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Nutritional hygiene of adolescents and prevention of alimentary-dependent diseases: Biological value of the diet, iron-deficiency anemia, endemic goiter, and prevalence of overweight and obesity among adolescents in Andijan

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Abstract. Adolescent nutritional hygiene is a cornerstone of preventive medicine, as rapid pubertal growth and cognitive maturation require diets of high biological value rich in complete proteins, bioavailable iron, and iodine. In rapidly urbanizing cities of the Fergana Valley such as Andijan, adolescents increasingly experience a dual burden of malnutrition, characterized by persistent micronutrient deficiencies alongside rising rates of overweight and obesity. This article synthesizes national nutrition surveillance data from Uzbekistan, regional Fergana Valley biogeochemical and thyroid studies, and international pediatric nutrition evidence to examine the biological value of adolescent diets and the epidemiology of iron-deficiency anemia, endemic goiter, and excess body weight. Findings indicate that replacing animal-source proteins and diverse whole foods with energy-dense, ultra-processed snacks and sugar-sweetened beverages lowers dietary amino acid and micronutrient density while driving adiposity, with more than 25 percent of adolescents in Uzbekistan now affected by overweight or obesity, particularly among boys. Simultaneously, despite mandatory salt iodization, median urinary iodine levels in the Fergana Valley remain suboptimal (85 µg/L, with 63.4 percent below 100 µg/L), sustaining endemic goiter risk, while iron-deficiency anemia remains a leading cause of non-fatal disability among adolescent girls. Strengthening school nutrition environments, staple food fortification, and targeted micronutrient prophylaxis is essential for preventing alimentary-dependent morbidity.

Keywords: Nutritional hygiene, adolescent diet, biological value, iron-deficiency anemia, endemic goiter, iodine deficiency, overweight and obesity, Andijan, Fergana Valley.

O‘smirlarning ovqatlanish gigiyenasi va alimentarga bog‘liq kasalliklar profilaktikasi: Andijon shahri o‘smirlari ratsionining biologik qiymati, temir tanqisligi anemiyasi, endemik buqoq va ortiqcha vazn (semizlik) tarqalishi

Annotatsiya. O‘smirlarning ovqatlanish gigiyenasi profilaktik tibbiyotning asosiy yo‘nalishlaridan biri bo‘lib, pubertat davridagi jadal o‘sish va aqliy yetilish yuqori biologik qiymatga ega oqsillar, temir hamda yodga boy ratsionni talab qiladi. Farg‘ona vodiysining Andijon shahri kabi jadal urbanizatsiyalashayotgan hududlarida o‘smirlar orasida mikronutriyent tanqisligi bilan bir qatorda ortiqcha vazn va semizlikning ortib borishi bilan tavsiflanuvchi ikki tomonlama ovqatlanish yuki kuzatilmoqda. Ushbu maqolada O‘zbekiston milliy ovqatlanish tadqiqotlari, Farg‘ona vodiysidagi yod ta’minoti ko‘rsatkichlari va xalqaro pediatrik adabiyotlar asosida o‘smirlar ratsionining biologik qiymati hamda temir tanqisligi anemiyasi, endemik buqoq va semizlik tarqalishi tahlil qilingan. Natijalar shuni ko‘rsatadiki, O‘zbekistonda o‘smirlarning 25 foizdan ortig‘ida, ayniqsa o‘g‘il bolalarda ortiqcha vazn va semizlik qayd etilmoqda, bu esa tez tayyorlanadigan va shirin ichimliklar iste’moli ortishi bilan bog‘liq. Shu bilan birga, Farg‘ona

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vodiysida yodlangan tuz qonunchiligiga qaramay, siydikdagi yod konsentratsiyasi ko‘pchilik tekshirilganlarda 100 mkg/L dan past bo‘lib qolmoqda, qizlar orasida esa temir tanqisligi anemiyasi dolzarbligini saqlamoqda.

Kalit so‘zlar: Ovqatlanish gigiyenasi, o‘smirlar ratsioni, biologik qiymat, temir tanqisligi anemiyasi, endemik buqoq, yod tanqisligi, ortiqcha vazn va semizlik, Andijon.

Гигиена питания подростков и профилактика алиментарно-зависимых заболеваний: биологическая ценность рациона, распространенность железодефицитной анемии, эндемического зоба и избыточной массы тела (ожирения) среди подростков города Андижана

Аннотация: Гигиена питания подростков занимает ключевое место в профилактической медицине, поскольку интенсивный пубертатный рост требует рациона с высокой биологической ценностью, полноценным белком, биодоступным железом и йодом. В быстро урбанизирующихся городах Ферганской долины, включая Андижан, среди подростков формируется двойное бремя неполноценного питания: сочетание дефицита микронутриентов с ростом избыточной массы тела и ожирения. В статье на основе данных национальных исследований в Узбекистане, региональных биогеохимических оценок по Ферганской долине и международных обзоров проанализированы биологическая ценность рациона, железодефицитная анемия, эндемический зоб и ожирение у подростков. Показано, что более 25% подростков в стране имеют избыточный вес или ожирение, особенно среди мальчиков, на фоне роста потребления ультрапереработанных продуктов. При этом в Ферганской долине у 63,4% обследованных сохраняется недостаточная обеспеченность йодом (медиана 85 мкг/л), а среди девочек-подростков высокой остается значимость железодефицитной анемии.

Ключевые слова: Гигиена питания, рацион подростков, биологическая ценность, железодефицитная анемия, эндемический зоб, йододефицит, избыточная масса тела, Андижан.

INTRODUCTION

Adolescence represents a critical developmental window during which nutritional intake directly governs linear skeletal growth, muscle mass accretion, endocrine maturation, neurocognitive performance, and long-term metabolic health [2, 5]. Because adolescents aged 10 to 19 years undergo the second fastest period of somatic growth after infancy, their physiological requirements for high-biological-value protein, essential amino acids, iron, iodine, zinc, and vitamins rise substantially [5, 6]. When daily diets fail to satisfy these heightened metabolic demands, or when caloric excess replaces nutrient density, adolescents develop alimentary-dependent disorders that compromise both current academic capacity and future adult productivity [1, 4].

Globally and across Central Asia, adolescent nutrition has entered a complex epidemiological transition characterized by the coexistence of micronutrient undernutrition and rising overweight and obesity [2, 3, 10]. Recent global surveillance by UNICEF highlights that for the first time in history, obesity now exceeds underweight among school-age children and adolescents worldwide, driven by aggressive marketing of ultra-processed foods, sugar-sweetened beverages, and sedentary urban lifestyles [10]. Within Uzbekistan, rapid urbanization and transformations in the school food environment have produced similar shifts, particularly in densely populated cities such as Andijan in the Fergana Valley [2, 3]. Adolescents in urban

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IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

secondary schools and vocational colleges increasingly substitute home-cooked, nutrient-dense meals with refined carbohydrates, fried street snacks, and sweetened drinks, elevating energy intake while eroding dietary biological value [3, 5].

Simultaneously, traditional biogeochemical and dietary vulnerabilities persist across the Fergana Valley. Continental mountain-valley ecosystems in Central Asia are historically iodine-poor, placing children and adolescents at elevated risk of endemic goiter and subclinical hypothyroidism unless universal salt iodization is rigorously maintained [7, 8]. Moreover, iron-deficiency anemia remains one of the leading global causes of healthy years lost due to disability among adolescents aged 10–19 years, disproportionately affecting adolescent girls following menarche when dietary heme iron intake is insufficient [1, 4]. Understanding how dietary biological value interacts with these three major alimentary-dependent conditions—iron-deficiency anemia, endemic goiter, and overweight or obesity—is essential for designing effective regional medical prevention strategies [2, 3].

The objective of this literature review is to evaluate the hygienic determinants of adolescent nutrition in Uzbekistan and the Fergana Valley context, examining the biological value of contemporary adolescent diets alongside the prevalence, pathophysiological drivers, and preventive strategies for iron-deficiency anemia, endemic goiter, and overweight and obesity.

Dietary behavior patterns such as skipping breakfast, irregular meal timing, and late-evening snacking further exacerbate nutritional imbalances during secondary school years [2, 3]. Adolescents who forego morning meals frequently compensate with high-glycemic, low-protein snacks between classes, triggering postprandial glycemic fluctuations, mid-day fatigue, and progressive visceral fat accumulation while failing to meet daily micronutrient targets [3, 5].

MATERIALS AND METHODS

This study was conducted as a structured narrative and analytical literature review formatted according to IMRAD scientific reporting standards. A comprehensive search of peer-reviewed biomedical databases and national public health assessments was performed, encompassing UNICEF Uzbekistan reports on adolescent nutrition and school food environments, World Health Organization (WHO) adolescent health and micronutrient guidelines, the Global Nutrition Report for Uzbekistan, recent Fergana Valley iodine-status clinical evaluations, and PubMed Central (PMC) reviews on pediatric protein biological value and large-scale food fortification [1, 2, 3, 4, 5, 6, 7, 8].

Sources were selected for inclusion if they provided quantitative data on adolescent dietary composition and protein biological value, national or Central Asian prevalence estimates of overweight and obesity among school-age adolescents, epidemiological or clinical biomarkers of iron-deficiency anemia and iodine deficiency (urinary iodine concentration and goiter), or policy evaluations of school meal programs and staple food fortification [2, 3, 4, 5, 7]. Studies restricted exclusively to infant breastfeeding, hospitalized geriatric malnutrition, or rare inborn errors of metabolism were excluded from the primary synthesis.

Extracted findings were organized across three core hygienic domains. The first domain evaluated the biological value of adolescent diets, comparing amino acid completeness, digestibility, and micronutrient bioavailability of animal-source versus predominantly plant- or refined-grain-based rations. The second domain analyzed the epidemiological burden and risk factors of iron-deficiency anemia and endemic goiter in Uzbekistan and the Fergana Valley. The third domain examined the rapid rise of adolescent overweight and obesity within changing school food environments and outlined integrated preventive interventions.

In interpreting regional nutritional indicators, special attention was paid to distinguishing between absolute caloric insufficiency and hidden hunger, wherein adolescents exhibit normal or

ISSN: 2224-6878 | Pakistan Volume 6, No. 11.

IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

elevated body mass index alongside biochemical depletion of iron, iodine, and essential trace elements [4, 7, 11]. Synthesizing clinical biomarker thresholds—including WHO urinary iodine cutoffs below 100 µg/L and age-sex hemoglobin norms—with school food-environment audits enabled a holistic hygienic appraisal [2, 7].

RESULTS

Evaluating the biological value (BV) of the adolescent diet provides a foundational metric for assessing nutritional adequacy beyond simple caloric sufficiency [5, 6]. Contemporary pediatric nutrition reviews define dietary protein quality by essential amino acid composition, digestibility, and accompanying micronutrient bioavailability [5]. International dietary reference guidelines recommend daily protein intakes of approximately 0.95 g/kg body weight for children aged 4–13 years and 0.85 g/kg/day (specifically 0.75 g/kg/day for females and 0.84 g/kg/day for males) for adolescents aged 14–18 years, increasing further during active sports participation [5, 6]. Animal-based proteins—including meat, dairy products, eggs, and fish—deliver high biological value with all nine essential amino acids alongside highly bioavailable heme iron, vitamin B12, zinc, selenium, riboflavin, vitamin D, and iodine [5]. Conversely, adolescent diets dominated by refined wheat bread, pastries, and plant-based staples with limited animal-source foods exhibit lower protein digestibility, incomplete amino acid profiles, and high phytate content that inhibits non-heme iron and zinc absorption [5, 6].

National and regional surveillance data from Uzbekistan demonstrate that shifts in school and household food environments directly compromise this dietary biological value [2, 3]. In 2026, complementary national assessments conducted by UNICEF and the Government of Uzbekistan—specifically the School Nutrition Environment Assessment (NEATs) and the National Adolescent Nutrition Survey—documented widespread availability and consumption of ultra-processed foods, sugar-sweetened beverages, and high-calorie, nutrient-poor snacks among school-age adolescents [2, 3]. Replacing balanced protein- and vegetable-rich meals with energy-dense snacks creates a paradoxical nutritional state in which total caloric intake meets or exceeds requirements while essential micronutrient and high-BV protein intake falls short [3, 5].

This nutritional imbalance is reflected in the rapidly escalating prevalence of overweight and obesity among Uzbek adolescents [2, 3, 9]. According to emerging national survey findings reported at the 2026 National Expert Dialogue on School Nutrition in Uzbekistan, more than 25 percent of adolescents are now overweight or obese, with a particularly pronounced prevalence among adolescent boys [2]. Situation analyses further confirm that adolescent overweight in Uzbekistan mirrors global trends, where over one in six adolescents aged 10–19 years is overweight and only one in five meets WHO daily physical activity guidelines [1, 9]. Excess adiposity established during adolescence strongly predicts persistence of obesity into adulthood, elevating early risks of insulin resistance, hypertension, and metabolic dysfunction-associated steatotic liver disease [2, 3].

At the opposite pole of the dual malnutrition burden, iron-deficiency anemia (IDA) remains a major public health concern, particularly among adolescent girls [1, 4]. WHO global health surveillance identifies iron-deficiency anemia as one of the leading causes of years lost due to disability among adolescents aged 10–19 years [1]. In Central Asia and Uzbekistan, adolescent anemia is driven by a convergence of inadequate dietary heme iron, high consumption of tea polyphenols and phytates with meals that block intestinal iron uptake, and increased physiological iron losses following menarche in girls [4, 5, 8]. Without adequate iron stores, adolescents experience impaired hemoglobin synthesis, chronic fatigue, reduced physical endurance, diminished immune competence, and measurable deficits in cognitive concentration and school performance [4, 6].

ISSN: 2224-6878 | Pakistan Volume 6, No. 11.

IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

Equally significant in the Fergana Valley—including Andijan—is the persistent challenge of iodine deficiency and endemic goiter [7, 8]. Although Uzbekistan enacted mandatory legislation for universal salt iodization [8], recent clinical-epidemiological monitoring indicates that population iodine sufficiency remains uneven across the Fergana Valley [7]. In a 2025–2026 Fergana region cross-sectional evaluation measuring spot morning urinary iodine concentration (UIC) alongside thyroid ultrasonography and hormone profiling, median UIC was only 85 µg/L—falling below the WHO sufficiency threshold of 100 µg/L—with 63.4 percent of examined participants exhibiting biochemical iodine deficiency (ranging from 58.6 to 70.4 percent across surveyed districts) and demonstrating dose-dependent reductions in thyroid function [7]. Complementing this finding, trace-element analyses of Central Asian university entrants confirm that regional geochemical conditions predispose adolescents and young adults to suboptimal iodine, iron, zinc, and selenium reserves [11].

Together, these data illustrate how declining dietary biological value, inadequate micronutrient fortification coverage, and energy-dense school snacking interact to sustain a triad of alimentary-dependent morbidity among adolescents in urban centers such as Andijan: iron-deficiency anemia in pubertal girls, subclinical iodine insufficiency and endemic goiter across both sexes, and rapidly rising overweight and obesity led by adolescent boys [2, 3, 7, 9].

A closer biochemical examination of regional dietary habits explains why iron-deficiency anemia and subclinical iodine insufficiency persist even where total caloric intake is adequate or excessive [4, 5, 7]. In traditional Central Asian household diets, black or green tea is routinely consumed alongside or immediately after meals; tea polyphenols and grain phytates form insoluble complexes with non-heme dietary iron in the intestinal lumen, sharply reducing iron bioavailability [4, 5]. Meanwhile, inadequate intake of heme-rich red meat, poultry, or fish—combined with reliance on refined bakery products—leaves adolescent girls particularly vulnerable to depleted serum ferritin stores long before clinical pallor or overt hemoglobin decline becomes apparent [4, 5].

Similarly, mild-to-moderate iodine deficiency exerts subtle yet clinically important effects on adolescent thyroid homeostasis and neurocognitive capacity [4, 7]. When median urinary iodine falls below 100 µg/L, the thyroid gland compensates by increasing iodine trapping and undergoing diffuse follicular hyperplasia, manifesting clinically as endemic goiter [4, 7]. Over time, sustained iodine insufficiency lowers circulating free thyroxine levels and elevates thyroid-stimulating hormone, contributing to sluggish basal metabolism, fatigue, impaired memory consolidation, and heightened susceptibility to weight gain [4, 7]. Addressing both iron and iodine deficits simultaneously is therefore critical because iron deficiency itself impairs thyroid peroxidase activity, blunting the physiological response to iodine supplementation [4, 5].

In addition to iron and iodine, suboptimal dietary biological value compromises skeletal mineralization and linear growth during puberty [5, 6]. Adequate dairy, egg, and fish intake provides bioavailable calcium, vitamin D, and sulfur-containing amino acids required for peak bone mass accrual, whereas diets skewed toward sweetened beverages displace milk and dairy consumption and increase urinary calcium loss [5, 10]. Consequently, adolescents experiencing rapid weight gain from ultra-processed foods may paradoxically harbor concurrent micronutrient and bone-mineral deficits [3, 5].

Furthermore, longitudinal pediatric evidence demonstrates that balanced protein-energy supplementation during growth-sensitive periods improves lean body mass and reduces stunting without inducing excess fat mass index when paired with physical activity [5, 6]. Conversely, diets dominated by simple sugars and saturated fats stimulate hyperinsulinemia and visceral

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adipogenesis while leaving essential amino acid and trace-element pathways under-supplied [3, 5, 10].

DISCUSSION

The coexistence of micronutrient deficiencies and excess body weight among adolescents in Andijan and across Uzbekistan underscores the urgency of modernizing school nutritional hygiene and preventive health services [2, 3]. Historically, public health nutrition programs focused predominantly on undernutrition in children under five years of age and pregnant women, leaving school-age adolescents aged 10–19 years underserved [3, 9]. However, as UNICEF's 2026 Uzbekistan nutrition assessments demonstrate, adolescence is precisely the stage when independent food purchasing outside the home surges and lifelong dietary habits solidify [2, 3].

Improving the biological value of adolescent rations in Andijan requires a coordinated shift in both school catering and family nutrition education [2, 5]. School canteens must be structured around balanced meal standards that guarantee adequate daily portions of complete animal-source proteins—such as lean meat, poultry, eggs, fish, and fermented dairy products—paired with legumes, whole grains, fresh vegetables, and seasonal fruits [5]. Ensuring that at least half of daily protein intake originates from high-BV sources safeguards essential amino acid availability for pubertal muscle and bone growth while naturally enhancing bioavailable iron, zinc, and vitamin B12 intake [5, 6]. Simultaneously, restricting the sale of sugar-sweetened beverages, ultra-processed pastries, and high-sodium snacks within school buffets is essential to curb the >25 percent adolescent overweight and obesity trajectory [2, 3].

Addressing endemic goiter and iron-deficiency anemia in the Fergana Valley additionally demands rigorous enforcement of large-scale food fortification and targeted clinical prophylaxis [4, 7, 8]. Because median urinary iodine levels in Fergana Valley cohorts remain below 100 µg/L despite mandatory salt iodization laws [7, 8], sanitary-epidemiological surveillance services must strengthen quality-control testing of iodized salt at retail markets, bakeries, and school kitchens, while educating families to store iodized salt in sealed, light-protected containers to prevent iodine volatilization [4, 7]. In parallel, ensuring consistent compliance with iron and folic acid fortification of wheat flour—coupled with intermittent iron-folic acid supplementation and hemoglobin screening for adolescent girls in secondary schools—offers a proven, cost-effective strategy to eliminate iron-deficiency anemia [1, 4].

Finally, effective prevention of alimentary-dependent diseases cannot rely solely on dietary modifications without addressing physical activity and nutrition literacy [1, 2]. With four out of five adolescents globally failing to meet WHO physical activity targets, expanding structured school sports, active recess, and community recreation in Andijan is indispensable for balancing energy expenditure and preventing adolescent obesity [1, 2]. Integrating practical nutrition education into biology and health curricula—teaching adolescents to evaluate food labels, separate tea consumption from iron-rich meals, and choose nutrient-dense snacks—empowers young people to protect their own metabolic and endocrine health [3, 5].

Future prospective hygienic and clinical studies specifically sampling secondary school and college adolescents in Andijan city are needed to quantify local 24-hour dietary recall profiles, serum ferritin and urinary iodine concentrations, thyroid ultrasound volumes, and BMI-for-age z-scores across 10–14 and 15–17 age strata [2, 7]. Such empirical baseline data will allow regional medical prevention departments to tailor school meal menus and micronutrient supplementation protocols to the exact nutritional gaps of Andijan's youth.

From an institutional prevention standpoint, schools and vocational colleges in Andijan represent the most equitable platform for delivering integrated nutritional interventions [2, 3]. Because adolescents spend a major portion of their day at school, upgrading school canteen

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IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

menus to include fortified wheat-flour products, iodized salt, daily fermented dairy, and fresh seasonal produce reaches youth across all socioeconomic strata [2, 4]. Simultaneously, establishing clear municipal standards that restrict ultra-processed snacks and sugar-sweetened beverages within and immediately surrounding school premises directly counters obesogenic dietary triggers [2, 3, 10].

Equally important is aligning preventive medical checkups with early biochemical and anthropometric screening [1, 7]. Annual school health evaluations should combine BMI-for-age z-score tracking with targeted hemoglobin screening for adolescent girls, thyroid palpation or ultrasonography in high-risk districts, and brief dietary diversity assessments [1, 7, 9]. By identifying subclinical iron depletion, early thyroid enlargement, and rapid weight gain before irreversible metabolic or endocrine complications develop, primary healthcare and medical prevention teams can safeguard the long-term health and academic potential of Andijan's adolescent population [2, 4].

Sustaining these gains over the long term requires coordinated governance across public health, education, agriculture, and municipal food-safety agencies, as emphasized in Uzbekistan's national school nutrition dialogues [2]. When school meal standards, staple fortification oversight, and family nutrition counseling operate in tandem, communities in Andijan and throughout the Fergana Valley can decisively curb anemia, endemic goiter, and adolescent obesity simultaneously [2, 4, 7].

Additionally, training school nurses and medical prevention specialists in standardized anthropometric and dietary assessment methods ensures consistent data quality across urban and peri-urban districts [2, 3]. Incorporating simple dietary diversity checklists and periodic iodized-salt rapid spot testing during routine school sanitary inspections strengthens accountability and enables rapid corrective action whenever nutritional indicators deteriorate [4, 7, 8].

Engaging parents alongside adolescents through community health outreach in Andijan neighborhoods reinforces healthy home cooking practices, such as preparing iron-rich legumes and meats with vitamin C-containing vegetables rather than pairing meals with strong tea [4, 5]. Together, school-level policy reforms and household nutritional literacy form a resilient defense against alimentary-dependent disease [2, 3].

CONCLUSION

Adolescent nutritional hygiene in Andijan and across Uzbekistan faces a dual challenge defined by declining dietary biological value and rising alimentary-dependent morbidity. While ultra-processed, energy-dense school food environments have driven adolescent overweight and obesity above 25 percent—particularly among boys—persistent micronutrient gaps continue to sustain iron-deficiency anemia in adolescent girls and widespread biochemical iodine insufficiency in the Fergana Valley despite salt iodization legislation. Preventing these conditions requires a comprehensive, multisectoral approach that combines nutritious, high-biological-value school meals, strict restrictions on unhealthy snacks and sugary drinks, rigorous quality monitoring of iodized salt and fortified flour, targeted iron-folic acid prophylaxis, and regular physical activity alongside nutrition education.

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