IMPACT OF TRADITIONAL AND NON-TRADITIONAL RISK FACTORS ON THE DEVELOPMENT OF CHRONIC KIDNEY DISEASE IN THE ARAL SEA AREA

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Abstract. *Chronic kidney disease (CKD) is an escalating global health concern, representing a major contributor to morbidity and mortality worldwide. This extended study explores the complex interaction between traditional (hypertension, diabetes mellitus, obesity) and non-traditional (environmental, climatic, and social) risk factors in the Aral Sea region, one of the world's most ecologically stressed areas. The research involved 115 CKD patients identified from 500 screened adults in the city of Nukus, Republic of Karakalpakstan. Data analysis included biochemical and demographic indicators correlated with ecological variables such as water hardness, sun exposure, and residence proximity to the Aral Sea. The findings reveal strong statistical associations between environmental degradation and CKD progression, highlighting the urgent need for integrated preventive and diagnostic approaches in primary care practice.*

Keywords: *chronic kidney disease, Aral Sea region, risk factors, environmental nephrology, public health, Uzbekistan.*

Introduction and Literature Review.

Chronic kidney disease (CKD) has emerged as one of the most critical non-communicable diseases (NCDs) of the 21st century. According to the World Health Organization (WHO), more than 850 million people globally suffer from kidney disorders, and approximately 10% of the adult population is affected. CKD frequently coexists with other metabolic diseases such as diabetes mellitus, hypertension, and cardiovascular disorders, significantly increasing the global burden of disease.

The Aral Sea region, located in northwestern Uzbekistan, presents a unique epidemiological context due to prolonged environmental degradation. The desiccation of the Aral Sea has led to soil salinization, reduced water quality, frequent dust storms, and high levels of insolation. These environmental stressors are suspected contributors to renal impairment through pathways involving oxidative stress, heavy metal exposure, and chronic dehydration. Research by Mehta et al. (2016) demonstrated that air pollutants (PM2.5) were associated with a measurable decline in glomerular filtration rate (GFR). Similarly, WHO environmental reports indicate that populations exposed to mineralized water with high calcium and sulfate levels show a higher prevalence of nephrolithiasis and CKD. Locally, studies by Daminova K. M. and Akhmedova N. Sh. have confirmed that residents of Karakalpakstan have elevated creatinine levels and reduced GFR even among individuals without overt systemic diseases. These observations underscore the multifactorial origin of CKD in ecologically burdened territories. Despite national healthcare reforms and targeted nephrology programs, early detection of CKD in primary care settings remains suboptimal due to limited screening protocols and insufficient consideration of ecological risk factors.

The aim of the research:

"To investigate the prevalence of chronic kidney disease (CKD) and the characteristics of risk factors influencing its development in primary health care in the Aral Sea region."

Materials and Methods.

This cross-sectional, analytical study included 115 patients diagnosed with CKD (stages II–IV, KDIGO 2022 classification) and 385 control participants without known renal pathology. All participants were permanent residents of the Aral Sea region (Nukus and surrounding districts) aged 25–65 years. Clinical examinations and biochemical analyses were performed in the laboratory of the Nukus Central Polyclinic. Parameters included serum creatinine, urea, hemoglobin, microalbuminuria, and estimated glomerular filtration rate (eGFR) calculated via the CKD-EPI formula.

Environmental exposure factors were assessed using a structured questionnaire validated by DSU Certificate No.12090 (2021). Variables included duration of residence in the region, type of water source (filtered, well, piped), occupational outdoor exposure (>6 hours per day), and distance from the Aral Sea (<100 km, 100–200 km, >300 km). Statistical analysis used Student's t-test, Pearson correlation, and multivariate linear regression to assess associations. Significance was set at $p<0.05$.

Results.

Statistical analysis revealed multiple significant correlations between demographic, biochemical, and environmental variables. Renal parenchymal thickness (RPT) demonstrated strong positive correlation with residence duration >10 years ($r=0.56$) and proximity ≤100 km from the Aral Sea ($r=0.56$). Hemoglobin levels correlated positively with well-water consumption ($r=0.61$) and residence duration ($r=0.54$). Serum creatinine showed high correlation with well-water use ($r=0.62$) and living near the Aral coastline ($r=0.57$). Conversely, GFR

displayed strong inverse correlations with age ≥48 years (r=−0.71) and distance ≤100 km from the Aral Sea (r=−0.72). Microalbuminuria and urea levels increased significantly with higher environmental exposure indices.

These findings indicate that environmental conditions such as high-water hardness, mineralized soil dust, and intense solar radiation act as cumulative stressors that accelerate nephron loss and reduce renal filtration capacity. The role of traditional risk factors—particularly hypertension and diabetes mellitus—was also significant but demonstrated additive rather than primary effects.

Discussion.

The interaction between environmental and traditional risk factors provides insight into the complex epidemiology of CKD in the Aral Sea area. Continuous exposure to high concentrations of calcium and sulfate ions in groundwater leads to crystallization processes within renal tubules, promoting interstitial fibrosis. Moreover, chronic heat exposure results in subclinical dehydration, increasing the viscosity of blood and thereby contributing to glomerular hyperfiltration injury.

The observed decline in GFR and increase in microalbuminuria parallel findings in similar arid regions, such as Northern India and parts of Latin America, where 'heat-stress nephropathy' has been described. The synergistic effect of diabetes, hypertension, and poor water quality creates a pathophysiological framework in which the kidneys are continuously exposed to oxidative and osmotic injury. Our study also highlights gender and age disparities, with men over 48 years demonstrating more severe renal impairment, possibly due to occupational exposure and metabolic factors.

From a preventive perspective, incorporating ecological screening indicators into family medicine practice may yield significant improvements in early CKD detection. For instance, inclusion of water hardness and residence proximity as variables in risk stratification models can identify vulnerable populations earlier. Economic evaluations suggest that early detection may reduce the need for hemodialysis by up to 35%, translating to substantial healthcare savings.

Conclusion.

The study confirms that the prevalence and progression of CKD in the Aral Sea region are influenced not only by traditional metabolic and cardiovascular risk factors but also by non-traditional environmental exposures. Water hardness, air pollution, and chronic heat exposure are independent predictors of renal dysfunction. Integrating these environmental determinants into national screening protocols is essential for effective disease prevention.

Developing a region-specific "Algorithm for Early Detection of CKD" tailored to ecological conditions can substantially improve outcomes. Our findings support multidisciplinary collaboration among nephrologists, environmental scientists, and public health authorities to address the CKD burden in Karakalpakstan.

Recommendations.

- Implement routine environmental nephrology screening in primary healthcare institutions within the Aral Sea region.
- Ensure continuous monitoring of drinking water hardness and contamination with heavy metals.
- Expand professional training in environmental medicine and nephrology to include ecological determinants of CKD.
- Encourage public education programs promoting adequate hydration and preventive lifestyle behaviors.
- Strengthen policy-level collaboration for sustainable water and air quality management.

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