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Major temporal trends and age-related characteristics of obesity morbidity in Arkhangelsk region population

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ABSTRACT

BACKGROUND: Obesity is a chronic disease that represents a significant risk factor of type 2 diabetes mellitus and cardiovascular diseases, as well as a primary contributor to disability. This condition affects individuals of all age groups, including children, which represents a particularly concerning trend. The incidence of obesity over multiple years has not been sufficiently studied in Russia. It is therefore pertinent to analyze the incidence of obesity over time in different age groups in order to identify the principal determining factors.

AIM: To evaluate the main dynamic and age-related characteristics of obesity morbidity in the Arkhangelsk Region.

MATERIALS AND METHODS: We conducted a retrospective, analytical, non-randomized study. The 1991–2022 changes in the primary obesity morbidity in the Arkhangelsk Region population was analyzed. The contribution of the incidence in different age groups to the total change in the primary morbidity and degree of chronification in the population was investigated. The extent of underreporting of obesity morbidity during the period of the pandemic was estimated. The study employed a variety of analytical techniques, including the use of standardized indicators, time series analysis, and index methods.

RESULTS: Our findings revealed a consistent increase in the primary morbidity of obesity over the 1991–2006 period, followed by a subsequent decline. The overall primary morbidity demonstrated a 506.4% increase. The changes in the primary obesity morbidity across the population are most closely aligned with those observed in the 0- to 14-year-old age group. The substantial fluctuations in the primary morbidity among the overall population are associated with those observed in the older age groups. Obesity is a chronic disease, and the proportion of individuals who are chronically obese is increasing. It is estimated that the primary morbidity of obesity was underreported by 16.8% during the period of the pandemic.

CONCLUSION: The analysis of the dynamic characteristics of the obesity morbidity allows for assuming its significant dependence on administrative factors, most notably on changes in diagnostic criteria. It is evident that there is an unmet need in the programs designed to report, treat, and prevent obesity, particularly in children, with the aim of reducing the cardiometabolic population burden and other risks. This is particularly pertinent in the context of the need to develop the Arctic zone of the Russian Federation and to protect health in the region.

Keywords: obesity incidence; population; Arkhangelsk region.

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Основные динамические и возрастные характеристики заболеваемости ожирением населения Архангельской области

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АННОТАЦИЯ

Обоснование. Ожирение — хроническое заболевание, являющееся основным фактором риска сахарного диабета 2-го типа, сердечно-сосудистых заболеваний и одной из основных причин инвалидности. Данная патология затрагивает все возрастные группы населения, включая детей, что является самой негативной тенденцией. В России недостаточный уровень изучения заболеваемости ожирением в многолетней перспективе. В связи с этим представляется актуальным анализ динамики уровня заболеваемости ожирением в различных возрастных группах с целью выявления основных возможных детерминирующих факторов.

Цель. Оценить основные динамические и возрастные характеристики заболеваемости ожирением населения Архангельской области.

Материалы и методы. Исследование ретроспективное аналитическое нерандомизированное. Проанализирована динамика показателей первичной заболеваемости ожирением населения Архангельской области за 1991–2022 гг. Изучен вклад заболеваемости в различных возрастных группах в общее изменение первичной заболеваемости и степень хронизации заболеваемости населения ожирением. Оценён уровень недоучёта заболеваемости ожирением в период пандемии COVID-19. Использованы стандартизованные показатели официальной медицинской статистики, а также методы анализа временны́х рядов, индексный метод.

Результаты. Установлено, что с 1991 до 2006 г. наблюдался непрерывный рост заболеваемости ожирением с последующим снижением. Общее увеличение первичной заболеваемости составило 506,4%. Динамика первичной заболеваемости населения ожирением максимально связана с динамикой первичной заболеваемости ожирением в группе 0–14 лет. Отдельные значительные колебания первичной заболеваемости всего населения связаны с колебаниями первичной заболеваемости в старших возрастных группах. Ожирение — хроническое заболевание, уровень его хронизации увеличивается. Недоучёт первичной заболеваемости в период пандемии COVID-19 составил 16,8%.

Заключение. Анализ динамических характеристик первичной заболеваемости ожирением позволяет сделать предположение о её значительной зависимости от административных факторов, прежде всего от изменений диагностических критериев. Требуются программы как учёта и лечения, так и профилактики ожирения, особенно детского, для снижения кардиометаболического популяционного груза и иных рисков в условиях запроса на развитие Арктической зоны Российской Федерации и здоровьесбережение в регионе.

Ключевые слова: заболеваемость ожирением; население; Архангельская область.

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阿尔汉格尔斯克州人口肥胖患病率的主要动态和年龄特征

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摘要

背景。肥胖是一种慢性疾病，是2型糖尿病、心血管疾病的主要风险因素之一，也是导致残疾的主要原因。这种疾病影响所有年龄段人群，包括儿童，这是一种负面趋势。在俄罗斯，对肥胖长期患病率的研究不足。因此，分析不同年龄组肥胖患病率的动态以发现可能的决定性因素显得尤为重要。

研究目的。评估阿尔汉格尔斯克州人口肥胖患病率的主要动态和年龄特征。

材料与方法。本研究为回顾性分析性非随机研究，分析了1991年至2022年间阿尔汉格尔斯克州人口肥胖初次患病率的动态，研究了不同年龄组患病率对整体肥胖初次患病率变化的贡献以及肥胖慢性化程度。同时评估了COVID-19大流行期间肥胖患病率的漏报情况。研究采用了官方医疗统计数据的标准化指标，以及时间序列分析和指数分析法。

结果。从1991年至2006年，肥胖患病率持续增长，随后出现下降，总体初次患病率增长了506.4%。人口肥胖初次患病率的动态与0-14岁年龄组肥胖初次患病率的动态高度相关。整个人口肥胖初次患病率的个别显著波动与老年组患病率的波动相关。肥胖是一种慢性疾病，其慢性化程度正在增加。在COVID-19大流行期间，肥胖初次患病率的漏报率为16.8%。

结论。对肥胖初次患病率动态特征的分析表明，其显著依赖于行政因素，尤其是诊断标准的变化。因此，需要制定肥胖的记录、治疗以及预防计划，特别是儿童肥胖的预防，以减轻心血代谢性疾病的负担以及其他健康风险。这在俄罗斯北极地区的发展和地区健康保护需求背景下尤为重要。

关键词：肥胖患病率；人口；阿尔汉格尔斯克州。

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BACKGROUND

Obesity is a chronic disease associated with excessive accumulation of body fat, which is a significant health threat and a major risk factor of other chronic diseases, including type 2 diabetes mellitus and cardiovascular diseases. Obesity had not been formally recognized in the International Classification of Diseases (ICD) until 1948. Alongside the ongoing debate on obesity classification, the population suffering from the condition has dramatically increased. By 2000, there were more than 300 million patients with obesity, prompting the World Health Organization (WHO) to define obesity as an epidemic of the 21st century [1]. Obesity is a key cause of disability and mortality worldwide, affecting individuals of all ages, including children and adolescents [2]. In the Russian Federation, 62.0% individuals were overweight and 26.2% were obese in 2016 [3]. One of the most adverse trends is the growing prevalence of obesity in children. For example, a 2017–2018 study conducted in Moscow with 2,166 7-year-old children as part of the WHO Childhood Obesity Surveillance Initiative (38 European countries, 2007) showed that 24% boys and 23% girls were overweight; whereas 10% and 7% were obese, respectively [4].

The available data is insufficient for the analysis of multiyear changes in obesity-related morbidity (ORM) in Russia. The majority of studies have a cross-sectional design. Therefore, it is important to study ORM trends in different age groups to identify the key determinants of the disease.

Aim: To evaluate the major dynamic and age-related characteristics of ORM in the Arkhangelsk Region.

MATERIALS AND METHODS

The study examined ORM (ICD-10, code E66) incidence and primary morbidity and chronicity rates in the population of the Arkhangelsk region.

The analysis covers the period from 1991 to 2022. We selected this period for analysis due to the onset of obesity diagnoses in 1991.

Data sources:

1) Morbidity rates were provided by the Medical Information and Analytical Center of the Arkhangelsk Region (Statistical Form No. 12, Information on the Number of Diseases Registered in Patients Living in the Service Area of the Healthcare Provider).

2) The population data by age were provided by the Russian Database on Fertility and Mortality of the Center for Demographic Research of the Russian Economic School [5].

Mathematical and statistical methods:

1) The morbidity rates were standardized using the direct method with a population standard of the Arkhangelsk Region in 2019.

2) Abnormal values (outliers) were detected by Irwin test.

3) The Chow test was used to estimate the structural instability of the time series.

4) The White test was used to assess the significance of morbidity differences.

5) The index method was used to calculate the contribution of morbidity changes in different age groups to the overall ORM trend.

6) Chronicity rates were calculated as the ratio of total morbidity to primary morbidity [6].

7) The Shapiro–Wilk test was used to determine the conformity of the model residuals to the normal distribution.

RESULTS

Dynamic Characteristics of Morbidity

From 1991 to 2022, the primary morbidity rate increased fivefold (506.4%). This rate is defined as the number of diseases detected for the first time. From 2011 to 2022, the average primary morbidity rate in the Arkhangelsk Region (277.9 cases per 100,000 people) was higher than that in the Russian Federation (270.9 cases per 100,000 people). However, the difference was not statistically significant ($p \geqslant 0.05$). The dynamics of the primary ORM can be divided into three periods, progressive growth (1991 to 2005), a sharp increase followed by a decline (2006 to 2014), and another increase followed by a decline (2015 to 2022) (see Fig. 1). The first period was characterized by a linear increase in primary morbidity ($p < 0.001$) with relatively small rate dispersion (mean [M]=93.9, standard deviation [SD]=45.8) compared to the second period (M=294.8; SD=63.1). Rate dispersion in the third period was comparable to that of the first period (M=292.8; SD=43.9). Thus, the highest instability in morbidity dynamics was observed in 2006–2014. Irwin test for 1991–2022 showed that the morbidity spike in 2006 was abnormal (λ=2.134; $\lambda_{critical}$=1.1). Therefore, the highest index instability period (2006–2014) was apparently due to a morbidity spike in 2006. Subsequently, the fluctuations slowed down and stabilized in 2015–2022. These findings and the linear growth in 1991–2014 showed that the primary morbidity rate peaked in 2006 and then began to decline. Thus, the morbidity rate increased by 547.4% in 1991–2005 followed by a decline by 41.2% and 37.7% in 2006–2014 and 2015–2022, respectively. The Chow test showed structural instability at the 2006 and 2015 points ($F(1, 30)$=127.284, p=0.0000 and $F(1, 30)$=8.98849, p=0.0054, respectively), which mathematically confirms our assumption of a trend change in these periods compared to the 1991–2005 trend. However, when comparing the dynamics in 2006–2022, the Chow test showed no structural instability at the 2015 point. This indicates that the dynamics did not change during that period ($F(1,15)$=0.0109575; p=0.9180). Therefore, the 2006–2015 and 2015–2022 periods do not differ in terms of rate dynamics. The chain growth rate analysis showed that the highest rate was in 1991–2005 (11.8%) with a decrease in 2006–2014 (10.9%) to the lowest rate in 2015–2022 (1.7%). These findings suggest that the rate of new cases slowed down in the.

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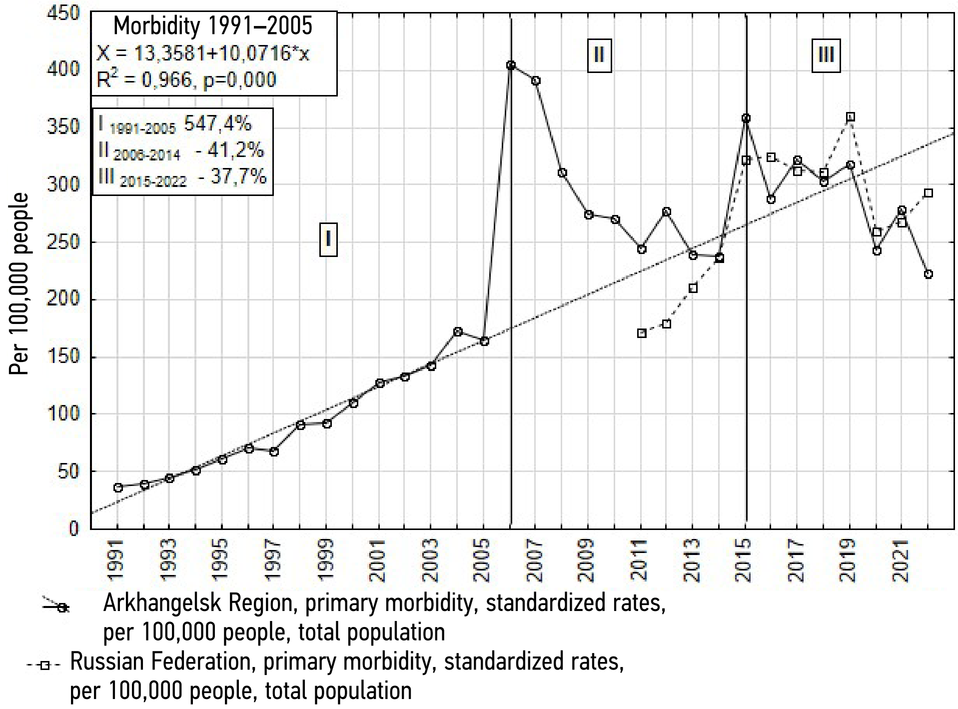

Fig. 1. Dynamics of primary obesity-related morbidity rates per 100,000 people in the Arkhangelsk Region in 1991–2022 (standardized).

Contribution of the Main age groups to the overall dynamics of obesity-related morbidity and its chronicity

We analyzed the contribution of ORM in the age groups 0–14, 15–17, and ⩾18 years to the overall dynamics of primary ORM.

The index method showed that the total primary morbidity increased by 506.4% in 1991–2022. This increase was mainly due to the primary morbidity growth in the 0–14 and older age groups (279.0%). The second largest contribution was the ⩾ 18 age group (176.6%).

When examining different periods, including the most significant increase in 2006, the major contributor was the ⩾ 18 years age group. The observed morbidity decline in 2006–2022 is attributed to a morbidity decrease in adults balanced by a morbidity increase in children (see Fig. 2).

Throughout the entire period, the chronicity coefficient exceeded 1.0 (M=5.0; SD=1.4). The dynamics of this coefficient showed two distinct periods, a decrease in 1991–2006 followed by an increase (see Fig. 3). The decrease in 1991–2006 was gradual (average growth rate: 1.9%; SD=14.0); whereas the subsequent growth was more rapid (average growth rate: 8.7%; SD=13.4). Overall, the indicator increased by 118.6% in 1991–2022, reaching the record high in 2022.

Underestimated morbidity during the COVID-19 pandemic

We used nonstandardized primary morbidity rates for 2017–2022 to study the underestimated primary morbidity during the COVID-19 pandemic. The Irwin test showed an outlier in 2022 (λ=1.8 at $\lambda_{critical}$=1.5). The primary ORM showed a 23.6% decrease in 2020 followed by an increase of 14.0% in 2021. We assumed that this outlier is attributable to a morbidity decrease associated with fewer outpatient visits during the COVID-19 pandemic. Given the nearly linear dynamics observed in 2018–2022, the calculation was based on the time average for this period with the 2020 figure excluded. The time average was 291.8 cases per 100,000 people. Considering the actual rate of 242.7 cases per 100,000 people in 2020, the difference was 49.1 cases per 100,000 people (555 individuals, 16.8%). Apparently, the 16.8% share of morbidity decrease in 2020 was attributable to the restrictive measures during the COVID-19 pandemic. Thus, the subsequent morbidity increase in 2021 may have been compensatory.

DISCUSSION

The dynamics analysis of the primary ORM in the population of the Arkhangelsk Region showed a systematic increase before 2005 followed by sharp fluctuations (see Fig. 1). The time series analysis showed that the dynamics changed in 2006. The observed changes in subsequent years allow for some assumption on their nature. First, the fluctuations, their strength, and the instantaneous increase in 2006 indicate their artificial nature and show that the changes are unrelated to the natural epidemiological process of morbidity changes. The period between 1997 and 2020 is characterized by epidemiological and clinical differences in the conceptualization of general obesity and abdominal obesity. These differences are represented by the dynamics of the primary ORM in the Arkhangelsk Region.

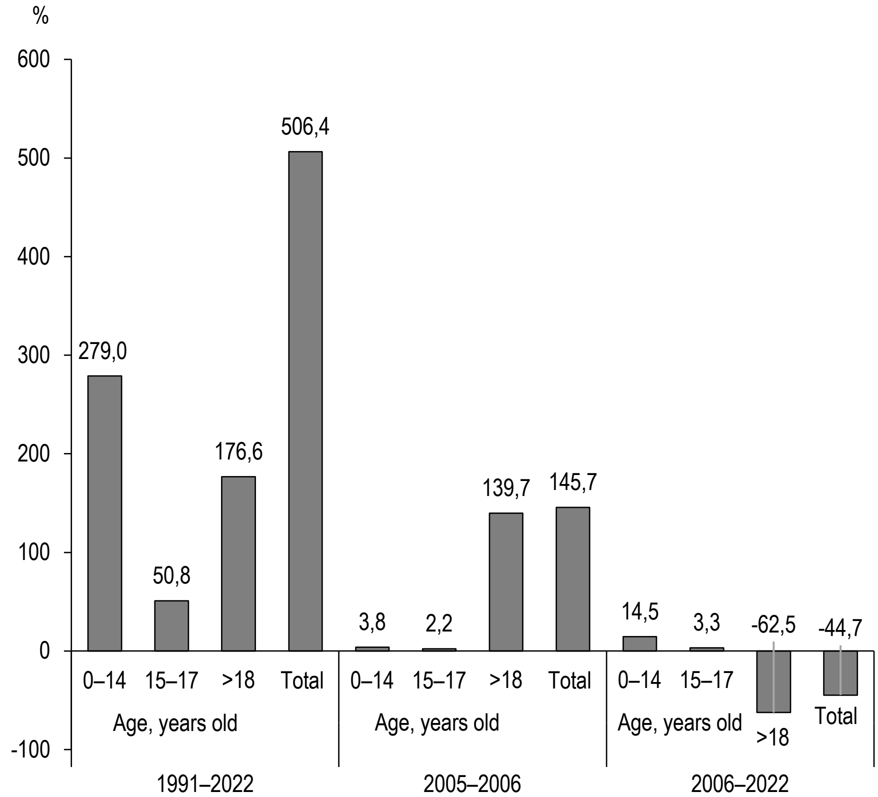

Fig. 2. Contribution of morbidity in separate age groups to the change in the primary obesity-related morbidity in the Arkhangelsk Region, %.

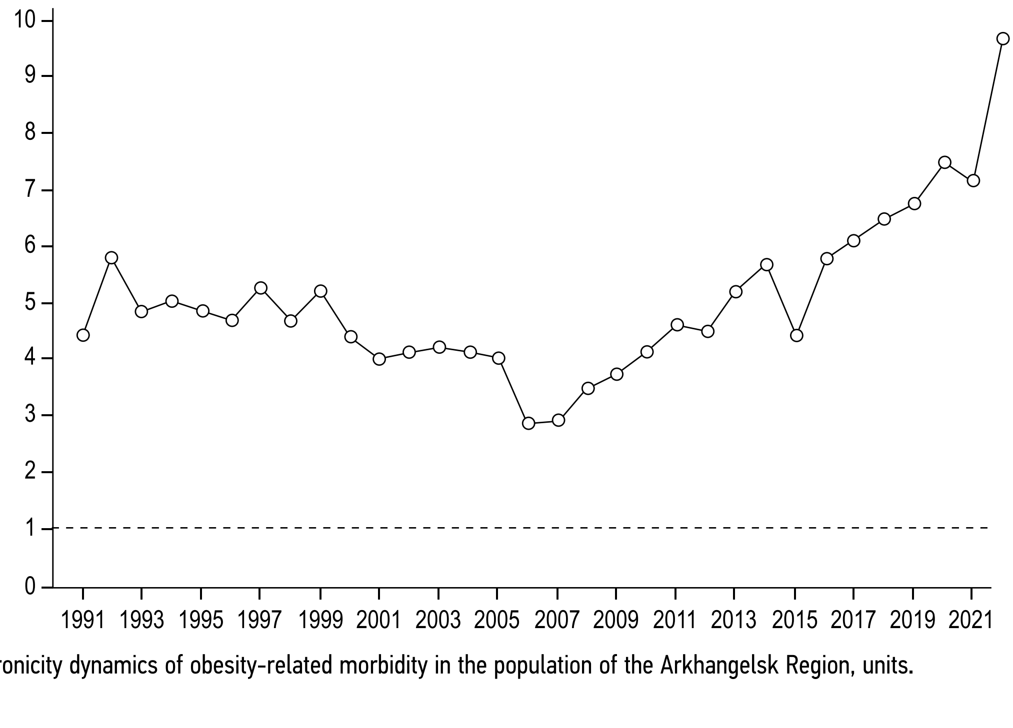

Fig. 3. Chronicity dynamics of obesity-related morbidity in the population of the Arkhangelsk Region, units.

Until 1997, the Body Mass Index (BMI), or the Quetelet index (1835), proposed by Ancel Keys in 1972, could be used in Russia to diagnose obesity. However, it is believed that Broca Index (1871) was more commonly used in Russian medical practice, i.e. ideal body mass=height (cm) – 100 cm±9.9% [7]. According to the classification proposed by Egorov and Levitsky (1964), the degree of obesity is determined by the percentage by which the actual body weight exceeds the ideal body weight calculated using the Broca Index.

In 1997, the WHO recommended changing the BMI standards to end at 25 kg/m^2 instead of 28.7 kg/m^2. Because of this, approximately 29 million previously healthy Americans were reclassified as overweight or obese [8].

Fig. 1 shows that the primary ORM has steadily increased in the Arkhangelsk Region since 1991 with an abnormal 2.5-fold spike (150%) in 2006 compared to 2005. It is believed that the steady increase in obesity rates in Russia is a consequence of the socio-economic stress in 1991. We agree with this assumption; however, the rapid growth of ORM in the Arkhangelsk Region in 2005 may indicate changes in the medical community's ideas about the metabolic syndrome (MS) and abdominal obesity rather than being a result of socio-economic problems. In other words, it is a consequence of changes in the diagnostic criteria of obesity. In 2005, the International Diabetes Federation (IDF) and the American Heart Association (AHA), along with the National Heart, Lung, and Blood Institute (NHLBI), proposed a unified concept of MS aligned with the European Group for the Study of Insulin Resistance (1999). This concept defined abdominal obesity with a waist circumference (WC) >94 cm for men and > 80 cm for women as the primary criterion for MS. This definition and understanding of the MS caused an abnormal increase in the primary ORM in the Arkhangelsk Region only in the adult population in 2005–2006 as a result of a change in diagnostic guidelines (see Fig. 1). Notably, ICD-10 does not have an MS category. Thus, before 2005, the MS symptom group was likely divided into hyperglycemia (E10, E11, E13, E14), hypertension (I10, I11), dyslipidemia (E78), and obesity (E66). After 2005, the key IDF, AHA, and NHLBI criterion (abdominal obesity with a WC of >94 cm in men and >80 cm in women) presumably became the basis for new obesity diagnoses. In addition, metformin therapy for abdominal obesity (MS) became available [7, 9].

However, the debate continued. In 2009, a new agreement on MS criteria was reached through the collaboration of leading international MS research organizations, including the IDF, NHLBI, AHA, World Heart Federation, International Atherosclerosis Society, and International Association for the Study of Obesity. This alliance excluded abdominal obesity from the priority MS criteria. All criteria are now equal and a diagnosis of MS requires that three of the five criteria from the unified definition should be met. There are also changes in the diagnostic WC thresholds of abdominal obesity. For example, the IDF recommends keeping WC values >94 cm for men and >80 cm for women in the Caucasian population. The WHO's stratification of the Caucasian population is based on the magnitude of cardiovascular risk; the risk is defined as moderate for men with a WC >94 cm and women with a WC >80 cm and significantly high for men with a WC >102 cm and women with a WC >88 cm. Today, these criteria (AHA/NHLBI/IDF, 2009) are included the final interpretation of the MS definition [10, 11].

In 2010, a WHO expert group published a report on its analysis on the pathophysiology and epidemiology of MS. Due to limitations and contradictions of the concept, the conclusion was that MS should not be used as a clinical diagnosis. In addition, MS is not included in the ICD-11. A sort of response to the WHO's conclusions is the graph showing the increase in primary ORM in Arkhangelsk in 2009–2014. It frozes and transitions to a horizontal trend (see Fig. 1). A new morbidity spike was observed in 2015 and apparently associated with higher medical activity.

In 2014, the American Association of Clinical Endocrinology and the American College of Endocrinology proposed a staging obesity classification that considers anthropometric and clinical data, including complications associated with excess body weight [12]. According to the proposed staging system, obesity may be diagnosed in individuals with anthropometric data of excess body weight and associated complications. Obesity-associated diseases/complications included prediabetes and type 2 diabetes mellitus, arterial hypertension, hypertriglyceridemia/dyslipidemia, obstructive sleep apnea syndrome, nonalcoholic fatty liver disease, polycystic ovary syndrome, and osteoarthritis. The proposed classification determined possible reasonable medical intervention and did not contradict the primary healthcare standard for obesity (E66) approved by Order No. 752n of the Ministry of Health of the Russian Federation on November 9, 2012. This Order governs the treatment of obesity with sibutramine, orlistat, and metformin [13]. The combination of new diagnostic techniques and therapeutic options contributed to the morbidity spike in 2015.

Thus, sharp morbidity rate fluctuations were the result of administrative interventions. This is indirectly confirmed by the return to the previously predicted morbidity rate in 2009 and the increased dispersion of morbidity rates after 2005 (see Fig. 1). In this case, linear regression dynamics passing through the 2013 and 2019 points are the most realistic.

Unlike the uneven increase in ORM in adults may be explained by the consequences of the 1990s and differences in diagnosis, the increased pediatric ORM in the Arkhangelsk Region is true as it reflects the metabolic pandemic with the onset at early development stages [14, 15]. Furthermore, other research results indicate a significant increase in obesity and overweight status in children of all ages in the Northwestern Federal District, particularly in large industrial centers [16–18].

To analyze this complex and multifactorial process, it is required to highlight several factors and discuss each of them in detail.

The first is the diagnosis of pediatric obesity. As with adults, the analyzed period was marked by changes in the approaches used to verify the diagnosis. Since the 1990s, BMI percentile charts have been gradually adopted in the Russian Federation, where a BMI above the 95th percentile is considered obese and a BMI between the 85th and 95th percentiles is considered overweight [8, 19]. As more global epidemiological data accumulated and the initial charts developed, the diagnostic obesity threshold has shifted from the 85th to the 95th percentile [20].

Since 2007, the Russian Federation has used the WHO diagnostic criteria of pediatric obesity. These criteria were developed based on a prospective study of 8440 healthy infants from six countries during the first 24 months of life followed by a cross-sectional examination at 18–71 months [21]. Importantly, the children were raised in environments conducive to physiological growth, including breastfeeding, balanced diets, preventive vaccinations, and avoidance of unhealthy lifestyle by their mothers. Based on the obtained data, height and weight standards were developed for children aged 0 to 5. In addition, height and weight standards were developed for children aged 5 to 19 based on mathematical models and a sample of children from the USA. This assessment system is advantageous as it determines criteria of healthy growth rather than the growth patterns of children in contemporary society, where obesity rates increase every decade [22]. According to WHO recommendations, obesity in children and adolescents aged 0 to 19 years was defined as a BMI ⩾2.0 BMI standard deviation score (SDS). Overweight was defined as a BMI between +1.0 and +2.0 BMI SDS, and normal body weight was defined as a BMI in the range of ±1.0 BMI SDS [23–25]. The diagnosis of pediatric obesity in real-life pediatric practice may have been affected both by the apparent complexity of the calculation and the existing algorithms and the delayed widespread availability of online calculators that allow for quick and accurate determination of overweight/obesity and its degree in different age groups. Thus, the probability of underdiagnosis of pediatric obesity is higher than overdiagnosis, given the potential methodological challenges.

Second, primary morbidity results from two sources, primary detection by pediatricians when admitting children with other diagnoses and targeted referral by parents concerned about their children's weight. Statistical Form No. 12 does not include medical examinations, including check-ups. Moreover, some experts believe that the Russian Federation exhibits a trend of delayed referrals to doctors for childhood obesity, despite the fact that a chubby baby has long ceased to symbolize health and well-being [26].

Therefore, neither changes in the diagnostic criteria of pediatric obesity nor the peculiarities of seeking medical help have resulted in a 300% increase in pediatric obesity rates in the Arkhangelsk Region, nor could they have caused general changes in ORM rates in the region over the thirty-year observation period driven by the 0–14 age group. For 30 years, the Arkhangelsk Region's pediatric services have worked "qualitatively" and kept pace with global statistics on pediatric obesity. This coincides with WHO data indicating that childhood obesity prevalence has tripled since 1975, as showed by our study [14, 27–30]. Today, Russian experts state that obesity in children and adolescents in the Russian Federation is the most prevalent endocrine disease with a strong trend of steady growth in obesity rates, including in young children (up to five years of age), i.e. before the adiposity rebound, ensuring that obesity will persist into adulthood [8, 31]. Moreover, this study indicates that obesity is a chronic condition. The data on the prevalence of childhood obesity in the Russian Federation is only the tip of the iceberg. The actual figures may be much higher [31–33].

Third, the increase in pediatric obesity, both locally and globally, must have a cause. Experts worldwide agree that simple polygenic exogenous-constitutional obesity is the primary cause, accounting for more than 90% of all cases. In this case, the environment is the key developmental factor [14].

Unlike North America and Europe, where 29% boys and 27% girls aged 2–15 are overweight or obese [34], several epidemiological and cohort studies in Russia have shown an uneven prevalence of the condition. The studies found that the prevalence of overweight cases was in the range of 3.9%–5.5% and the prevalence of obesity was in the range of 1.2%–25.3%, depending on the age, sex, and living conditions of the children in different regions of the Russian Federation [16–18, 31].

Such unevenness depends on several factors, including the environment in the residence region, residence duration, economy, and other environmental conditions. Together, these factors predict modifiable and non-modifiable risks of lipid and energy metabolism disorders, making a specific map of obesity in each climate and geographic area. Accordingly, the share of pediatric obesity in the total population of the Arkhangelsk Region and other regions will be determined by the presence and accessibility of obesity triggers at different stages of a child's life in a given region [14]. The concept proposed by Kozlov *et al.* highlights the importance of human ecosystem factors [35]. The authors investigate the uneven growth and population of the metabolic pandemic in relation to previously proposed hypotheses (*thrifty genotype, drifting genotype*, and *late thriftiness*) considering the genogeography and human ecosystem of the region of residence. This approach aims to eliminate contradictions in relation to the limited genetic contribution (up to 20%) to obesity pathogenesis. The authors use reference conditions of successful adaptation as a basis for comparison, considering environmental parameters that determine the adaptive characteristics of basic metabolic intensity and adipose tissue content in different populations from 60,000 to 10,000 years ago [35–43]. From this perspective, one factor contributing to the spread of obesity could be the migration of groups that have adapted to specific conditions to areas with different natural stresses, such as extreme cold or heat. The Arkhangelsk Region, which is huge in terms of territory but small in terms of population, is undoubtedly genetically diverse and may be used a model for these processes. The region is inhabited by indigenous Arctic peoples (Nenets and Komi) and other ethnic groups from different regions of the former USSR, who arrived at different times and for various reasons.

For example, native inhabitants of the Far North have a phylogenic protein and lipid metabolism, low availability of "fast" carbohydrates, and significant natural cold stress. Moving to an urban environment farther south with an abundance of sugars in food, including imported fruit and juices, which are useful but foreign to the individual, will affect optimal energy metabolism. Conversely, someone else will experience heat stress, insolation, periods of hypocaloric intake, motor

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stress, and a lack of traditional foods in relatively harsh climatic conditions in a region with an abundance of food and excess calories. In other words, phylogenic morphophysiological characteristics that were once adaptive have become maladaptive and healthy stresses associated with metabolic optimization are displaced or supplemented by anxiety disorders related to eating disorders. This assumption seems plausible when considering the ethnic diversity of the small population in the Arkhangelsk Region.

Importantly, in addition to population-level assumptions that explain the growth of metabolic disorders, individual hypotheses (*thrifty phenotype*) are becoming more prevalent. These assumptions provide that cardiometabolic disorders in a fetus caused by maternal malnutrition is epigenetically programmed during fetal development. These risks manifest later in life with abundant food and sedentary behavior [44, 45]. Maternal malnutrition may be true. In this case, the difficulties of the 1990s and the low birth rate in the Russian Federation during this period would support the *thrifty phenotype* hypothesis. However, malnutrition could also be caused by unconscious neurotic anorexia (fear of gaining weight in the Barbie era) or existing metabolic disorders in the pregnant woman (e.g., arterial hypertension, gestational and pregestational diabetes, and obesity) and excessive weight gain during pregnancy.

Moreover, it is difficult to overfeed a child with healthy food. However, it is quite possible to overfeed a child with “fast” carbohydrates, including as a reward for the behavior expected from the child. Several psychological factors act as prerequisites for obesity in children and adolescents, including personal traits such as low self-esteem, high levels of comfort eating, increased anxiety, and alexithymia, as well as sociocultural factors such as family food priorities, social expectations, and reference groups. Sociocultural factors play a fundamental role in developing destructive eating habits during childhood and adolescence. Personal traits also contribute to this process. From birth to early adolescence, the family is the main determinant of a child’s food behavior as children depend on adult eating behavior models at this age. These models are adopted uncritically and later influence unconscious lifestyle attitudes.

The psychosomatic model of emotiogenic eating behavior reflects the phenomenon of using food to encourage desired child behavior and provide comfort in times of adversity. This model combines social learning theory and stress theory. For example, in contemporary society, the idea of finishing an entire meal is stronger than the idea of eating only what is necessary to satisfy hunger. The image of a good child who eats everything offered to avoid irritating or offending an adult is often promoted. The discrepancy between natural hunger-quenching needs and the demands of food stereotypes and adult expectations creates psychosocial tension. This shifts control from internal satiety signals to external stimuli, such as rewards or reprimands, which contributes to the development of externalized eating disorders. These disorders may lead to emotiogenic eating disorders in adulthood when faced with long-term or chronic stress [46].

Thus, a 300% true increase in obesity in children (aged 0–14) was observed in the Arkhangelsk Region in 1991–2022. Background factors may include regional diversity of *thrifty genotypes* and *phenotypes, drifting genes, late thrifty genes*, and human ecosystem conditions such as the region’s environment and management system. The catalysts are the difficulties of the 1990s followed by prosperity; computer game hypodynamia, which has led to a loss of the natural need for movement in children; a higher share of fast food in diets; the sheer quantity, appeal, and availability of surrogate sweet calories, and neurotic pressure from adults in the form of demands and expectations.

The underestimation of ORM rates in the Arkhangelsk Region during the COVID-19 pandemic seems to be related to healthcare system restructuring and its shift in focus to primary infectious disease treatment.

Although the analyzed morbidity rates are related to the utilization of healthcare services, which may affect the reliability of the initial data given the described diagnostic peculiarities, the child population (aged 0–14) is not the true and main contributor to the growth of ORM rates in the Arkhangelsk Region in 1991–2022. Instead, it may be an early manifestation of a large-scale maladaptation of the population outside of ecological homeostasis. Research indicates that 7 to 9 out of 10 obese preschool children will remain obese by the age of 14, as well as 7 to 8 obese adolescents out of 10 will remain obese in adulthood [14, 47].

CONCLUSION

The study of the dynamic characteristics of primary ORM in the population showed its growth until 2006 followed by a decrease and a slower increase in morbidity rates. During the thirty-year observation period, changes in primary ORM were driven by morbidity changes in the 0–14 age group. However, separate fluctuations, including the decrease in morbidity in 2006–2022, were driven by changes in ORM in adults. The chronic nature of ORM in the population is characterized by a persistent trend towards increased chronicity. During the COVID-19 pandemic, 16.8% (555 people) primary ORM cases were uncounted.

We need obesity recording, treatment, and prevention programs, especially pediatric obesity, to reduce the cardiometabolic burden on the population and mitigate other risks. This is particularly important given the demand for development of the Russian Arctic and the need to protect the region’s health.

ADDITIONAL INFORMATION

Authors’ contribution. K.V. Shelygin — concept development, mathematical and statistical analysis of data, writing and editing of the article, preparation of the article; A.V. Strelkova — literature review, collection and analysis of literary sources, writing and editing of the article; L.I. Lozhkina — literature review, collection

and analysis of literary sources, writing and editing of the article; S.I. Malyavskaya — writing and editing of the article. All authors confirm that their authorship meets the international ICMJE criteria (all authors have made a significant contribution to the development of the concept, research and preparation of the article, read and approved the final version before publication).

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Вклад авторов. К.В. Шелыгин — разработка концепции, математико-статистический анализ данных, написание текста и редактирование статьи, подготовка статьи, А.В. Стрелкова — обзор литературы, сбор и анализ литературных источников, написание текста и редактирование статьи; Л.И. Ложкина — обзор литературы, сбор и анализ литературных источников, написание текста и редактирование статьи; С.И. Малявская — написание текста и редактирование статьи. Все авторы подтверждают соответствие своего авторства международным критериям ICMJE (все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией).

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