THE RATIONALE FOR INVESTIGATING ENVIRONMENTAL EXPOSURE AND NEURODEVELOPMENT IN PRESCHOOL CHILDREN IN THE ARAL SEA REGION

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The shrinkage of the Aral Sea, large-scale diversion of river water for irrigation, agricultural chemicals, salinisation of soil and water, and dust from the exposed seabed have created a complex environmental setting in the Aral Sea region [1]. Exposure in this setting warrants investigation in child neurology, particularly during prenatal life and early childhood, when the central nervous system is developing rapidly [2]. A review of child health in the Aral Sea region examined 26 peer-reviewed articles and four major reports published between 1994 and 2008. It identified anaemia, diarrhoeal disease and high body burdens of toxic contaminants as important concerns, but found limited evidence on the specific clinical consequences of exposure to persistent organic pollutants [1]. Environmental contamination alone therefore does not establish that children in the region have neurological disorders. A pilot study in Karakalpakstan detected organochlorine compounds, including β-hexachlorocyclohexane (β-HCH), p,p′-DDE and hexachlorobenzene, in maternal blood, umbilical cord blood and breast milk. Selected food samples were also examined [3]. These findings support the possibility of prenatal and postnatal exposure. Historical data from a small sample, however, cannot be applied directly to the individual chemical burden or neurodevelopmental status of today's preschool children.

Bartrem and colleagues analysed 140 water, soil and sediment samples collected at 79 sites in Karakalpakstan in March–April 2023 [4]. β-HCH was detected in all 50 water samples tested for pesticides; concentrations in 45 exceeded the US Environmental Protection Agency's regional screening level. This screening level is neither an enforceable drinking-water standard in Uzbekistan nor a measure of a child's individual dose. The samples came from different water sources, and the study did not assess children's neurodevelopment. International epidemiological evidence provides a further rationale for investigation. In a prospective Mexican cohort, cognitive outcomes were assessed in 203 children aged 42–60 months. After adjustment, a doubling of maternal serum p,p′-DDE concentration in the third trimester was associated with a mean 1.37-point lower general cognitive index [5]. This association concerns an individual prenatal biomarker and cannot be equated directly with water-sample results or area of residence in the Aral Sea region.

A systematic review of pesticides and child neurodevelopment included 31 studies from 11 low- and middle-income countries; 23 reported an adverse association in at least one neurodevelopmental domain [6]. The review covered several pesticide classes. Differences in exposure assessment, children's ages and outcome tests precluded a pooled effect estimate. These findings do not establish a causal effect of β-HCH or p,p′-DDE in children in Karakalpakstan.

This brief narrative synthesis draws on selected published studies of environmental contamination and human biomonitoring in the Aral Sea region, alongside international epidemiological research on child neurodevelopment. The sources were selected to illustrate the evidence gap rather than through a comprehensive systematic search or formal assessment of study quality. They cover different periods, populations and exposure measures. The studies reviewed do not directly establish an association between individual organochlorine pesticide exposure and standardised cognitive outcomes in preschool children currently living in Karakalpakstan.

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A future study could compare preschool children living in areas with different environmental conditions, document residential histories and water sources, and combine age-appropriate standardised cognitive assessments with clinical neurological examinations. In this multilingual population, assessments should be culturally and linguistically appropriate, with standardised procedures and trained examiners. Where feasible, individual biomarkers could complement area-level measurements, while repeated assessments could track developmental change. Analyses should account for age, sex, perinatal history, parental education, socioeconomic circumstances, nutrition and the home learning environment. Haemoglobin measurement can help identify anaemia, while serum ferritin provides information on iron stores. Because ferritin is an acute-phase reactant, its interpretation should account for inflammation, using appropriate markers such as C-reactive protein and, where indicated, α1-acid glycoprotein [7]. Children living in the same locality should not be assumed to have identical individual exposures.

Earlier biomonitoring studies documented organochlorine compounds in biological samples from Karakalpakstan, while more recent environmental monitoring identified pesticide residues in water. International research has found associations between prenatal exposure to some pesticides and selected cognitive outcomes, but these findings do not establish pesticide-related neurodevelopmental impairment among preschool children in Karakalpakstan. Research integrating environmental monitoring, individual exposure assessment, clinical neurological examinations and standardised cognitive testing could help address this evidence gap.

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