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LEAD DISTRIBUTION IN PATIENTS WITH ALLERGIC DISEASES – A SEVEN-YEAR EPIDERMIOLOGICAL STUDY

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ტყვიის განაწილება ალერგიული დაავადებების მქონე პაციენტებში - შვიდწლიანი ეპიდერმიოლოგიური კვლევა

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რეზიუმე

მიზანი: შეფასდეს ტყვიის, როგორც გარემოს ტოქსიკური აგენტის და ალერგიული დაავადებების კლინიკური გამოვლინებების პოტენციური ასოციაცია.

მეთოდები: მრავალწლიანი ჯვარედინი ტყვიის და იმუნოლოგიური პარამეტრები შეფასდა 418 ალერგიულ პაციენტში და 92 ჯანმრთელ კონტროლში. ბიოქიმიური და იმუნოლოგიური ანალიზები ჩატარდა თანამედროვე ლაბორატორიული ტექნიკის გამოყენებით (ICP-MS, ELISA, იმუნოფლუორესცენცია), ხოლო სტატისტიკური ანალიზი STATA–ს გამოყენებით. IgE, ჰისტამინის და ანტი-IgE, ისევე როგორც ეოზინოფილების რაოდენობა, მნიშვნელოვნად იყო მომატებული ალერგიულ ჯგუფში (P<0.05).

დასკვნა: ტყვიის მომატებული დონე შეიძლება კავშირში იყოს ალერგიულ პროცესთან, განსაკუთრებით პედიატრიულ პაციენტებში, რაც ხაზს უსვამს გარემოს ჯანმრთელობის დაცვის მნიშვნელობას.

Introduction. The complex epidemiological landscape of allergic diseases and the growing significance of associated environmental factors have become the focus of active research in the fields of medicine and public health over the past decades. One such factor is lead — a heavy metal widely present in the environment, known for its toxic effects on various organs and systems.

Despite existing studies that examine lead levels in different biological substrates and its relationship to the formation of immunological inflammatory responses, there is still no definitive conclusion regarding the exact dose and mechanisms by which lead is involved in the pathogenesis of allergic diseases [1,3,5,7,10,11,13].

It is evident that lead accumulation in the human body is a globally widespread phenomenon, as confirmed by both international and local epidemiological data. At the same time, the prevalence of allergic diseases is also steadily increasing [12].

Against this background, the aim of the present study was to investigate lead concentrations in patients with allergic diseases (asthma, atopic dermatitis/eczema, allergic rhinitis, food allergy, urticaria) and to evaluate its potential association with clinical manifestations of the disease.

Objectives and Methods. The aim of this study was to assess lead concentrations in the bodies of patients with allergic diseases. To achieve this goal, a multi-indicator study was conducted over a period of 7 years. Venous blood samples were collected from 418 patients with allergic diseases (Group G1), aged between 2 and 69 years. This group included 186 children, 152 young adults, and 80 patients over the age of 40; 249 were female and 169 were male. Patients were selected randomly and enrolled in the study based on prior informed consent. All of them had presented to Clinic " XXI saukune" for various medical reasons. Additionally, a control group (Group G2) was included in the study, consisting of 92 healthy individuals - 31 children and 61 young adults; among them, 50 were female and 42 were male. The demographic characteristics of the groups involved in the study are presented in the following tables.

Table 1. Distribution of Allergic Diseases in Group G1

Allergy Disease	Total (n)	Children (n)	Adults (n)
Asthma	41	24	17
Atopic Dermatitis	115	54	61
Allergic Rhinitis	52	4	48
Food Allergy	53	21	32
Urticaria (total)	211	83	128
-Acute Urticaria	134	-	-
-Chronic Urticaria	77	-	-

Table 2. Demographic Characteristics of Study Participants

Groups	Total (n)	Children (2-15y)	Young Adults (18-39y)	Old Adults (>40y)	Females	Males
G1 (Allergic patients)	418	186	152	80	249	169
G2 (Healthy controls)	92	31	61	0	50	42

Blood samples were collected for measurement of lead concentrations via inductively coupled plasma mass spectrometry (ICP-MS). Immunological assessments included total IgE, histamine, anti-IgE levels (via ELISA and immunofluorescence), and eosinophil count (via microscopy). All participants provided informed consent, and ethical approval was obtained from the institutional review board. Statistical analyses were conducted using STATA version 18, with significance defined at $p < 0.05$.

Results. The analysis revealed significantly higher blood lead concentrations in the allergic patient group (G1) compared to the healthy control group (G2). Elevated blood lead levels (>10 μg/dL) were detected in 302 out of 418 allergic patients (72%) and in 31 out of 92 participants in the control group (33%).

Table 3. Frequency of Elevated Blood Lead Levels in Study Groups

Groups	Total Participants (n)	Lead Elevated Level (>10 μg/dL)	Percentage (%)
G1 (Allergic patients)	418	302	72%
G2 (Healthy controls)	92	31	33%

This significant difference suggests a possible association between allergic diseases and elevated lead levels. Among allergic patients (Group G1), the prevalence of high blood lead levels (BLL >10 μg/dL) varied by disease type and age group. A detailed breakdown is presented below:

Table 4. Prevalence of Elevated Blood Lead Levels (BLL >10 μg/dL) Among Allergic Patients by Disease Type and Age Group

Allergic Disease	Patients (n)	Children (n)	Lead Elevated Leven (BLL) in Children (n/%)	Adults (n)	Lead Elevated Level (BLL) in Adults (n/%)
Asthma	41	24	19 (79%)	17	12 (71%)
Atopic Dermatitis	115	54	31 (57%)	61	32 (52%)
Allergic Rhinitis	52	4	2 (50%)	48	18 (38%)
Food Allergy	53	21	17 (81%)	32	27 (84%)
Urticaria	211	83	63 (76%)	128	78 (61%)

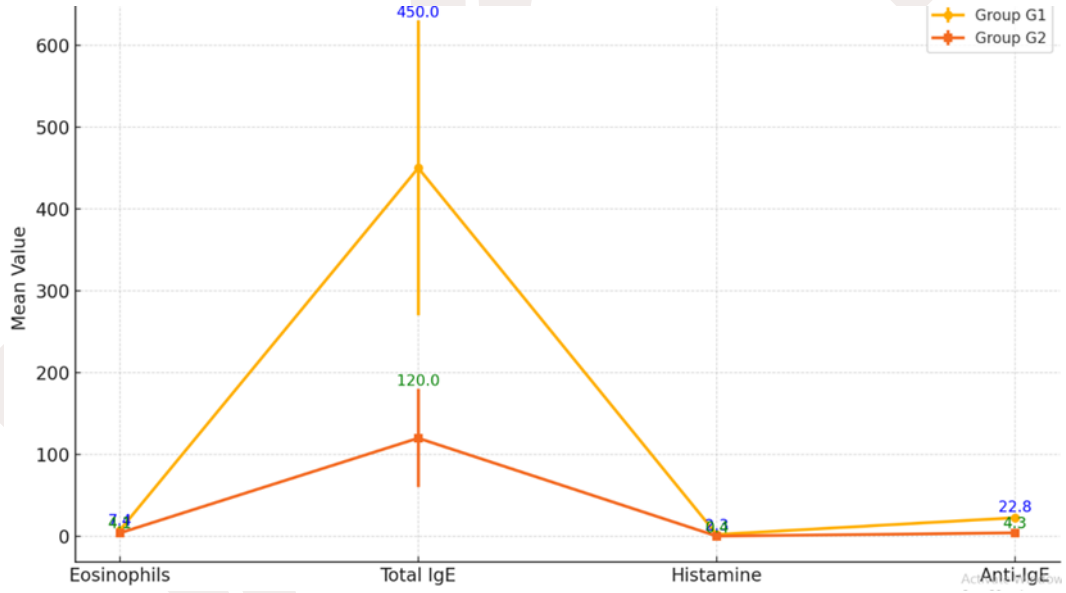
According to Table 4, all subgroups of children with allergic diseases showed high levels of lead in the blood, ranging from 70% to 81%. Among adults, elevated lead levels were observed in patients with asthma, urticaria, and food allergies (61%–71%). The most frequent cases of elevated lead levels were recorded in patients with food allergies (81%) and asthma (79%), whereas the lowest prevalence was found in adults with allergic dermatitis (52%) and allergic rhinitis (38%).

The distribution of immunological parameters also revealed interesting differences between the studied groups. Specifically, the average eosinophil count in Group G1 was 7.4 ± 2.1, compared to 4.1 ± 1.5 in Group G2 ($p < 0.001$), indicating a statistically significant difference. Total IgE concentration in Group G1 was 450 ± 180 IU/mL, while in Group G2 it was 120 ± 60 IU/mL ($p < 0.01$). Histamine levels also differed significantly between the groups (G1: 2.3 ± 1.1, G2: 0.4 ± 0.1, $p = 0.03$). The level of anti-IgE was significantly higher in Group G1 (22.8 ± 2.7) compared to Group G2 (4.3 ± 1.3, $p = 0.05$).

Table 5. Comparison of Immunological Parameters Between Groups G1 and G2

Parameters	G1 Mean ± SD	G2 Mean ± SD	P - value
Eosinophils (x106/L)	7.4 ± 2.1	4.1 ± 1.5	p<0.001
Total IgE (IU/mL)	450 ± 180	120 ± 60	p<0.01
Histamine (ng/mL)	2.3 ± 1.1	0.4 ± 0.1	p=0.03
Anti-IgE (KU/I)	22.8 ± 2.7	4.3 ± 1.3	p=0.05

The above-mentioned correlations of immunological markers are clearly illustrated in Diagram 1.



Interpretation and Analysis. The data indicate a high prevalence of elevated blood lead levels (BLL >10 µg/dL) among allergic patients, particularly within the pediatric age group. In children, high lead levels were observed across all types of allergic diseases and exceeded those found in adults.

The highest BLL was recorded in: Children with food allergies (81%) and asthma (79%); Elevated levels were also observed in children with urticaria (76%) and atopic dermatitis (70%). In adults, elevated lead levels were also significant, though generally lower. Specifically: The highest levels were found in adults with asthma (71%) and urticaria (61%); The lowest prevalence was observed in cases of atopic dermatitis (52%) and allergic rhinitis (38%). Notably: Patients with urticaria showed the highest average levels of both IgE and anti-IgE; Elevated eosinophil levels were observed in cases of urticaria and atopic dermatitis.

This trend may suggest a possible link between lead exposure and allergic sensitization or disease severity, particularly among younger individuals. The disproportionately high lead levels in children may be explained by both physiological and behavioral factors - including increased intestinal absorption of lead and greater exposure to environmental risks during early developmental stages.

The findings underscore the need for further research to identify environmental and lifestyle factors contributing to lead exposure in allergic individuals, with special attention to early-life exposure. Furthermore, the data highlight an important public health imperative - the development and implementation of screening and preventive measures for vulnerable populations.

Discussion. The results of this study confirm the high prevalence of elevated blood lead levels (BLL >10 μg/dL) among patients with allergic diseases, particularly within the pediatric population. This association was especially pronounced in children with food allergies (81%) and asthma (79%), suggesting that individuals with allergic conditions at a young age may be more susceptible to lead accumulation.

The age-dependent differences in lead levels are likely explained by both physiological and behavioral factors. Children absorb lead more efficiently through the gastrointestinal tract compared to adults and are also at higher risk of exposure to lead-containing environmental sources - such as contaminated soil, dust, or household items. Such exposure, especially during critical stages of immune system development, may contribute to heightened allergic sensitization or the exacerbation of existing conditions.

The study clearly demonstrated that the increase in lead burden is particularly significant in allergic children. These findings are consistent with international research that has identified children as more vulnerable to lead toxicity [4]. Lead is known to promote a Th2-skewed immune response, which is one of the mechanisms underlying enhanced allergic inflammation [6].

In adults, elevated BLL may reflect chronic, long-term environmental exposure or the lasting effects of early-life lead burden. Lead exposure may also operate at the cellular level, contributing to oxidative stress, disruption of epithelial barrier function, and cytokine imbalance.

From a pathophysiological standpoint, lead has been shown to impact the immune system by promoting Th2-type immune responses, which are closely associated with allergic inflammation [2]. Elevated lead levels may also induce oxidative stress, damage epithelial barriers, and modulate cytokine profiles, thereby intensifying allergic reactions [6].

These findings align with previous studies linking heavy metal exposure to increased levels of IgE, histamine, and eosinophilia in allergic patients.

In our study, elevated lead levels were also detected in adults - most notably in cases of asthma (71%) and urticaria (61%) - though overall levels were lower than those observed in children. These differences may reflect cumulative or occupational exposure, chronic environmental influences, or long-term effects of early-life lead exposure.

Lead can cause epigenetic changes (e.g., DNA methylation, histone modification) that affect the expression of genes involved in allergic responses [8]. Therefore, the varying levels of lead burden across different types of allergic diseases may indicate that certain conditions are more sensitive to environmental toxins. For example, elevated lead levels observed in both acute and chronic urticaria may suggest a role for lead in non-IgE-mediated hypersensitivity or mast cell activation.

Given that lead is widely present in urban environments and may exacerbate or even trigger allergic diseases, our findings underscore the importance of environmental health monitoring. Targeted lead screening among high-risk allergic patients - especially children - should become an integral part of clinical and public health strategies.

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SUMMARY

Objective: To evaluate the potential association between lead, as an environmental toxic agent, and the clinical manifestations of allergic diseases.

Methods: As part of a multi-year cross-sectional study, lead levels and immunological parameters were assessed in 418 allergic patients and 92 healthy controls. Biochemical and immunological analyses were performed using modern laboratory techniques (ICP-MS, ELISA, immunofluorescence), and statistical analysis was conducted using STATA 18.

Results: Lead concentration was significantly higher in the allergic patient group (BLL >10 μg/dL observed in 72%), especially among children. Levels of IgE, histamine, and anti-IgE, as well as eosinophil counts, were significantly elevated in the allergic group ($p < 0.05$).

Conclusion: Elevated lead levels may be associated with the allergic sensitization process, particularly in pediatric patients, highlighting the need for environmental health protection.

Keywords: Lead, allergy, environmental toxicology, immunological markers, body burden, BLL, children, asthma, urticaria, food allergy