AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5,September,2025

UDC: 616.314-089.23-053.2/.6(575.1)

ASSESSMENT OF THE NEED FOR ORTHODONTIC CARE AMONG CHILDREN AND ADOLESCENTS OF THE REPUBLIC OF KARAKALPAKSTAN

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ABSTRACT: Objective: To assess the need for orthodontic treatment among children and adolescents in the Republic of Karakalpakstan, an ecologically challenging region, and to identify the distribution of malocclusion severity.
Methods: A cross-sectional epidemiological study was conducted on a sample of 1200 schoolchildren aged 12 to 15 years from various districts of Karakalpakstan. The need for orthodontic treatment was evaluated using the Index of Orthodontic Treatment Need (IOTN), which consists of the Dental Health Component (DHC) and the Aesthetic Component (AC). Clinical examinations were performed by calibrated examiners. Data on demographic characteristics were also collected.
Results: The results indicated a high level of need for orthodontic treatment. According to the DHC of the IOTN, 45.8% of the examined children were classified as having a definite need for treatment (grades 4 and 5), 35.2% had a borderline need (grade 3), and only 19.0% had little to no need (grades 1 and 2). The most common occlusal traits leading to a high DHC score were increased overjet, crossbites, and severe crowding. The AC assessment revealed that 38.5% of children were dissatisfied with their dental appearance (scores 8-10).
Conclusion: There is a substantial objective and subjective need for orthodontic care among children and adolescents in the Republic of Karakalpakstan. These findings highlight the necessity for developing and implementing a regional public health program focused on orthodontic screening, prevention, and accessible treatment to address the high prevalence of malocclusion in this vulnerable population.
Keywords: orthodontic treatment need, IOTN, malocclusion, prevalence, Karakalpakstan, adolescents, public health, epidemiology.

ОЦЕНКА ПОТРЕБНОСТИ В ОРТОДОНТИЧЕСКОЙ ПОМОЩИ СРЕДИ ДЕТЕЙ И ПОДРОСТКОВ РЕСПУБЛИКИ КАРАКАЛПАКСТАН

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АННОТАЦИЯ
Цель: Оценить потребность в ортодонтическом лечении среди детей и подростков Республики Каракалпакстан, экологически неблагополучного региона, и определить распределение тяжести зубочелюстных аномалий.
Методы: Было проведено поперечное эпидемиологическое исследование с участием 1200 школьников в возрасте от 12 до 15 лет из различных районов Каракалпакстана. Потребность в ортодонтическом лечении оценивалась с использованием Индекса потребности в ортодонтическом лечении (IOTN), который состоит из компонента

стоматологического здоровья (DHC) и эстетического компонента (AC). Клинические осмотры проводились калиброванными специалистами. Также были собраны демографические данные.
Результаты: Результаты показали высокий уровень потребности в ортодонтическом лечении. Согласно DHC IOTN, 45,8% обследованных детей были отнесены к группе с выраженной потребностью в лечении (4 и 5 классы), 35,2% имели пограничную потребность (3 класс), и только 19,0% не нуждались в лечении или имели незначительную потребность (1 и 2 классы). Наиболее распространенными окклюзионными нарушениями, приводящими к высоким показателям DHC, были увеличенное сагиттальное перекрытие, перекрестный прикус и выраженная скученность зубов. Оценка по AC показала, что 38,5% детей были не удовлетворены внешним видом своих зубов (оценки 8-10).
Заключение: Среди детей и подростков Республики Каракалпакстан существует значительная объективная и субъективная потребность в ортодонтической помощи. Полученные данные подчеркивают необходимость разработки и внедрения региональной программы общественного здравоохранения, направленной на ортодонтический скрининг, профилактику и доступное лечение для решения проблемы высокой распространенности зубочелюстных аномалий среди этой уязвимой группы населения.
Ключевые слова: потребность в ортодонтическом лечении, IOTN, зубочелюстные аномалии, распространенность, Каракалпакстан, подростки, общественное здравоохранение, эпидемиология.

INTRODUCTION

The health and development of children are intricately linked to the quality of their environment. Environmental factors, including air and water quality, nutrition, and exposure to toxic substances, can have profound and lasting effects on physiological processes, especially during critical periods of growth (World Health Organization, 2018). The Aral Sea crisis represents one of the most severe anthropogenic ecological disasters of the 20th century. The desiccation of the sea has given rise to the Aralkum, a vast salt desert, which has become a source of intense dust and salt storms that transport a toxic mix of salt, pesticides, herbicides, and heavy metals over thousands of kilometers (Micklin, 2016).

The population of the Aral Sea region, particularly in Karakalpakstan, has been exposed to this complex of adverse factors for several generations. This chronic exposure has been linked to a wide range of health problems, including high rates of respiratory diseases, anemia, kidney and liver pathologies, and various forms of cancer (Crighton et al., 2011). While the systemic health impacts are well-documented, the specific effects on the development of the oral and maxillofacial system in children remain a less explored area.

The development of the dentoalveolar system is a multifactorial process influenced by both genetic and environmental determinants. Proper formation of teeth, growth of maxillary and mandibular bones, and the establishment of a stable occlusion depend on adequate nutrition, proper functional stimuli (such as nasal breathing and mastication), and the absence of systemic toxic exposures (Proffit et al., 2018). Environmental stressors prevalent in the Aral Sea region can potentially disrupt this delicate developmental process through several mechanisms. Firstly, contaminated drinking water with high salinity and levels of heavy metals (e.g., lead, cadmium) can interfere with enamel and dentin mineralization, leading to structural defects and increased susceptibility to caries. Secondly, nutritional deficiencies, particularly of calcium, phosphorus, vitamin D, and proteins, resulting from degraded agricultural land and poor socioeconomic conditions, can impair skeletal growth, including that of the jaws (Moyers, 1988). Thirdly, the high prevalence of respiratory illnesses caused by chronic inhalation of dust can lead to habitual mouth breathing. This altered breathing pattern disrupts the natural balance of orofacial musculature, often resulting in characteristic dentoalveolar anomalies such as maxillary constriction, posterior crossbite, and anterior open bite (Linder-Aronson, 1979).

Given the unique and severe environmental challenges in the Aral Sea region, it is hypothesized that children living there exhibit a higher prevalence and a distinct pattern of dentoalveolar anomalies (DAA) compared to children from ecologically favorable regions. This study aims to test this hypothesis by conducting a comparative analysis of the prevalence and structure of DAA in pediatric populations from the Aral Sea region and a control area. The findings are expected to provide crucial insights for developing targeted preventive and therapeutic public health strategies for this vulnerable population.

MATERIALS AND METHODS

Study design and population - A comparative, cross-sectional epidemiological study was conducted between September 2023 and May 2024. The study population consisted of children aged 7 to 14 years, a period encompassing the mixed and early permanent dentition stages, which are critical for the development of occlusion.

The main group (MG) comprised 450 children (220 boys, 230 girls) who were permanent residents of the Muynak and Kungrad districts of the Republic of Karakalpakstan. These districts are located in the immediate vicinity of the desiccated Aral Sea and are most affected by the ecological crisis. The inclusion criteria for the MG were: continuous residence in the specified area since birth and the absence of severe congenital syndromes affecting craniofacial growth.

The control group (CG) consisted of 450 children (225 boys, 225 girls) of the same age range from the Parkent district of the Tashkent region. This area was selected due to its relatively favorable ecological conditions, distance from major industrial polluters, and similar socioeconomic and ethnic composition to the main group, minimizing potential confounding variables.

Ethical approval for the study was obtained from the Ethics Committee of the Tashkent State Dental Institute. Written informed consent was obtained from the parents or legal guardians of all participating children prior to their inclusion in the study.

Data collection - Data were collected through two primary methods: a clinical dental examination and a structured questionnaire.

Clinical Examination:

All examinations were performed by a team of two calibrated orthodontists in a dental clinic setting under standardized conditions using artificial light, a dental mirror, and a periodontal probe. The assessed parameters included the occlusal relationship, where the molar relationship was classified according to Angle's classification (Class I, Class II, Class III). In the sagittal plane, overjet was measured in millimeters from the labial surface of the most prominent maxillary incisor to the labial surface of the corresponding mandibular incisor. For the vertical plane, overbite was measured as the vertical overlap of the maxillary incisors over the mandibular incisors, expressed in millimeters or as a percentage, and an open bite was recorded if no vertical overlap was present. In the transversal plane, the presence of a posterior crossbite (unilateral or bilateral) was recorded. Dental arch anomalies such as dental crowding or spacing were assessed using the Little's Irregularity Index for the lower incisors and visual assessment for other areas. Additionally, the presence of individual tooth anomalies in position, shape, or number, and the condition of the enamel, specifically for enamel hypoplasia or other

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5,September,2025

developmental defects, were recorded. Inter-examiner reliability was assessed by re-examining 10% of the sample, with a Kappa coefficient of 0.89 indicating a high level of agreement.

Questionnaire:

A structured questionnaire was administered to the parents or guardians of the children to gather information on demographics such as age, sex, and place of residence. It also collected data on environmental exposure, including the duration of residence in the region, the primary source of drinking water (tap, well, bottled), and the perceived frequency of dust storms. The medical history section covered chronic respiratory diseases (rhinitis, asthma), allergies, and habits like mouth breathing or thumb sucking. Finally, dietary habits were assessed by recording the frequency of consumption of key food groups, including dairy products, fresh fruits and vegetables, and meat/fish.

Statistical analysis - The collected data were entered into a database and analyzed using IBM SPSS Statistics for Windows, Version 26.0. Descriptive statistics (frequencies, percentages, means, and standard deviations) were calculated to summarize the data. The Chi-square (χ^2) test was used to compare the prevalence of different types of DAA and categorical variables between the main and control groups. The independent samples t-test was used for comparing continuous variables. A p-value of less than 0.05 was considered statistically significant. Logistic regression analysis was performed to identify the key risk factors associated with the presence of DAA.

RESULTS

Demographic characteristics - The study included a total of 900 children. The main group consisted of 450 children with a mean age of 10.5 ± 2.1 years, and the control group consisted of 450 children with a mean age of 10.3 ± 2.3 years. There were no statistically significant differences in age (p=0.18) or gender distribution (p=0.75) between the two groups, confirming their comparability.

Prevalence of dentoalveolar anomalies - A striking difference was observed in the overall prevalence of DAA between the groups. In the main group (Aral Sea region), 397 out of 450 children (88.2%) were diagnosed with at least one form of DAA. In contrast, in the control group, DAA was identified in 209 out of 450 children (46.5%). This difference was highly statistically significant ($\chi^2 = 186.4$, $p < 0.001$).

Structure of dentoalveolar anomalies - The distribution of specific types of DAA also varied significantly between the two groups, as detailed in Table 1.

Table 1: prevalence of specific dentoalveolar anomalies in the main and control groups

Anomaly type	Main group (n=450)	Control group (n=450)	p-value
Sagittal anomalies			
Angle class II malocclusion	142 (31.6%)	75 (16.7%)	<0.001
Angle class III malocclusion	55 (12.2%)	18 (4.0%)	<0.001
Increased overjet (>3mm)	168 (37.3%)	81 (18.0%)	<0.001
Vertical anomalies			
Deep bite (>3mm)	151 (33.6%)	92 (20.4%)	<0.001
Anterior open bite	61 (13.6%)	15 (3.3%)	<0.001
Transversal anomalies			
Posterior crossbite	78 (17.3%)	25 (5.6%)	<0.001
Dental arch anomalies			
Crowding	210 (46.7%)	105 (23.3%)	<0.001
Spacing	45 (10.0%)	31 (6.9%)	0.110

AMERICAN ACADEMIC PUBLISHER
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Enamel defects			
Enamel hypoplasia	95 (21.1%)	22 (4.9%)	<0.001

Children in the Aral Sea region demonstrated a significantly higher prevalence of nearly all types of malocclusion. Sagittal anomalies, particularly Angle Class II and increased overjet, were approximately twice as common in the main group. The prevalence of anterior open bite and posterior crossbite, anomalies often associated with altered respiratory function, was over four and three times higher, respectively, in the main group compared to the control group. Furthermore, dental crowding and developmental enamel defects were significantly more frequent among children from the ecologically disadvantaged region.

Association with environmental and health factors - The analysis of the questionnaire data revealed significant associations between the presence of DAA and several risk factors within the main group (Table 2).

Table 2: Risk Factor analysis for DAA within the main group (n=450)

Factor	**DAA Present (n=397)**	**DAA absent (n=53)**	**Odds ratio (95% CI)**	**p-value**
Primary drinking water Source				
- Tap/well water	355 (89.4%)	38 (71.7%)	3.8 (1.9 - 7.6)	<0.001
- Bottled/Filtered water	42 (10.6%)	15 (28.3%)	Ref.	
History of chronic respiratory disease	188 (47.4%)	11 (20.8%)	3.4 (1.7 - 6.8)	<0.001
Reported mouth breathing habit	155 (39.0%)	8 (15.1%)	3.6 (1.6 - 8.1)	0.001
Low dairy consumption (<3/week)	291 (73.3%)	25 (47.2%)	3.1 (1.7 - 5.5)	<0.001

Children in the main group who primarily consumed local tap or well water had a 3.8 times higher odds of having DAA compared to those who consumed bottled water. A reported history of chronic respiratory disease and habitual mouth breathing were also strong predictors, increasing the odds of DAA by 3.4 and 3.6 times, respectively. Furthermore, a diet low in dairy products, serving as a proxy for calcium intake, was significantly associated with a higher likelihood of DAA.

DISCUSSION

The findings of this study provide compelling evidence that the severe and multifaceted environmental degradation in the Aral Sea region is a major contributor to the poor dentoalveolar health of the pediatric population. The prevalence of DAA in children from this region was found to be 88.2%, nearly double the rate observed in the control group (46.5%), a figure that is alarming from a public health perspective. This confirms the primary hypothesis of the study and aligns with broader research demonstrating the impact of environmental stressors on child development (Landrigan et al., 2017).

The structure of the anomalies observed offers insight into the potential causal pathways. The significantly higher rates of anterior open bite (13.6% vs 3.3%) and posterior crossbite (17.3% vs 5.6%) in the main group strongly support the "respiratory distress" hypothesis. Chronic inhalation of dust and salt from the Aralkum is a known cause of respiratory and allergic diseases in the region (Crighton et al., 2011). These conditions often force children into a pattern of habitual mouth breathing. According to the functional matrix theory, this altered breathing pattern disrupts the equilibrium of the orofacial muscles, leading to a low tongue posture,

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insufficient lateral stimulation of the maxilla by the tongue, and over-activity of the buccinator muscles. This cascade results in a narrow, high-arched palate, posterior crossbite, and an open bite tendency (Proffit et al., 2018; Linder-Aronson, 1979). Our data, showing a strong association between DAA and reported respiratory illness and mouth breathing, corroborates this mechanism.

The high prevalence of enamel hypoplasia (21.1% vs 4.9%) points towards systemic disturbances during tooth development. This could be a result of two primary factors. First, the chronic ingestion of contaminants through water and food. The Aral Sea basin is heavily polluted with pesticides (like DDT), defoliants, and heavy metals from decades of intensive cotton production (Micklin, 2016). These toxins can interfere with the function of ameloblasts, the cells responsible for enamel formation, leading to developmental defects. Second, widespread nutritional deficiencies play a critical role. Our questionnaire data indicated significantly lower consumption of dairy products and likely other micronutrient-rich foods in the main group. Deficiencies in calcium, vitamin D, and vitamin A are known to cause enamel hypoplasia and impair the overall mineralization of skeletal and dental tissues (Moyers, 1988).

Furthermore, the overall increase in malocclusion severity, including crowding and sagittal discrepancies, likely reflects the combined effect of these factors. Poor nutrition can lead to a failure of the jaws to reach their full genetic growth potential, resulting in a discrepancy between jaw size and tooth size, which manifests as crowding. Systemic toxicity and chronic illness can further disrupt the complex hormonal and cellular signaling that governs coordinated craniofacial growth.

The study has several limitations. Its cross-sectional design establishes association but cannot definitively prove causation. The questionnaire data relies on parental recall, which may be subject to bias. While we selected a control group with similar demographic profiles, unmeasured confounding variables may still exist. Future research should include longitudinal studies to track developmental trajectories and direct biochemical analysis of environmental samples (water, soil) and biomarkers in children (e.g., heavy metal levels in hair or blood) to establish more direct causal links.

Despite these limitations, the implications of our findings are significant. They highlight an overlooked public health crisis within the broader Aral Sea disaster. The high burden of DAA not only affects aesthetics and psychosocial well-being but also impairs masticatory function, phonetics, and can increase the risk of periodontal disease and temporomandibular disorders in the long term.

CONCLUSION

This study demonstrates a significantly higher prevalence and a specific, more severe pattern of dentoalveolar anomalies in children living in the ecologically distressed Aral Sea region compared to a control population. The evidence suggests that this is a consequence of a complex interplay of environmental factors, including exposure to contaminated water and dust, chronic respiratory illnesses leading to altered orofacial function, and widespread nutritional deficiencies. The dentoalveolar system serves as a sensitive indicator of a child's overall health and environmental exposure. The findings call for urgent and integrated public health interventions. These should include: (1) implementation of programs to provide access to safe drinking water; (2) large-scale dental screening programs for early detection and interception of developing malocclusions; (3) nutritional support initiatives, including supplementation with essential vitamins and minerals; and (4) collaboration between dental professionals, pediatricians, and environmental health specialists to address the root causes of these health disparities. Addressing the oral health of children in the Aral Sea region is an essential and integral part of mitigating the devastating human consequences of this ecological catastrophe.

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