiac rhythm nervous regulation features were obtained; an assessment of the body's adaptive capability was carried out; the body's functional state was studied depending on the educational process organization form [10].

Monitoring the health and lifestyle indicators of students in higher education institutions allows one to obtain the data necessary for identifying the causes of the emergence and spread of non-communicable diseases among student youth, and developing a system of preventive measures for both group and individual purposes.

The study aimed to test the use of the Valeoscan hardware and software system for monitoring the functional health status and diet features in students within the framework of the medical university curriculum.

METHODS

A total of 3676 1st-year, 4th-year, and 6th-year students of the Tula State University aged 17–24 years (2459 females and 1217 males) were enrolled. Follow-up period: years 2016–2023.

To implement a comprehensive personalized approach to monitoring the students' body functional state and nutritional characteristics, the Valeoscan software package was introduced into the educational process at the Tula State University Medical Institute (Certificate of state registration of a computer program No. 2024689385 RF. "Valeoscan", developers Venevtseva YuL, Melnikov AKh, Prokhorov PYu, Putilin LV; Russia). The survey of students was carried out over eight years of follow-up (2016–2023), including the study of the indicators of the 2017 recruitment course over six years of study (in the 1st, 4th and 6th years). The testing frequency was determined by the need to study the degree of health-preserving skill development during mastering a medical specialty. The survey, conducted in the first year, allowed us to evaluate the knowledge and skills in health preservation formed by the time of entering the medical university, as well as to study the body's functional state characteristics in the new educational environment. The survey, conducted in the 4th year, allowed us to assess the dynamics of the body's functional indicators, the knowledge and skills in health preservation after mastering the program of the discipline "Hygiene" and other educational programs in the departments focused on theoretical training. The survey, conducted in the 6th year, allowed us to assess the dynamics of the indicators monitored, considering changes in academic load, preparation for the state final certification, internship.

The Valeoscan software package included 45 survey items and nine psychophysiological tests that allowed us to study the body's psycho-emotional state, cognitive functions, and mental performance of students. The color test by M. Luscher was used to assess the psycho-emotional state and the level of aggressiveness; the correction test was used to assess the mental performance; cognitive characteristics were studied using the methods "Sequence of Images", "Exclusion of Concepts". Computer testing was used to assess the prevalence of health complaints and vision loss, dietary patterns and eating habits. The examination protocol included information on systolic and diastolic blood pressure, heart rate, height and body weight, and the body mass index (BMI) was calculated. The questionnaire part of the program was developed by the research author with the help of specialists accredited in the specialties "Hygiene of Children and Adolescents", "Hygiene Education".

The study of nutritional characteristics was carried out taking into account the analysis of the daily diet, which was assessed in accordance with the approved regulatory and methodological documents [11].

Based on the examination results, the Valeoscan hardware and software system generated a list of individual preventive measures taking into account the identified deviations from the physiological norm in the state of the cardiovascular, nervous, digestive, musculoskeletal systems, the facts of having excess body weight, hypo/hypertension.

When compiling the recommendations, the criteria presented in the documents issue by the World Health Organization (WHO) were taken into account, regarding the diet adjustment (reducing the consumption of table salt, increasing the consumption of vegetables and fruits), optimizing psychological well-being, the use of hardening measures (taking a shower, bathing with regulation of the water temperature and duration of the procedure); recommendations were proposed for the use of music and aromatherapy elements [12].

Statistical processing of the data obtained was performed by standard methods using the MS Office Excel (Microsoft; USA), Statistica 12.0 (StatSoft; USA) software. The differences were considered significant at $p < 0.05$.

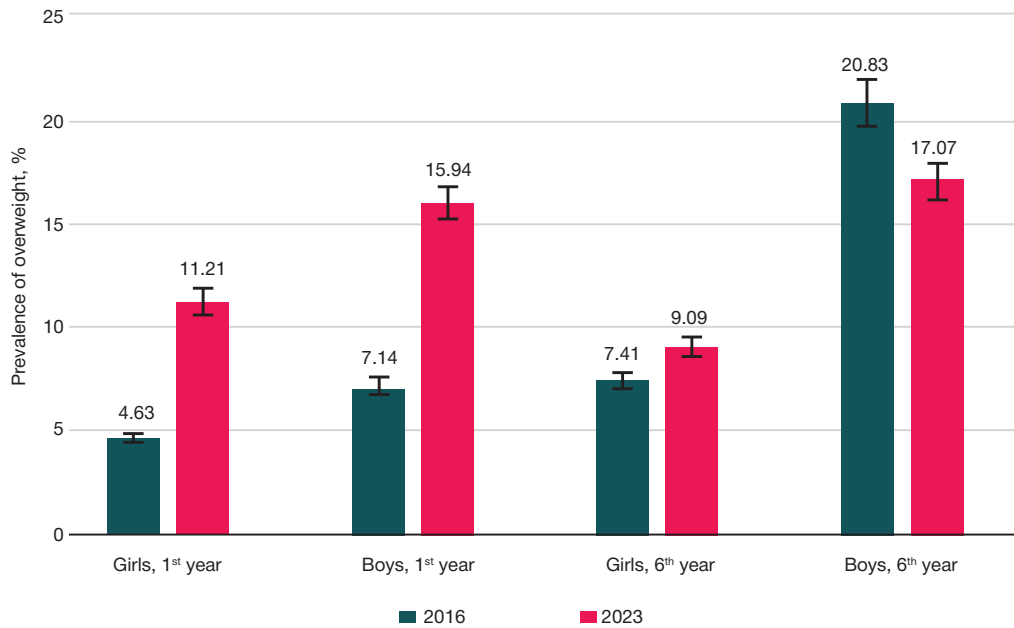


Fig. 1. Prevalence of overweight among 1st- and 6th-year medical university students (BMI range ≥ 29 kg/m²) in 2016 and 2023, %

RESULTS

Monitoring the indicators controlled yielded the following results. During the eight-year follow-up (2016–2023) a significant ($p < 0.05$) decrease in the proportion of the 1st- and 6th-year with normal body weight and an increase in the proportion of overweight students, including in the range of BMI ≥ 29 kg/m², was noted (Fig. 1).

During the eight-year follow-up (2016–2023) first-year students showed a significant ($p < 0.05$) increase in the time of psychophysiological test completion. The correction test completion time increased from 200.59 ± 4.21 s to 231.83 ± 5.71 in females, from 202.40 ± 6.02 s to 229.00 ± 7.34 in males. At the same time, the number of errors made in the correction test remained stable. In the “Sequence of Images” test, the number of images remembered increased significantly ($p < 0.05$) in students of both sexes; the test completion time also increased in females: from 46.08 ± 1.22 s (2016) to 49.72 ± 1.07 s (2023);

$p < 0.05$). In the “Exclusion of Concepts” test, girls also showed a significant ($p < 0.05$) increase in the number of correct answers against the background of an increase in the test completion time: from 122.60 ± 2.60 s to 130.93 ± 2.92 s ($p < 0.05$).

The eight-year follow-up (2016–2023) showed that among first-year students higher anxiety levels were observed in females compared to males, along with the increase in the levels of psycho-emotional stress in male first-year students to the levels reported for female first-year students (Fig. 2).

A study of students' diets over the years of study (from the 1st to 6th year) revealed a number of features.

Among first-year students, excess fat in the diet was significantly more often ($p < 0.05$) observed in males ($46.94 \pm 0.28\%$) compared to females ($13.72 \pm 0.09\%$). Water deficit was observed in more than 60% of students, excess salt was reported for $27.62 \pm 0.02\%$ of females and $18.83 \pm 0.73\%$ of males.

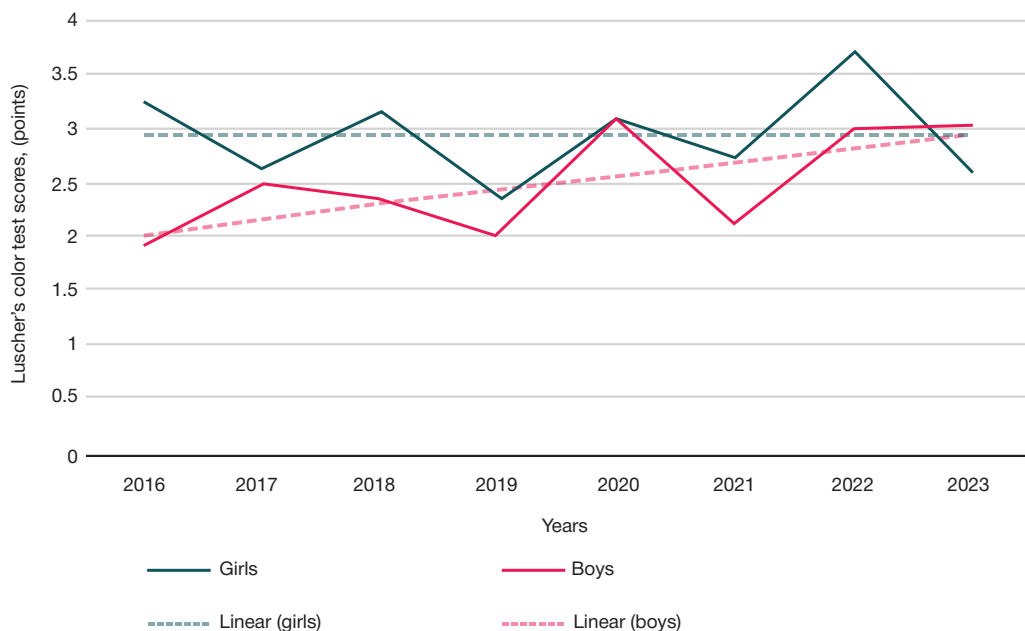


Fig. 2. Dynamic changes in anxiety levels of 1st-year students in 2016–2023, points

In the 6th year, compared to the 1st year, the proportion of students with water deficit significantly decreased (from 72.41 ± 0.12 to $66.73 \pm 0.21\%$ in females, $p < 0.05$; from 71.85 ± 0.13 to $66.72 \pm 0.21\%$ in males, $p < 0.05$); the number of students with excess fat in their diet has decreased (from 13.72 ± 0.09 to $8.32 \pm 0.04\%$ in females, $p < 0.05$; from 46.94 ± 0.28 to $6.72 \pm 0.05\%$ in males, $p = 0.00039$); the proportion of students who adhered to healthy eating principles increased (from 73.26 ± 0.64 to $81.39 \pm 0.73\%$ in females, $p < 0.05$; from 62.86 ± 0.52 to $65.71 \pm 0.54\%$ in males, $p < 0.05$).

The average BMI value in students of both sexes has increased significantly over the years their studies (from the 1st to 6th year): in females, 20.81 ± 0.30 kg/m² in the 1st year, 22.45 ± 0.41 kg/m² in the 6th year ($p < 0.05$); in males, 22.71 ± 0.65 kg/m² in the 1st year, 24.24 ± 0.54 kg/m² in the 6th year ($p < 0.05$).

DISCUSSION

Medical university students in various years were reported to be overweight, which is consistent with the literature data [13, 14]. An increase in the proportion of students with the BMI ≥ 29 kg/m² in the 1st and 6th years was reported in eight years of follow-up, which suggests the increase in the proportion of medical students with undeveloped health-preserving skills and may be accompanied by the body's functional state violation, deterioration in the quality of life. In 2023, excess body weight with the BMI массы ≥ 29 kg/m² was determined in every 10th girl (11.21%) in the 1st year and every 11th one (9.09%) in the 6th years, as well as in every 6th boy in the 1st (15.94%) and 6th (17.07%) years. An increase in the average BMI value was reported in students of both sexes over the years of study (from the 1st to 6th year), which results from insufficient development of rational nutrition skills among medical students, violation of healthy lifestyle principles. This suggests the need to expand the training program for medical university students on these topics.

High levels of anxiety, especially among female students in their 1st year of study, and psycho-emotional stress

can be the cause of poor academic performance and early termination of training. According to the literature, the reasons for increased psycho-emotional stress and anxiety may be high activity on social networks and non-compliance with the principles of digital hygiene [15], what can be considered as an area of prevention to be implemented at a medical university.

The reduction in the proportion of students of both sexes with a fluid deficiency and excess fat in their diet, registered in the 6th year, and the increase in the proportion of students who tried to follow healthy eating rules in the 6th year may be the result of mastering the training program, but the list and completeness of mastery of the issues covered are insufficient, as demonstrated by the above research results.

The introduction of monitoring the body's functional state indicators and nutritional characteristics into the curriculum will facilitate the development of individual prevention programs aimed, among other things, at reducing psycho-emotional discomfort and optimizing the diet [6, 16].

CONCLUSIONS

The monitoring system organized at the Tula State University provided dynamic control over the indicators of the body's functional state and the nutritional characteristics of students over eight years of follow-up (2016 to 2023), as well as over the years of study (from the 1st to 6th year), made it possible to develop individual prevention programs for students and evaluate their effectiveness throughout the period of study at the medical university. The introduction of automated software systems into the medical university educational process in various years of study contributes to the development of health-preserving skills in future doctors, maintaining their health, acquiring skills in self-diagnosis of health problems, developing preventive programs and evaluating their effectiveness, which ultimately forms a specialist competent in health-preserving issues. The knowledge acquired allow one to identify gaps in students' knowledge and skills related to health preservation issues and can serve as a basis for optimizing educational programs.

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NUTRITION OPTIMIZATION AND EDUCATIONAL TECHNOLOGIES IN THE SYSTEM OF PERSONALIZED PREVENTION OF OBESITY COMPLICATIONS: HYGIENIC ASPECTS

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Obesity is a global epidemic of the 21st century and a core component in the development of nutrition-related diseases. In the Russian Federation (RF), more than 60% of the adult population is overweight or obese, which necessitates designing and implementing new prevention strategies. This study aimed to provide a scientific basis for the role of personalized dietary interventions and educational technologies in preventing obesity-related complications. We reviewed papers from PubMed and eLIBRARY databases (2020–2026) found by keywords "obesity," "nutrition," "education," "prevention". The analysis showed that the effectiveness of the traditional approaches to diet therapy is insufficient. It was established that the key to successful prevention is extended diagnostics providing data on the individual metabolic phenotypes. Healthy Nutrition educational cluster and digital components of the NIAP system (research-based educational and analytical platform) are important tools in increasing obesity-related public awareness and professional training of medical specialists. Effective personalized prevention of obesity complications requires concurrent realization of three interrelated initiatives: diet correction based on instrumental diagnostics; adoption of educational technologies for doctors and patients; and reinforcement of sanitary and epidemiological surveillance measures. The proposed multilevel approach, which integrates hygiene-related measures and modern digital tools, enables a reduction in the prevalence of obesity and the achievement of strategic public health-saving goals in the Russian population.

Keywords: review, obesity, nutrition, prevention, education, health saving

Funding: the study was conducted within the framework of the State Assignment FGMF-2026-0014.

Author contribution: Lapik IA — study concept and design, article authoring; Tarmaeva IYu — editing; Nikityuk DB — approval of the final version of the article; all authors are responsible for the integrity of all of its parts.

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Received: 09.04.2026 **Accepted:** 21.05.2026 **Published online:** 29.06.2026

DOI: 10.24075/rbh.2026.167

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ОПТИМИЗАЦИЯ ПИТАНИЯ И ОБРАЗОВАТЕЛЬНЫЕ ТЕХНОЛОГИИ В СИСТЕМЕ ПЕРСОНАЛИЗИРОВАННОЙ ПРОФИЛАКТИКИ ОСЛОЖНЕНИЙ ОЖИРЕНИЯ: ГИГИЕНИЧЕСКИЕ АСПЕКТЫ

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Ожирение является пандемией XXI в. и ключевым звеном в развитии алиментарно-зависимых заболеваний. В Российской Федерации (РФ) более 60% взрослого населения имеют избыточную массу тела или ожирение, что требует внедрения новых стратегий профилактики. Целью работы было представить научное обоснование роли персонализированной коррекции рациона и образовательных технологий в системе профилактики осложнений ожирения. Выполнен обзор публикаций в базах данных PubMed и eLIBRARY (2020–2026) по ключевым словам: «ожирение», «питание», «образование», «профилактика». Анализ показал, что традиционные подходы к диетотерапии демонстрируют недостаточную эффективность. Установлено, что ключевым условием успешной профилактики является расширенная диагностика, направленная на идентификацию индивидуальных метаболических фенотипов. Важным инструментом повышения грамотности населения и профессиональной подготовки кадров выступает образовательный кластер «Здоровое питание» в совокупности с цифровыми возможностями платформы научно-информационного и аналитического просвещения (НИАП). Эффективная персонализированная профилактика осложнений ожирения требует одновременной реализации трех взаимосвязанных компонентов: коррекции рациона на основе инструментальной диагностики; внедрения образовательных технологий для врачей и пациентов; усиления мер санитарно-эпидемиологического надзора. Предложенный многоуровневый подход, интегрирующий гигиенические аспекты и современные цифровые инструменты, является необходимым условием для снижения распространенности ожирения и достижения стратегических задач здоровьесбережения населения РФ.

Ключевые слова: обзор, ожирение, питание, профилактика, образование, здоровьесбережение

Финансирование: работа выполнена в рамках государственного задания FGMF-2026-0014.

Вклад авторов: И. А. Лапик — концепция и дизайн, написание текста статьи; И. Ю. Тармаева — редактирование; Д. Б. Никитюк — утверждение окончательного варианта статьи; все авторы — ответственность за целостность всех частей статьи.

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Статья получена: 09.04.2026 **Статья принята к печати:** 21.05.2026 **Опубликована онлайн:** 29.06.2026

DOI: 10.24075/rbh.2026.167

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Obesity, which is a leading alimentary disease, is one of the priority problems of hygiene and practical healthcare. More than a billion people in the world are obese [1], and by 2050 the number of overweight and obese adults may increase significantly [2]. In the Russian Federation (RF), the prevalence of overweight and obesity among the adult population exceeds 60% [3]. The economic damage from obesity amounts to 3% of global gross domestic product [4]. The problem of obesity acquires particular urgency in the context of the effort to increase the length of life in RF, which is one of the national targets [5]. The portion of life expectancy lost to food quality and adverse nutritional factors offers a significant potential for preventive interventions [5]. Diet-related diseases account for the largest share of mortality in the Russian population and cause significant economic losses [6].

A key nutritional risk factor for obesity is a persistent deviation from healthy dietary patterns common in the population: insufficient consumption of vegetables, fruits, dairy products, and excessive amounts of fats, salt, and added sugar [7]. People in Russia eat less fruits and vegetables than is optimal for them, which significantly increases the risk of alimentary diseases [8]. At the same time, traditional approaches to obesity prevention based on standard dietary recommendations that do not factor in individual characteristics of body composition and metabolic profile have proven to be insufficiently effective: with standard diet therapy, a significant share of patients lose muscle mass, and the lost fat returns within a few years [9, 10]. These limitations of standard approaches necessitate finding new prevention strategies that integrate personalized diagnostics, modern educational technologies, and hygiene aspects.

This study aimed to systematize current data on the role of nutritional factors in the development of obesity and its complications, to substantiate the role of nutrition optimization and educational technologies in the personalized obesity prevention system based on digital technology, and to describe a multi-tier prevention framework emphasizing hygienic aspects of the public health-saving efforts.

Materials and methods

We conducted an analytical review of publications in the PubMed and eLIBRARY databases for the period 2020–2026 using the keywords "obesity," "nutrition," "education," and "prevention."

Nutritional risk factors for obesity

Obesity, resulting from a persistent imbalance between energy consumption and expenditure, is largely determined by modifiable nutritional and environmental factors. In Russia, nutritional disorders common in the population are some of the core factors of this kind (Fig. 1). One of the country's main diet-related problems is habitual dietary patterns: inadequate intake of fruits, vegetables, and dairy products, and excessive consumption of saturated fats, salt, and simple carbohydrates [7]. Such patterns are associated with an increased risk of obesity and its metabolic complications. A particularly alarming trend is the growing consumption of ultra-processed foods, which are high in calories, low in nutrients, and contain flavor enhancers and preservatives [4, 11].

Economic indicators support the significance of the problem: alimentary diseases cause a considerable proportion of deaths in Russia, they are associated with significant economic damage [6]. At the same time, available data indicate that sanitary and epidemiological control measures have been effective: over the past 10 years, the prevalence of foodborne

diseases and the frequency of food-quality violations have decreased significantly [5]. Nevertheless, the persisting unhealthy dietary patterns combined with insufficient physical activity and socio-economic determinants continue to support the growing prevalence of obesity and related damage to health and reduction of life expectancy.

Nutrition optimization as a priority area of prevention

Optimizing the nutrition of the population is one of the priorities of the state policy of the RF in the field of health saving. A personalized approach to obesity-related diet therapy based on comprehensive medical examination (including bioimpedance measurements, indirect calorimetry, laboratory diagnostics) should be implemented with the identified gender and age characteristics factored in. For obese men, whose rate of fat oxidation is reduced, the main goals are to limit saturated fats, increase the proportion of polyunsaturated fatty acids, and ensure adequate protein intake to preserve muscle mass. For obese women, whose rate of carbohydrate oxidation is reduced, the main recommendations are an even distribution of carbohydrates throughout the day, an emphasis on low glycemic index foods, sufficient fiber intake from vegetables and whole grains, and an adequate protein supply [12–15]. At the same time, individual nutrition optimization should be complemented by population-wide prevention measures. The level of fruit and vegetable consumption in Russia remains below suboptimal, and international experience shows that the most effective measures are information and communication campaigns, economic support mechanisms (subsidizing healthy eating), and legislative regulation of product labeling indicating the content of added sugars and saturated fats [8, 16]. The implementation of such measures can significantly reduce the incidence of alimentary diseases [8].

In the context of the development of population-based and personalized approaches, nutrition digital analysis tools are particularly interesting; they are considered as components of the strategy of development of the science of nutrition [17]. Digital technology gives rise to a fundamentally new ecosystem of nutrition management, integrating data from instrumental diagnostics (bioimpedance measurement, indirect calorimetry), laboratory monitoring, and actual diet analysis. Food diary applications, wearable devices monitoring physical activity, and telemedicine platforms are being integrated into preventive programs as a tool to increase patient adherence.

However, the effectiveness of digital interventions may decrease with time, which underscores the need to develop strategies to maintain long-term patient commitment to prevention programs. As a solution to this problem, and as a way to ensure seamless connection between individual dietary correction and population-wide educational efforts, Federal Research Center for Nutrition, Biotechnology and Food Safety has developed NIAP, a research-based educational and analytical platform usable through the Scientific Nutrition Analysis Tool program (Software State Registration Certificate No. 2023680849 of 05.10.2023). This software automatically evaluates patients' diets, enables compilation of personalized balanced menus in both manual and automated modes using machine learning algorithms, and generates individual recommendations for nutrition correction. The program accepts and stores personal data of the patients (anthropometric indicators, medical history, eating habits, food diary), and automatically processes and analyzes them. Based on the inputs, factoring in chemical composition of products and ready meals, the software designs balanced diets,

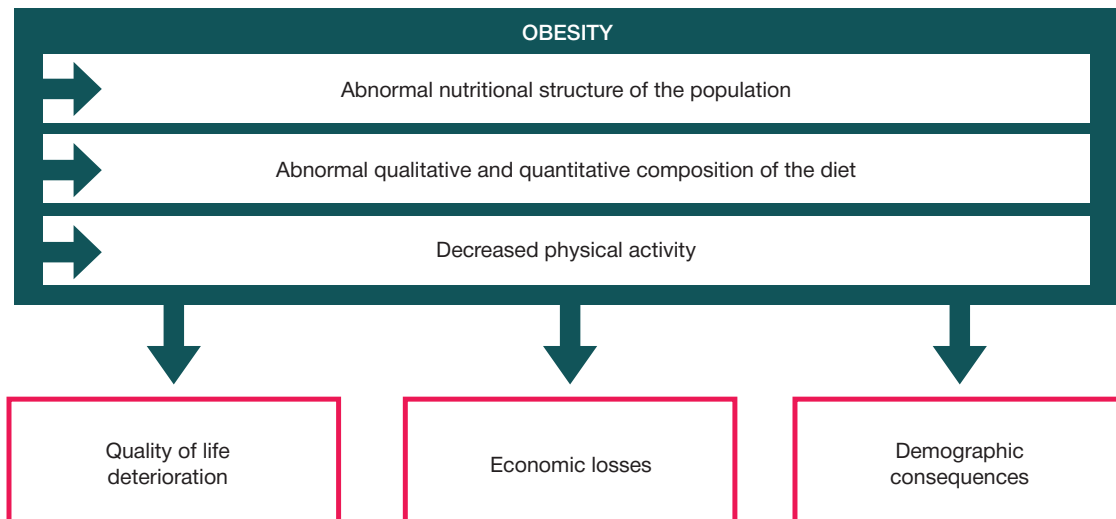


Fig. 1. Nutritional and environmental risk factors for obesity

individual recommendations, and generates reports. Integration of bioimpedance measurement, indirect calorimetry, laboratory monitoring and digital analysis of actual nutrition within NIAP platform creates the basis for personalized next-generation nutrition recommendations that can be used by doctors of various specialties, nutritionists and other specialists in the field of nutrition. An important prerequisite for the effective implementation of such recommendations is the availability of specialized food products that meet modern requirements for nutritional value and micronutrient composition. To this end, as part of the implementation of comprehensive scientific programs under the auspices of the Ministry of Science and Higher Education of the Russian Federation, the consortium "Health Preservation, Nutrition, Demography" coordinates development and deployment of innovative food technologies, including specialized products enriched with micronutrients. Together with digital tools, this work determines the current vector of development of preventive medicine.

Healthy Nutrition educational cluster as a tool in population-wide prevention programs

The effectiveness of preventive measures is largely determined by the level of training of medical personnel and the literacy of the population in matters of healthy nutrition. For this purpose, the Healthy Nutrition educational cluster has been created and is successfully operating on the basis of the Federal Research Center for Nutrition, Biotechnology and Food Safety. It combines the potential of a leading research center and the educational capabilities of specialized departments of medical universities [18]. The Healthy Nutrition cluster is an integrated system of educational and regulatory initiatives aimed at reducing the prevalence of obesity and alimentary diseases in the Russian population. The concept of the cluster is based on a three-vector approach: professional training of specialists, hygienic education of the population, and conducting information and educational campaigns. Professional training of specialists involves the acquisition of competencies in the field of nutritional diagnostics, personalized diets, clinical application of bioimpedance and indirect calorimetry methods, as well as interpretation of biochemical indicators of nutritional status. The lack of nutritional training for doctors is recognized as a key systemic problem in modern healthcare. According to an international review, a significant proportion of clinicians lack sufficient practical skills in dietary counseling, which

substantially reduces the effectiveness of preventing diet-related diseases [19]. The inclusion of courses on the principles of nutritional science, vitamins, minerals, and bioactive food components in professional educational programs provides the necessary evidence base for clinically sound dietary recommendations [20]. Hygienic education of the population is aimed at learning the standards and rules of rational nutrition, development of healthy lifestyle skills, and limiting the consumption of saturated fats, ultra-processed foods, and simple sugars. The results of the analysis of randomized controlled trials demonstrate that preventive interventions at school, including dietary adjustments, increased physical activity, and general organizational changes, significantly reduce body mass index in children and adolescents [21].

The cluster actively uses digital technologies, mobile applications, and telemedicine, which enables wide audience coverage, personalized recommendations, and continuous monitoring of dietary patterns [22]. Information and educational campaigns are aimed at increasing the nutritional literacy of the population as a key predictor of healthy eating behavior. Studies show that comprehensive education for obese patients, combining dietary counseling and self-control exercises, significantly reduces body weight, waist circumference, and glycated hemoglobin levels compared with standard medical care [23]. The work of the educational cluster relies on systemic mechanisms, sanitary and epidemiological monitoring, and legislative regulation of food labeling, which enables creation of a conducive food environment and ensure the consistency of educational and regulatory interventions. Thus, Healthy Nutrition is a multi-level system integrating professional training of doctors, hygienic education of the population, and information and educational campaigns. The implementation of a three-vector approach, combined with digital technologies and regulatory mechanisms, creates the basis for sustainable healthy eating skills and reducing the prevalence of alimentary diseases. Further development of the cluster should be aimed at standardizing nutritional education programs, expanding population coverage with preventive measures, and deepening interagency cooperation in the field of health care.

Multi-tier system of prevention of obesity complications

The modern paradigm of obesity prevention is based on the principle of several tiers, involving the integration

MULTI-TIER SYSTEM FOR PREVENTION OF OBESITY COMPLICATIONS

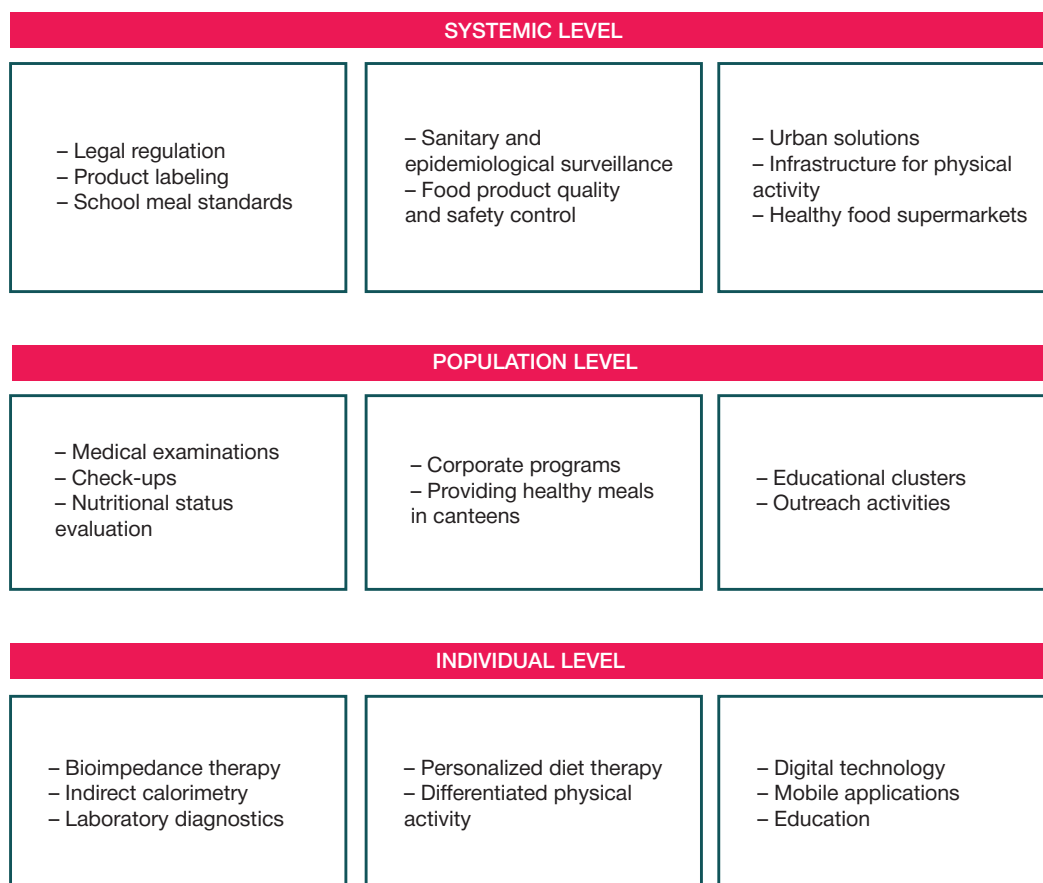


Fig. 2. Multi-tier system for prevention of obesity complications in the context of population's health preservation efforts

of individual, population, and systemic interventions to achieve a positive effect (Fig. 2). Long-term studies show that single interventions aimed at only one patient or one risk group do not achieve a sustainable reduction in the population-wide burden of the disease. In this regard, the development of multi-tier prevention systems working on the systemic, population, and individual levels is a methodologically sound approach [24–26].

At the systemic level, the efforts are aimed at legislative regulation, food labeling, school nutrition standards, sanitary and epidemiological supervision, food quality and safety control, urban planning solutions and deployment of infrastructure for physical activity, and launching healthy food supermarkets. Experts recognize structural changes in the environment that create conditions for healthy behavior as more effective than isolated educational programs, since they affect risk factors before they are realized at the level of a single person [26].

At the population level, the work revolves around general medical and preventive examinations, assessment of nutritional status, corporate health programs, provision of healthy meals in canteens, as well as the development of educational clusters and awareness-raising activities. The level of an individual involves digital technologies and mobile applications, educational programs for patients, personalized diet therapy, differentiated physical activity, as well as diagnostic methods for metabolic disorders (bioimpedance, indirect calorimetry, laboratory diagnostics).

A personalized approach that accounts for individual metabolic, genetic, and behavioral characteristics of the patient, ensures higher adherence to treatment and long-term control of body weight [27–29]. Personalized obesity therapy is based

on the identification of the patient's metabolic phenotypes. The indirect calorimetry method allows determining the respiratory coefficient and calculating the rate of oxidation of carbohydrates and fats, which enables prediction of the effectiveness of diet therapy and tailored selection of the ratio of macronutrients [12]. Bioimpedance measurements show the total volume of fat and its distribution, and reveal the musculoskeletal mass and phase angle that reflect the integrity of cell membranes and the quality of nutrition of the patient [30, 31]. An additional method that increases the accuracy of personalization is the analysis of biochemical markers of nutritional status (carbohydrate and lipid profiles, vitamins, minerals, hormonal status) and genetic polymorphisms (FTO, MC4R, PPARG, ADRB2, ADRB3) associated with the risk of obesity and the rate of metabolic processes [32, 33]. Consequently, the multi-tier system of prevention of obesity complications is a complex model in which systemic, population-based, and individual interventions mutually reinforce each other. At the same time, it is at the individual level that the data of bioimpedance measurements, indirect calorimetry, and molecular genetic analysis are integrated for personalization of therapeutic and preventive measures, which is critically important for the formation of a stable commitment of patients and the prevention of relapses of the disease.

CONCLUSION

The analysis confirms that obesity is a multifactorial disease based not only on individual metabolic characteristics, but also on structural features of the food environment that form patterns of poor nutrition at the population level [7, 8]. Our findings

are consistent with the results of global epidemiological studies demonstrating a stable relationship between the availability of ultra-processed foods, low physical activity, and an increase in the prevalence of obesity [4, 11]. Traditional approaches to prevention, limited to dietary counseling not taking into account the metabolic phenotype, show low effectiveness in the long term, which is confirmed by high rates of repeated weight gain after the end of diet therapy [9, 10].

The key result of this work is the justification of the need to move from unified dietary recommendations to a personalized strategy that integrates instrumental diagnostic data. The use of bioimpedance allows not only to quantify fat and musculoskeletal mass, but also to determine the phase angle, which is considered as an integral marker of nutritional status and cellular health [30, 31]. In turn, indirect calorimetry enables calculation of the respiratory coefficient and the individual rate of oxidation of substrates, which is critically important for predicting the effectiveness of diet therapy and preventing a slowdown of basal metabolism in response to caloric restriction [12]. An additional predictor that increases the accuracy of personalization is the analysis of genetic polymorphisms associated with the risk of obesity and the rate of metabolic processes [33]. The integration of these methods into clinical practice is in line with current trends in the development of personalized medicine; it enables realization of the individual approach to nutritional support, taking into account the patient's metabolic, genetic characteristics and eating behavior. The three-level prevention model presented in the review, combining systemic, population-based, and individual interventions, deserves special attention. Literature data indicate that structural changes in the food environment have greater population effectiveness compared to isolated educational programs, since they affect risk factors before they are realized at the individual level [34].

However, the success of systemic measures directly depends on the level of nutritional literacy of doctors and the population, which underscores the important role of the Healthy Nutrition educational cluster. The insufficient level of dietary competence among clinicians, confirmed by international reviews [19, 20], limits the implementation of personalized prevention. In this regard, the development of a system of continuing medical education in the field of nutrition, as well as the implementation of school hygiene education programs that have proven effective in reducing

body mass index in children [21, 22], should be considered as public health policy priorities. An important practical result of the work is the description of the NIAP software that integrates bioimpedance measurement, indirect calorimetry, and laboratory tests data to generate personalized nutrition recommendations. According to modern research, digital platforms of this type can increase patient adherence to treatment by visualizing progress, automating diet control, and providing real-time feedback [17]. Thus, the results of the analysis allow formulating key provisions that are important for the scientifically based organization of obesity prevention: firstly, the assessment of the metabolic phenotype using bioimpedance and indirect calorimetry is a prerequisite for the personalization of diet therapy; secondly, a multi-tier prevention system should simultaneously be implemented at the systemic, population, and individual levels, prioritizing structural changes; thirdly, the training of qualified personnel and increasing the awareness of the population with the help of the Healthy Nutrition educational cluster are necessary to ensure effectiveness of preventive programs. The implementation of such a system requires coordination of efforts at all stages — from the formation of a health-saving environment and population screening to personalized diet therapy based on advanced diagnostics. The introduction of these methods into general medical and preventive examination programs will allow identifying high-risk metabolic phenotypes and developing individual nutrition recommendations, which aligns with the strategic objectives of health preservation of the population of the Russian Federation. However, their effective deployment is impossible without the proper level of training of medical personnel and literacy of the population. The development of the Healthy Nutrition educational cluster and the introduction of digital tools, including the NIAP platform, create an infrastructure for improving the competencies of specialists and educating the population, which, together with sanitary and epidemiological monitoring measures, forms the basis for long-term body weight control and reducing the prevalence of alimentary diseases. In order to implement these tasks in real clinical practice, further research should aim to evaluate the clinical and economic effectiveness of the proposed educational and diagnostic technologies in primary health care, as well to develop national clinical recommendations for personalized prevention of obesity that factor in the hygienic aspects of nutrition.

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