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Research Article

Hematological Parameters as Potential Biomarkers for Allergy and Eczema

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Abstract:

This study investigated the association between hematological parameters, allergy, and eczema in a population from Al-Najaf Al-Ashraf Governorate, Iraq. Blood samples were collected from individuals with eczema, allergies, and healthy controls. Complete blood count (CBC) and serum IgE levels were analyzed. Results demonstrated significant variations in hematological parameters across different groups. Occupation, age, and disease status influenced these parameters. For instance, farmers exhibited higher IgE levels, while government employees had elevated WBC counts. Eczema patients showed age-related differences in blood parameters, with younger individuals presenting higher IgE and WBC levels. Allergy patients also exhibited elevated WBC counts, particularly in children. These findings suggest that hematological parameters may serve as potential biomarkers for allergy and eczema. However, the complex interplay between occupation, age, and disease status highlights the need for further research to elucidate the underlying mechanisms and establish definitive diagnostic or prognostic value.

Keywords: hematological parameters, allergy, eczema, occupation, age, biomarkers.

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INTRODUCTION

Allergic diseases, including eczema and allergic rhinitis, are increasing globally and significantly impact quality of life (Pärna et al., 2015). These complex conditions arise from a combination of genetic predisposition and environmental factors (Harding et al., 2021). Exposure to allergens, including pollens, dust mites, and chemicals, triggers immune responses leading to inflammation and symptoms (Lei & Grammer, 2019). Climate change exacerbates these issues by increasing allergen levels and air pollution (Luschkova et al., 2022; Wypych-Slusarska et al., 2022). Occupational and environmental factors also play a crucial role in developing contact dermatitis, a type of eczema, with exposure to irritants and allergens being primary causes (Al-Imam et al., 2023). Indoor allergens, including dust mites, cockroaches, pets, and molds, are significant contributors to allergic diseases such as asthma, allergic rhinitis, and eczema (Morsy et al., 2021; Kalayci et al., 2022). These allergens can trigger immune responses leading to the production of IgE antibodies, resulting in allergic symptoms (Ahluwalia & Matsui, 2018). Studies have shown that exposure to indoor allergens, particularly house dust mites and pet dander, is associated with increased prevalence of allergic diseases (AlShatti & Ziyab, 2020). Factors such as living in older buildings, residing in urban areas, and pet ownership can increase the risk of developing these allergies. Indoor allergens, including dust mites, mold, pet dander, and cockroaches, are significant contributors to allergic diseases. Dust mites are the most prevalent indoor allergen, causing allergic rhinitis, asthma, and atopic dermatitis (Lin et al., 2022). Mold exposure, particularly during pregnancy, is associated with increased risk of atopic dermatitis (Eun Lee et al., 2020). Pet dander, especially from cats and dogs, triggers allergic asthma and rhinitis (Roesner et al., 2021). Cockroaches carry pathogens and their allergens contribute to allergic rhinitis, asthma, and atopic dermatitis (Algailany et al., 2023; Luo et al., 2022; Tayeb, 2023). These allergens can trigger immune responses, leading to inflammation and allergic symptoms. Indoor and outdoor environmental factors significantly contribute to allergic and respiratory diseases. Inadequate ventilation, high humidity levels, and exposure to pollutants, including volatile organic compounds (VOCs) and pollen, can trigger or exacerbate these conditions (Uter et al., 2023; Beckett et al., 2022; Fluhr et al., 2023). Chemical irritants are prevalent in our environment and contribute significantly to allergic and irritant contact dermatitis. Exposure to chemicals in various products, including detergents, cosmetics, and industrial materials, can induce skin inflammation and allergic reactions (Jusoh & Ko, 2019). Fragrances and preservatives are common culprits in allergic contact dermatitis, with fragrances affecting a wide range of individuals and preservatives like isothiazolinones showing increasing prevalence (Amornruk et al., 2022). Understanding the sources of chemical exposure is crucial for preventing skin diseases, as these substances can have long-lasting effects on skin health (Isaac & Scheinman, 2017). Dyes, detergents, and heavy metals are common culprits in allergic and irritant contact dermatitis. Textile dyes, particularly disperse and reactive dyes, can induce allergic reactions (Liszewski & Warshaw, 2019). Pigments in tattoo inks and isothiazolinones in paints have also been implicated in allergic contact dermatitis (Amsler et al., 2017). Detergents containing fragrances, preservatives, and surfactants can cause allergic and irritant contact dermatitis (Norman et al., 2023). Heavy metals, such as nickel, are common allergens and irritants, with occupational exposure being a significant risk factor (Bharti & Sharma, 2022). While some studies have linked heavy metals to skin conditions, the relationship between blood levels of cadmium, lead, and mercury and eczema remains inconclusive (Wei & Zhang, 2019). Industrial and agricultural pollutants are significantly linked to allergic skin conditions. Chemical exposures in industrial settings, including cement dust and refinery emissions, can trigger allergic responses through mechanisms involving IgE antibody production and mast cell activation (Fu, et al., 2023). Cogeneration plants and other industrial sources release pollutants that contribute to asthma, allergic rhinitis, and atopic dermatitis (Moon, 2020). Additionally, pesticides used in agriculture have been associated with increased atopy, allergic rhinitis, and dermatitis (Raherison et al., 2019). These pollutants can enter the human body through inhalation, ingestion, and dermal contact, leading to various health issues, including respiratory problems and skin allergies.

The aim of this study is to undertake drawing blood samples from diagnosed cases by an allergy and eczema consultant for conducting some immunological tests, and taking information according to a special form prepared for this purpose for each diagnosed case, and suggest a management plan to avoid developing allergies and eczema.

MATERIALS AND METHODS

Blood samples were collected from participants in Al-Najaf Al-Ashraf Governorate, Iraq. Study subjects included 26 individuals with eczema, 46 with allergies, and a control group of 29 healthy individuals. Diagnostic cases were recruited from Al-Sadr Teaching Hospital. Venous blood was drawn using a sterile syringe and divided into two tubes. An EDTA tube was used for complete blood count (CBC) analysis on a Sysmex XP-300™ hematology analyzer. A plain tube was used for serum separation, which was achieved through centrifugation using a Benchmark Scientific LC-8 Plus centrifuge. Serum IgE levels were subsequently determined using an ELISA-based method (Human IgE ELISA kit, Cygnus F170- Korean).

RESULTS AND DISCUSSION

Eczema prevalence was categorized by occupation and compared to a control group Figure 1. Farmers exhibited the highest mean IgE levels (159.162 ± 0.238) compared to the control group (94.193 ± 0.140). Agricultural environments are recognized as significant sources of allergens, with soil composition implicated in skin diseases (Śpiewak et al., 2017). (Skoet et al., 20174) reported a lower atopic dermatitis prevalence (11.3%) in potentially exposed occupations, suggesting occupational selection bias. Furthermore, agricultural bacteria may contribute to skin inflammation (Śpiewak et al., 2017). While no significant difference in IgE levels was found between farmers and other groups ($P>0.05$), a significant correlation existed ($P=0.012$). Conversely, individuals in "other professions" showed the lowest mean IgE (104.585 ± 0.453), without significant differences to other groups ($P>0.05$, $P=0.086$). This might reflect a younger demographic less exposed to environmental triggers, as suggested by Lam et al. (Lam et al., 2016).

Government employees exhibited the highest mean white blood cell (WBC) count (10.085 ± 0.950), significantly exceeding the control group (7.463 ± 1.630; $P<0.001$) Figure 2. This finding contrasts with studies showing decreased WBC counts in certain occupational groups, such as petrol station workers (Al-Sormy & Banafa, 2023) and radiologists (Güngördü et al., 2023). Previous research has linked elevated WBC counts to metabolic syndrome (Lohsoonthorn et al., 2007; Babio et al., 2013). Significant correlations were observed between the WBC counts of government employees and other occupational groups, except for craft professionals. Farmers also showed correlations with other groups and their respective controls.

Red blood cell (RBC) counts were significantly lower in individuals engaged in craft professions (5.538 ± 0.324) compared to the control group (5.939 ± 0.938) Figure 3. These findings are partially supported by (Uzoma et al., 2021), Who reported increased RBC counts in mill workers. However, our results contrast with those of (Alfadaly et al., 2016), who observed decreased RBC counts in gasoline workers exposed to benzene. (Dakieva et al., 2020) reported variations in enzyme activity among workers in different workshops, suggesting potential occupational-related hematological alterations. Government employees exhibited the lowest RBC count (4.716 ± 0.428) compared to other groups. Statistical analysis revealed significant differences between groups ($p<0.05$), with notable correlations observed between craft professions, government employees, and the control group.

Hemoglobin levels varied significantly among eczema patients based on occupation. Craft professionals exhibited the highest average hemoglobin (17.157 ± 1.943), which differed significantly from other groups ($P<0.05$, $P=0.033$). Conversely, other professions had the lowest average (12.378 ± 1.341), lower than the control group (16.840 ± 1.925) and also

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significantly different (P<0.05, P=0.006) Figure 4. These findings contrast with studies on welders (Kazi et al., 2021) and car mechanics (Zalat, 2011) Who reported decreased hemoglobin levels. However, research on greenhouse workers (García-García et al., 2016) showed increased hemoglobin, suggesting the impact of specific occupational exposures. Potential factors influencing hemoglobin levels in our study include formaldehyde exposure (Kim et al., 2021) and other occupational irritants. Further research is needed to elucidate the complex relationship between occupation, hemoglobin levels, and eczema.

As showen in Figure 5, Neutrophil (NEU) counts were significantly elevated in farmers (8.403 ± 1.290) compared to the control group (5.340 ± 1.497) (p=0.023). This finding aligns with previous research suggesting that chronic pesticide exposure in farmers can lead to alterations in blood parameters, including increased neutrophil counts (Nejatifar et al., 2022). Given the potential for increased pollen exposure in agricultural environments (Braun-Fahrländer et al., 1999), further investigation into the relationship between pollen exposure and neutrophil levels in this population is warranted. In contrast, individuals in craft professions exhibited the lowest NEU counts (4.714 ± 0.925) (p=0.004).

Lymphocyte levels were significantly higher in government employees (mean: 3.003 ± 0.883) compared to controls (mean: 2.041 ± 0.328) ($p < 0.05$) Figure 6. In contrast, farmers exhibited the lowest lymphocyte counts (mean: 2.024 ± 0.249). No significant differences were observed in the "other profession" category ($p > 0.05$). While government employees showed a significant correlation with all control groups, farmers correlated significantly with both government employees and the "other" category. Additionally, the "craft profession" group correlated with all control groups except farmers.

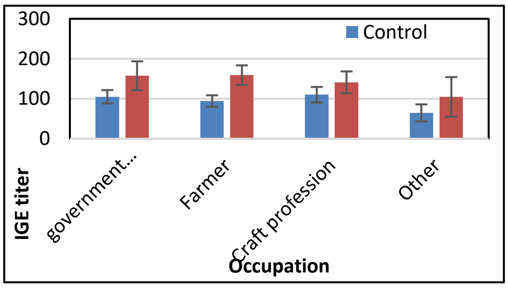

Figure 1. The Rate of IGE for Eczema According to the job

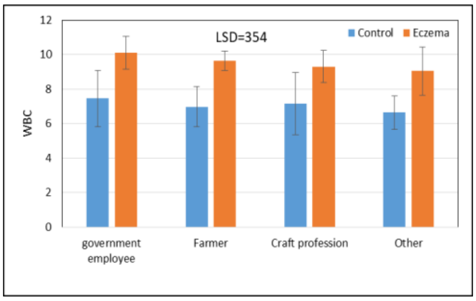

Figure 2. WBC Rate Relative to the Job

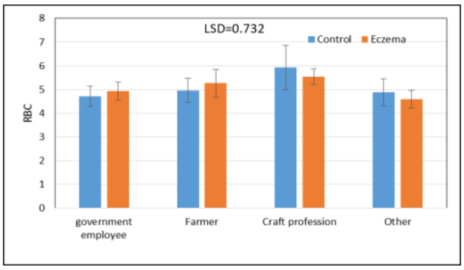

Figure 3. RBC Rate Relative to the Job

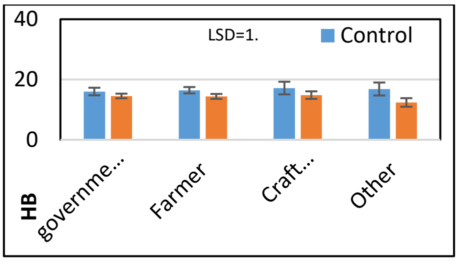

Figure 4. Hb Rate Relative to the Job

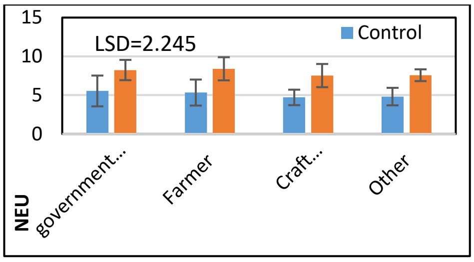

Figure 5. NEU Rate Relative to the Job

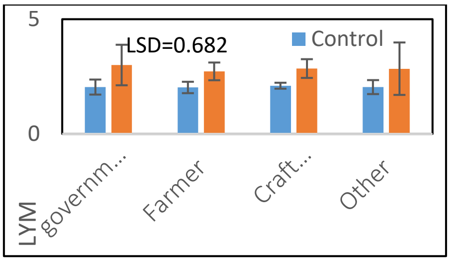

Figure 6. LYM Rate Relative to the Job

IgE-mediated allergies affect a significant portion of the population, with even minimal allergen exposure triggering antibody production in susceptible individuals (Shamji et al., 2021). Our findings revealed elevated IgE levels in the craft profession group compared to the control group (115.405 ± 0.280 vs. 110.135 ± 0.189, respectively) Figure 7. Previous research has shown conflicting results regarding IgE levels and occupational exposure. While Hossain and Islam (Hossain & Islam, 2016) reported increased IgE levels in tannery workers without corresponding allergic symptoms, attributing this to environmental factors, (Spierenburg et al., 2017) observed lower IgE positivity and allergy prevalence in farmers due to endotoxin exposure. In our study, no significant difference in IgE levels was found between the "other" category and the control group ($p=0.736$). However, significant correlations were observed between the "craft profession" and "farmer" groups compared to the "other" group. These findings suggest potential occupational influences on IgE levels, although further investigation is required to establish definitive conclusions.

White blood cell (WBC) counts were highest among individuals in craft professions (8.872 ± 0.999), significantly exceeding the control group (6.706 ± 1.694) ($p<0.05$). This elevation aligns with findings by (Oko'Ose & Oko-Ose, 2023), who reported increased WBCs, particularly neutrophils and eosinophils, among fossil fuel bakery workers due to exposure to combustion products. Similarly, (Krawczyk-Szulc et al., 2014) observed a twofold increase in WBCs, including eosinophils, in woodworkers with occupational asthma and allergies. Conversely, the lowest WBC counts were observed in the farmer group (5.584 ± 0.728) ($p<0.05$). This finding is consistent with (Frei et al., 2014), who reported decreased cytokine gene expression in WBCs of farmer children, suggesting a potential role of the hygiene hypothesis in developing innate immunity and modulating immune responses. However, (Yaqub et al., 2014) reported a decrease in WBCs among farmers exposed to organophosphate pesticides, potentially linked to severe anemia. Significant differences in WBC counts were observed between craft professions and other occupational groups**.** Correlation analysis revealed a strong association between the craft profession group and all other groups, including their respective controls. Farmers exhibited significant differences from other groups and their controls, while government employees showed correlations with all groups and controls Figure 8.

As showen in Figure 9, red blood cell (RBC) counts were highest among craft professionals (5.939 ± 0.938), with a significant difference ($P<0.05$; 0.209) compared to other groups**.** This elevation aligns with previous studies demonstrating increased RBC counts in workers exposed to harmful substances. (Getu et al., 2020) reported higher RBC levels in gasoline workers due to exposure to toxins. However. Furthermore, (Kent et al., 2011) linked flour dust exposure to increased RBC counts due to respiratory obstruction and subsequent erythropoietin stimulation. Conversely, the lowest RBC count was observed in the "other professions" group (4.688 ± 0.501), with no significant differences ($P>0.05$; 0.889). This finding is consistent with research demonstrating decreased RBC counts among workers exposed to benzene (Teklu et al., 2021) and Chromium (Mattia et al., 2004). Prolonged

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exposure to these substances can inhibit bone marrow activity, leading to reduced RBC production and anemia. Significant correlations were found between the craft profession group and all other groups except for government employees and their respective control groups. These findings suggest potential associations between occupational exposures and RBC levels, warranting further investigation.

Figure 10 illustrates hemoglobin levels in allergy patients, which mirrored the pattern observed in red blood cell counts. Other professions exhibited the highest hemoglobin mean (17.600 ± 2.103), with significant differences noted across all groups ($p<0.05$, $p=0.035$). These findings align with previous research. For instance, (Bono et al., 2021) reported elevated hemoglobin levels in workers exposed to formaldehyde in plastic sheet factories, attributing this to the chemical's toxicity and its impact on respiratory health. Conversely, (Hayat et al., 2018) observed decreased hemoglobin levels in pesticide industry workers due to exposure to toxic pesticides. Our analysis revealed significant correlations in hemoglobin levels between various occupational groups. However, the lowest hemoglobin mean (12.794 ± 1.330) was observed in the "other occupations" group ($p=0.008$). This aligns with (Nacira et al., 2018), who reported decreased hemoglobin levels in construction workers exposed to paint solvents. These solvents can induce blood disorders, including reductions in white blood cells and neutrophils, due to their toxic components and persistent environmental presence.

Figure 11 demonstrates a significantly higher mean neutrophil count (7.747 ± 1.202) in allergy patients compared to the control group of government employees (5.500 ± 1.616) ($p=0.001$). These findings align with those of (Nynäs et al., 2023), who reported increased neutrophil levels in individuals exposed to workplace moisture damage. Furthermore, neutrophils have been shown to be elevated in asthma patients compared to non-asthmatic individuals. The observed high neutrophil count in internal office employees may be attributed to exposure to indoor toxins, as suggested by (Akpinar-Elci et al., 2013) and (Rezaei et al., 2004), who linked these toxins to allergic rhinitis. In contrast, allergy patients in the "other professions" group exhibited the lowest neutrophil count (4.940 ± 1.009), with significant differences compared to other groups ($p=0.033$). Significant correlations were identified between allergy patients in the government employee, farmer, and craft profession groups and all control groups. Additionally, the "other professions" group showed significant correlations with the control groups of farmers, craft professionals, and others.

Lymphocyte levels were significantly elevated in the government employee group with allergies compared to all other groups Figure 12, with a mean of 2.692 ± 0.679 (SD). This value was notably higher than the control group's mean of 2.149 ± 0.315 (SD) ($p < 0.05$; $p = 0.015$), conversely, the lowest lymphocyte count was observed in the craft professions group at 1.957 ± 0.199 (SD), demonstrating a significant difference ($p < 0.05$; $p = 0.036$). Correlations were identified between the government employee group and both the allergy group and the control group. Similar correlations were found between the farmer, craft profession, and other groups and their respective control groups.

Figure 13 showed the highest mean total IgE level was observed in the 20-30 age group of eczema patients (182.029 ± 0.175), significantly exceeding the control group (114.953 ± 0.144) ($P=0.002$). These findings align with previous research by (Salama et al., 2022) and (Kumar et al., 2018), which reported elevated IgE levels in younger eczema patients. (Rasdeed & Al-Khazraji, 2018) also observed increased IgE levels in eczema patients aged 15-44, attributing this to immunological deviations and elevated IL-4 and IL-13 levels. Conversely, the lowest mean IgE level was found in the over-60 age group (101.942 ± 0.189), with significant differences observed compared to other age groups ($P<0.05$; $P=0.100$) Figure 13. This decrease in IgE levels with age is consistent with findings by (Yuqing Hu et al., 2020) and (Tanei, 2015), who reported lower IgE levels in older age groups. While this might suggest immune properties against malignant tumors in elderly individuals with IgE allergies, further research is needed to clarify this association. Significant correlations were identified between IgE levels in different age groups of eczema patients and control groups.

Figure 14 illustrates WBC levels across different age groups. The highest WBC count was observed in the under-10 age group (10.457 ± 0.797), significantly higher than the control group (6.558 ± 1.724; $p<0.05$). While the 10-20 age group also exhibited elevated WBC levels, differences between age groups were less pronounced.

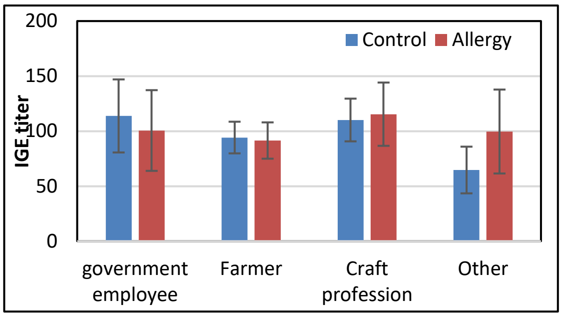

Figure 7. IGE Rate Relative to the Job

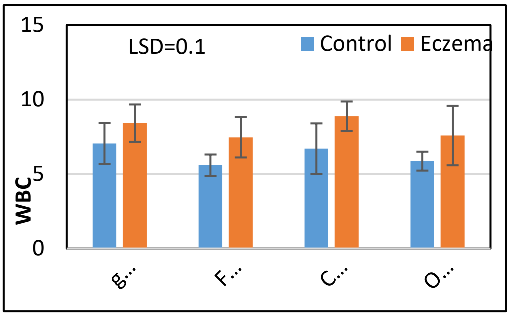

Figure 8. WBC Rate Relative to the Job

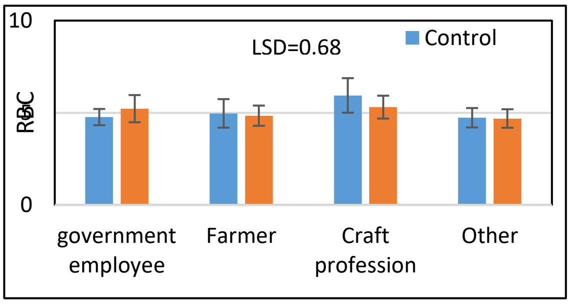

Figure 9. RBC Rate Relative to the Job

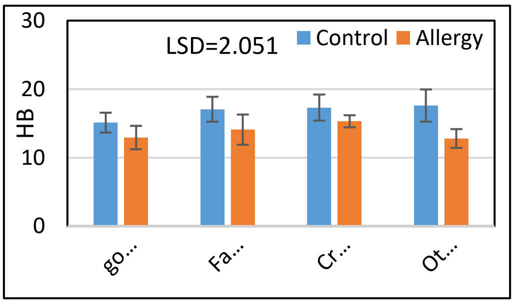

Figure 10. Hemoglobin Rate Relative to the Job

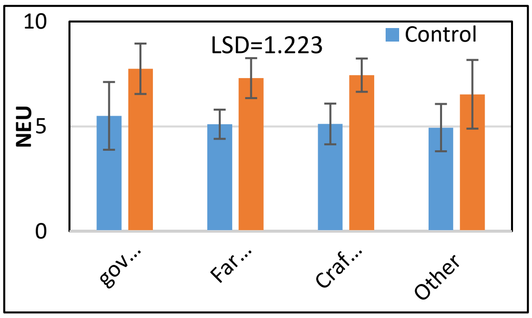

Figure 11. Neutrophils Rate Relative to the Job

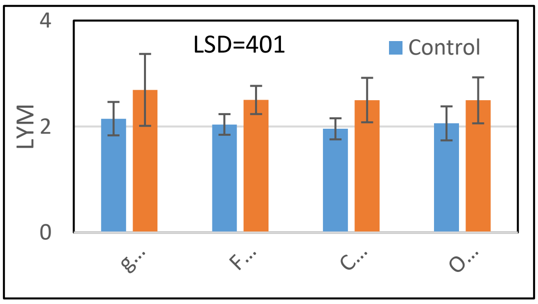

Figure 12. Lymphocytes Rate Relative to the Job

These findings align with previous research by (Seo et al., 2019) who reported increased WBC counts in children under three. This is likely due to heightened exposure to inhaled allergens in younger individuals. In the Iraqi context, a similar trend of elevated WBC levels in this age group has been observed. This may be attributed to the excessive cytokine production by lymphocytes in individuals with eczema, as reported by (Al-asady & Al-Rubaeaee, 2023). Conversely, the 30-40 age group showed the lowest WBC count (6.485 ±

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0.702) without significant differences compared to other groups (p=0.531). A decline in WBC count among the elderly is supported by (Piscazzi et al., 2023). WHO reported a case of a 75-year-old eczema patient with significantly reduced WBC levels.

As illustrated in Figure 15, the highest mean RBC count among eczema patients was observed in the 50-60 age group (5.825 ± 0.857). This finding aligns with the observations of (Hoxha et al., 2023), who suggested that increased RBC counts might be attributed to excessive sun exposure, leading to skin inflammation and barrier disruption. Conversely, the lowest mean RBC count was found in the over-60 age group for both eczema patients (4.413 ± 0.348) and the control group (4.705 ± 0.499), with a significant difference ($P \leq 0.05$; 0.497). This decrease in RBC count among the elderly is consistent with the findings of (Su et al., 2015). Overall, the results indicate that RBC counts vary significantly across age groups, with a potential association between increased RBC counts and younger age, particularly in eczema patients. However, further research is needed to elucidate the underlying mechanisms and clinical implications of these findings.

Hemoglobin (Hb) levels exhibited a significant increase in the 50-60 age group (18.025 ± 1.925), with a p-value of <0.05 and a correlation coefficient of 0.201 Figure 16. Conversely, the lowest Hb levels were observed in the over-60 age group (12.350 ± 1.258), which was significantly lower than the control group (17.250 ± 1.947). These findings align with (Dayag et al., 2019), Who reported a marked decrease in hemoglobin levels in an 80-year-old patient with severe eczema. Statistical analysis revealed significant correlations between the control and eczema groups for age ranges less than 10, 10-20, 20-30, 30-40, and 40-50 years compared to the 50-60 and over-60 eczema groups. Additionally, significant differences were observed between the control group (aged 50-60 and over 60) and the control groups aged less than 10, 20-30, and 40-50 years, as well as across all eczema patient groups.

Children with eczema, particularly those under 10 years old, exhibited significantly higher neutrophil counts compared to the control group Figure 17, mean: 8.573 ± 1.138 vs. 5.925 ± 0.898, $p < 0.05$. This finding aligns with previous research suggesting a correlation between elevated neutrophil levels and eczema severity in children (Dogru & Citli, 2017). The immature immune system of children may contribute to this increased neutrophil response, as suggested by (Brodin et al., 2015). Conversely, the lowest neutrophil counts were observed in the 50-60 age group (4.400 ± 0.255, $p < 0.05$). The use of azathioprine, an immunosuppressant drug, was associated with significantly reduced neutrophil levels in the eczema patients aged 47-71 years, consistent with its known side effects (Huang et al., 2020). Significant differences in neutrophil counts were observed between specific age groups, both within the control and eczema cohorts. For instance, the control group aged less than 10 years differed significantly from those aged 30-40, 40-50, and 50-60 years. Similarly, all eczema groups showed significant differences compared to all control groups, with the 10-20 year old control group differing significantly from the 20-30, 30-40, and 50-60 year old control groups. Lymphocyte levels were significantly elevated in the 40-50 age group of eczema patients (mean ± SD: 3.615 ± 1.181) compared to controls (2.150 ± 0.112). This finding aligns with previous research demonstrating a correlation between eczema severity, inflammation, and elevated lymphocyte counts in younger populations (Inokuchi-Sakata et al., 2021; Čelakovská et al., 2023). The observed increase in lymphocyte levels among younger eczema patients may be attributed to their higher occupational exposure to potential skin irritants (Brans et al., 2015). Conversely, the lowest lymphocyte count was observed in the 30-40 age group (1.820 ± 0.224) of eczema patients, which was significantly different from the control group ($P<0.05$). Figure 18 graphically illustrates these significant differences in lymphocyte levels between specific age groups in both eczema patients and controls.

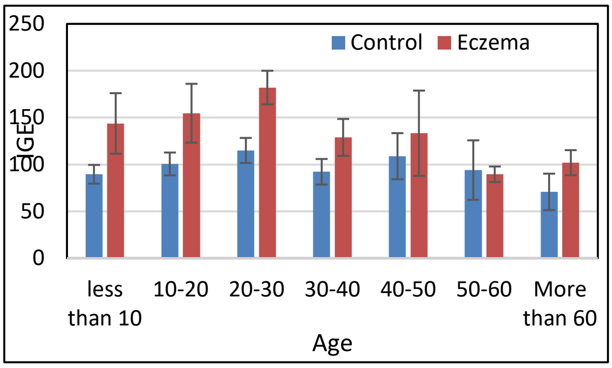

Figure 13. IGE in Eczema Relative to the age

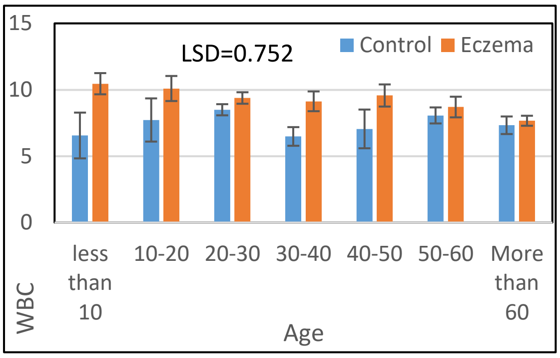

Figure 14. WBC in Eczema Relative to the age

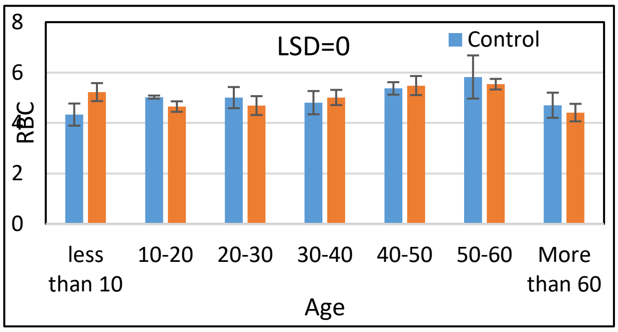

Figure 15. RBC In Eczema Relative to the age

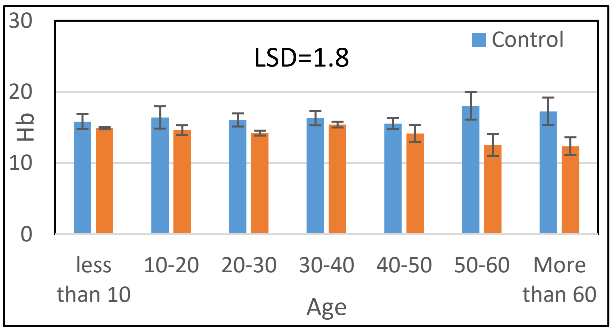

Figure 16. Hemoglobin In Eczema Relative to the age

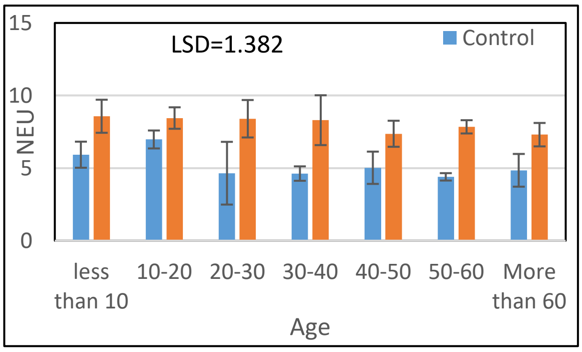

Figure 17. Neutrophils In Eczema Relative to the age

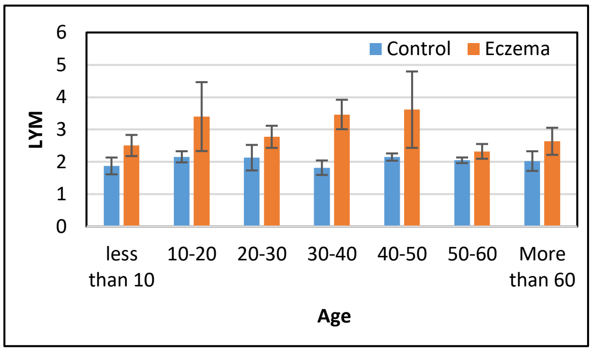

Figure 18. Lymphocytes In Eczema Relative to the age

IgE levels were significantly elevated in the 10-20 age group (adolescents and adults) (113.915 ± 0.485) compared to other age groups ($p > 0.05$, $p = 0.726$). Conversely, the lowest IgE levels were observed in the over-60 age group (85.658 ± 0.206), with significant differences noted ($p < 0.05$, $p = 0.314$) Figure 19. These findings align with previous research indicating a higher prevalence of IgE-mediated allergies in younger individuals. (Hollams et al., 2010) proposed a mechanism linking bacterial infections, T-cell dysregulation, and elevated IgE levels in allergic adolescents, which is consistent with our observations. Additionally, (Bozek & Jarzab, 2013) reported increased IgE levels in the 50-60 age group associated with Artemisia and grass allergies. Our study did not specifically investigate allergen types, the overall trend of decreasing IgE levels with age is supported by our findings. A significant correlation was observed between the control group aged 10-20 and both the younger (less than 10) and older (over 60) control groups, as well as their corresponding eczema cohorts.

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A significant elevation in white blood cell (WBC) count was observed in allergy patients, with the most pronounced increase in children under 10 years (8.963 ± 1.178) compared to the control group (5.838 ± 1.327). This finding aligns with previous research suggesting that exposure to environmental pollutants, such as organochlorine compounds, can influence immune responses and elevate WBC levels in children, particularly those with allergic disorders (Karmaus et al., 2021). However, our results contradict those of (Kutluğ et al., 2002), who reported no significant differences in WBC levels between patients and controls in the 5-18 age group. Statistically significant differences ($p < 0.05$, $p = 0.008$) were noted in WBC counts across different age groups. The 30-40 age group exhibited the lowest WBC level (5.278 ± 0.711) without significant variation ($p = 0.522$) Figure 20. Correlational analysis revealed significant associations between all allergy patient groups and all control age groups, with specific subgroups demonstrating stronger correlations. Notably, the control group aged 10-20 exhibited significant differences compared to those aged less than 10, 30-40, and 40-50. Additionally, significant correlations were found between the control groups aged 20-30 and 50-60, as well as between the less than 10, 10-20, 20-30, and 40-50 groups and the 30-40, 50-60, and over 60 groups.

The highest mean red blood cell (RBC) count was observed in the 40-50 age group (6.440 ± 0.962). These findings contrast with the study by (Van Den Heuvel et al., 2002), Which reported normal RBC-to-WBC ratios in young individuals exposed to dioxin-like and polychlorinated vinyl compounds. This suggests that the impact of these compounds on immune responses might be less pronounced. A significant difference ($p<0.05$) was found in RBC counts between allergy subjects and controls, with the lowest mean RBC count observed in the under-10 age group of allergy subjects (4.622 ± 0.345) compared to controls (4.335 ± 0.438) ($p=0.332$) Figure 21.

Figure 22 illustrates that the highest hemoglobin levels were observed in the 40-50 age group (18.275 ± 1.575). This finding contrasts with a study by (Dananah et al., 2020), which reported a decrease in hemoglobin levels among allergic rhinitis patients aged 15-60 years, correlating with elevated IL-6 levels. IL-6, a cytokine implicated in immune responses, has been associated with a cytokine storm, a potentially fatal condition characterized by excessive T-cell activity and interleukin production (Sakashita et al., 2010). However, our data did not reveal a significant correlation between hemoglobin levels and symptom severity, suggesting that clinical assessment of low hemoglobin levels should prioritize inflammatory symptoms rather than solely relying on this parameter (Dananah et al., 2020). Significantly lower hemoglobin levels ($P<0.05$, 0.005) were observed in the 50-60 age group of allergy subjects (12.233 ±1.156) compared to controls (16.975 ±1.895). Conversely, the 40-50 age group exhibited higher hemoglobin levels and was significantly different from all other groups. This group often displays heightened sensitivity to seasonal pollen and dust mite allergies (Sakashita et al., 2010). However, (Tanaka et al., 2014) reported a decrease in sensitivity to these allergens in the 20-55 age group, contradicting our findings and those of (Sakashita et al., 2010).

As illustrated in Figure 23, the 20-30 age group exhibited the highest neutrophil count (7.783 ± 1.363). This finding aligns with the observation that chronic inflammation can prolong neutrophil lifespan, potentially improving disease prognosis through apoptosis inhibition (Boskabady et al., 2010). A study focusing on aspirin-induced asthma highlighted the role of neutrophils in adult allergic asthma, demonstrating elevated neutrophil activation through increased IL-8 production and CD11p expression (Niemeijer & De Monchy, 1992). The significantly higher neutrophil count ($P<0.05$, $P=0.002$) in the 20-30 age group might be attributed to occupational factors influencing sensitivity parameters, consistent with findings by Kim et al., 2019). Conversely, the control group aged 20-30 showed the lowest neutrophil levels (4.150 ± 0.687). Statistical analysis revealed significant differences between several age groups within both control and allergy patient populations. These findings suggest complex interactions between age, occupation, and immune response in neutrophil levels.

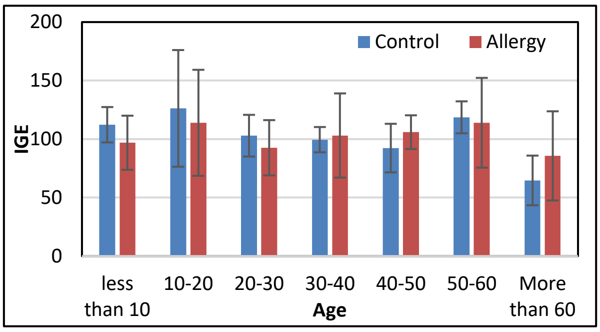

Figure 19. IGE In Allergy related to age

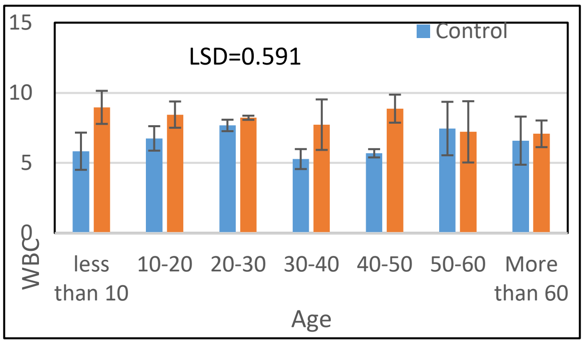

Figure 20. WBC In Allergy In Allergy related to age

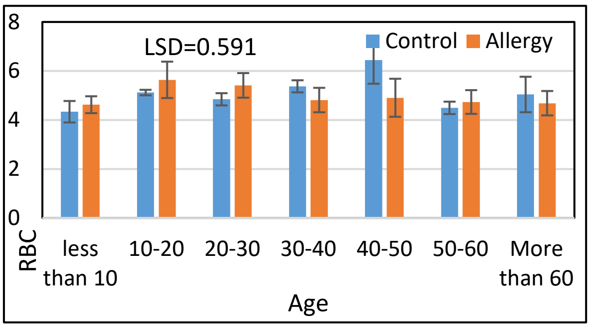

Figure 21. RBC In Allergy related to age

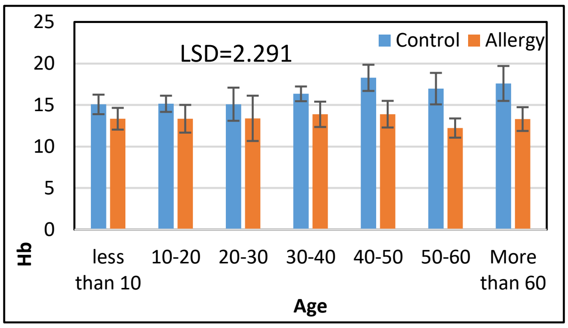

Figure 22. HB in Allergy related to age

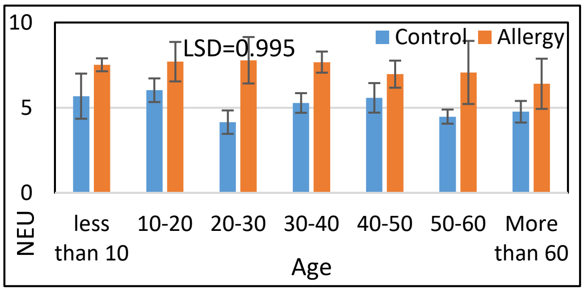

Figure 23. NEU in Allergy related to age

REFERENCES

Pärna, E., Aluoja, A., & Kingo, K. (2015). Quality of life and emotional state in chronic skin disease. Acta dermato-venereologica, 95(3), 312-316.

Harding, A. L., Murdoch, C., Danby, S., Hasan, M. Z., Nakanishi, H., Furuno, T. & Colley, H. E. (2021). Determination of chemical irritation potential using a defined gene signature set on tissue-engineered human skin equivalents. JID Innovations, 1(2), 100011

Lei, D. K., & Grammer, L. C. (2019, November). An overview of allergens. In Allergy & Asthma Proceedings (Vol. 40, No. 6).

Luschkova, D., Traidl-Hoffmann, C., & Ludwig, A. (2022). Climate change and allergies. Allergo Journal International, 31(4), 114-120 .

https://doi.org/10.58614/jahsm471

Wypych-Slusarska, Agata & Niewiadomska, Ewa & Głogowska-Ligus, Joanna. (2022). Asthma, bronchitis respiratory symptoms, allergies and home environment: how are they related?. Advances in Dermatology and Allergology. 39. 10.5114/ada.2021.109696.

Al-Imam, A., Al-Baghdadi, M. H., Abdullah, S. T., Al-Jawhar, S. H., & Michalak, M. (2023). Sleep Disturbances and Female Gender Predict a Poor Quality of Life in Iraqi Contact Dermatitis Patients: A Cross-sectional Study. Journal of Dermatology and Dermatologic Surgery, 27(2), 66-70 .

Morsy, T. A., SHARAF, S. G., & EL-SHAHAT, S. A. (2021). Allergens, public health risks, avoidance and treatment. Journal of the Egyptian Society of Parasitology, 51(3), 647-660 .

Kalayci, O., Miligkos, M., Beltrán, C. F. P., El-Sayed, Z. A., Gómez, R. M., Hossny, E. & Papadopoulos, N. G. (2022). The role of environmental allergen control in the management of asthma. World Allergy Organization Journal, 15(3), 100634 .

Ahluwalia, S. K., & Matsui, E. C. (2018). Indoor environmental interventions for furry pet allergens, pest allergens, and mold: looking to the future. The Journal of Allergy and Clinical Immunology: In Practice, 6(1), 9-19.

AlShatti, K. A., & Ziyab, A. H. (2020). Pet-Keeping in relation to asthma, rhinitis, and eczema symptoms among adolescents in Kuwait: a cross-sectional study. Frontiers in Pediatrics, 8, 331.

Lin, J., Chen, D., Guan, L., Chang, K., Li, D., Sun, B. & Liu, Z. (2022). House dust mite exposure enhances immune responses to ovalbumin-induced intestinal allergy. Scientific Reports, 12(1), 5216.

Eun Lee, E., Choi, K. Y., Kang, M. J., Lee, S. Y., Yoon, J., Cho, H. J., & Hong, S. J. (2020). Prenatal mold exposure is associated with development of atopic dermatitis in infants through allergic inflammation. Jornal de pediatria, 96, 125-131.

Roesner, L. M., Swiontek, K., Lentz, D., Begemann, G., Kienlin, P., Hentges, F. & Hilger, C. (2021). Atopic dermatitis patients with pet dander sensitization mount IgE and T cell responses to mammalian cystatins including the human self-protein. J Investig Allergol Clin Immunol, 32(5), 5.

Algailany, M., alhadidi, S., & molan, A. L. (2023). Iraqi household cockroaches collected from Diyala Province are potential vectors of medically-important parasites.

Luo, X., Chen, J., Yang, H., Hu, X., Alphonse, M. P., Shen, Y. & Gao, P. (2022). Dendritic cell immunoreceptor drives atopic dermatitis by modulating oxidized CaMKII-involved mast cell activation. JCI insight, 7(5) .

Tayeb, M. M. S. (2023). Cockroach Allergy: Is It Common in Jeddah City. A retrospective study .

Uter, W., Johansen, J. D., Macan, J., Symanzik, C., & John, S. M. (2023). Diagnostics and prevention of occupational allergy in hairdressers. Current Allergy and Asthma Reports, 1-9 .

Beckett, E. M., Miller, E., Unice, K., Russman, E., & Pierce, J. S. (2022). Evaluation of volatile organic compound (VOC) emissions from memory foam mattresses and potential implications for consumer health risk. Chemosphere, 303, 134945.

Fluhr, J., Stevanovic, K., Joshi, P., Bergmann, K. C., Herzog, L. S., Alwaheed, Y.& Zuberbier, T. (2023). Skin physiology, mucosal functions and symptoms are modulated by grass pollen and ozone double exposure in allergic patients. Skin Pharmacology and Physiology, 1-1.

Jusoh, N., Ko, J., & Jeon, N. L. (2019). Microfluidics-based skin irritation test using in vitro 3D angiogenesis platform. APL bioengineering, 3(3) .

Amornruk, N., Siranart, N., Sittiwattanawong, P., Kueanjinda, P., Loplumlert, S.& Wongpiyabovorn, J. (2022). The immediate patch test reaction to fragrance in patients with allergic contact dermatitis to fragrance: A prospective study. Journal of the American Academy of Dermatology, 87(5), 1042-1048.

Isaac, J., & Scheinman, P. L. (2017). Benzalkonium chloride: an irritant and sensitizer. Dermatitis, 28(6), 346-352 .

Liszewski, W., & Warshaw, E. M. (2019). Pigments in American tattoo inks and their propensity to elicit allergic contact dermatitis. Journal of the American Academy of Dermatology, 81(2), 379-385 .

Amsler, E., Aerts, O., Raison-Peyron, N., Debons, M., Milpied, B., Giordano-Labadie, F.& Dermatology Allergy Group (DAG) of the French Society of Dermatology. (2017). Airborne allergic contact dermatitis caused by isothiazolinones in water-based paints: a retrospective study of 44 cases. Contact Dermatitis, 77(3), 163-170 .

Norman, T., Johnson, H., Yu, J., & Adler, B. L. (2023). Is Laundry Detergent a Common Cause of Allergic Contact Dermatitis?. Cutis, 111(4), 172-175 .

Bharti, R., & Sharma, R. (2022). Effect of heavy metals: An overview. Materials Today: Proceedings, 51, 880-885.

Wei, J., Zhang, J., & Ji, J. S. (2019). Association of environmental exposure to heavy metals and eczema in US population: Analysis of blood cadmium, lead, and mercury. Archives of Environmental & Occupational Health, 74(5), 239-251.

Fu, S., Gong, M., & Xing, G. (2023). Relationship between chemical industrial environment and allergic skin diseases. Acta Biochimica Polonica, 70(4), 899-904.

Moon, J. (2020). Cogeneration plant and environmental allergic diseases: is it really an eco-friendly energy source?. Annals of Occupational and Environmental Medicine, 32 .

Raherison, C., Baldi, I., Pouquet, M., Berteaud, E., Moesch, C., Bouvier, G., & Canal-Raffin, M. (2019). Pesticides exposure by air in vineyard rural area and respiratory health in children: a pilot study. Environmental research, 169, 189-195 .

Śpiewak, R., Góra-Florek, A., Horoch, A., Jarosz, M. J., Doryńska, A., Golec, M., & Dutkiewicz, J. (2017). Risk factors for work-related eczema and urticaria among vocational students of agriculture. Annals of Agricultural and Environmental Medicine, 24(4).

Skoet, R., Olsen, J., Mathiesen, B., Iversen, L., Johansen, J. D., & Agner, T. (2004). A survey of occupational hand eczema in Denmark. Contact dermatitis, 51(4), 159-166.

Lam, H. C. Y., Li, A. M., Chan, E. Y. Y., & Goggins, W. B. (2016). The short-term association between asthma hospitalisations, ambient temperature, other meteorological factors and air pollutants in Hong Kong: a time-series study. Thorax, 71(12), 1097-1109 .

https://doi.org/10.58614/jahsm471

Al-Sormy, A. A. Y. A., & Banafa, A. M. (2023). Associations of Exposure to Lead with Hematological Change among Petrol Station Workers in Sana'a City-Yemen. Sana'a University Journal of Medicine and Health Sciences, 17(2) .

Güngördü, N., Kurtul, S., Özdil, A., & Erdoğan, M. S. (2023). Does occupational ionizing radiation exposure in healthcare workers affect their hematological parameters?. Archives of Environmental & Occupational Health, 78(2), 80-87 .

Lohsoonthorn, V., Jiamjarasrungsi, W., & Williams, M. A. (2007). Association of hematological parameters with clustered components of metabolic syndrome among professional and office workers in Bangkok, Thailand. Diabetes & Metabolic Syndrome: Clinical Research & Reviews, 1(3), 143-149.

Babio, N., Ibarrola-Jurado, N., Bulló, M., Martínez-González, M. Á., Wärnberg, J., Salaverría, I.& PREDIMED Study Investigators. (2013). White blood cell counts as risk markers of developing metabolic syndrome and its components in the PREDIMED study. PloS one, 8(3), e58354.

Uzoma, I. C., Ugwu, C., Ozoamusi, E., Okhuevbie, D., & Okenwa, C. (2021). Evaluation of human allergen-specific immunoglobulin G, total immunoglobulin E, hematological parameters, and lung function in mill workers exposed to grain dust in South-East Nigeria. The Egyptian Journal of Chest Diseases and Tuberculosis, 70(1), 128-134.

Alfadaly, N., Aboul-Hagag, K. E., Al-Robaee, A., Al Shobaili, H., & Azoliban, A. (2016). Toxicological Study on the Health Effects of Long Term Exposure To Benzene in Benzene Filling Workers, Qassim Region, Ksa. The Egyptian Journal of Forensic Sciences and Applied Toxicology, 16(1), 81-94.

Dakieva, K. Z., Tsyganov, A. P., Egorina, A. V., Sharipkhanova, A. S., Sedelev, V. A., Sadykanova, G. E., & Chursin, A. S. (2020). The effect of work environment on the biochemical profile of workers operating at the Ust-Kamenogorsk Titanium and Magnesium Plant. Toxicology and Industrial Health, 36(8), 591-603.

Kazi, T. G., Baloch, S., Baig, J. A., Afridi, H. I., & Arain, M. B. (2021). Evaluate the adverse impact of metal oxide on workers of different age groups that engage with gas metal arc welding process: health risk assessment. Environmental Science and Pollution Research, 28, 8652-8661.

Zalat, M. M. A. A. (2011). Dermatoses and Hematological Disorders Among car Mechanics in Zagazig City and their Effects on Quality of Life .

García-García, C. R., Parrón, T., Requena, M., Alarcón, R., Tsatsakis, A. M., & Hernández, A. F. (2016). Occupational pesticide exposure and adverse health effects at the clinical, hematological and biochemical level. Life sciences, 145, 274-283 .

Kim, Y. M., Kim, J., Ha, S. C., & Ahn, K. (2021). Effects of exposure to indoor fine particulate matter on atopic dermatitis in children. International Journal of Environmental Research and Public Health, 18(21), 11509 .

Nejatifar, F., Abdollahi, M., Attarchi, M., Roushan, Z. A., Deilami, A. E., Joshan, M., ... & Kojidi, H. M. (2022). Evaluation of hematological indices among insecticides factory workers. Heliyon, 8(3) .

Braun-Fahrländer, C. H., Gassner, M., Grize, L., Neu, U., Sennhauser, F. H., Varonier, H. S., ... & Wüthrich, B. (1999). Prevalence of hay fever and allergic sensitization in farmer's children and their peers living in the same rural community. Clinical and experimental allergy, 29(1), 28-34.

Shamji, M. H., Valenta, R., Jardetzky, T., Verhasselt, V., Durham, S. R., Würtzen, P. A., & van Neerven, R. J. (2021). The role of allergen‐specific IgE, IgG and IgA in allergic disease. Allergy, 76(12), 3627-3641 .

Hossain, M. A., & Islam, L. N. (2016). Effect of occupational exposure on allergic diseases and relationship with serum IgE levels in the tannery workers in Bangladesh. Bioresearch Communications-(BRC), 2(1), 158-163.

Spierenburg, E. A., Smit, L. A., Krop, E. J., Heederik, D., Hylkema, M. N., & Wouters, I. M. (2017). Occupational endotoxin exposure in association with atopic sensitization and respiratory health in adults: Results of a 5-year follow-up. Plos one, 12(12), e0189097 .

Oko'Ose, J. N., & Oko-Ose, N. O. (2023). Comparative Study of Haematological Parameters in Exposed Fossil Fuel Bakery Workers and Administrative Officers of a Government Ministry in Benin City Nigeria. Journal of Medical and Basic Scientific Research, 4(1-2), 57-63 .

Krawczyk-Szulc, P., Wiszniewska, M., Pałczyński, C., Nowakowska-Świrta, E., Kozak, A., & Walusiak-Skorupa, J. (2014). Occupational asthma caused by samba (Triplochiton scleroxylon) wood dust in a professional maker of wooden models of airplanes: A case study. International journal of occupational medicine and environmental health, 27, 512-519 .

Frei, R., Roduit, C., Bieli, C., Loeliger, S., Waser, M., Scheynius, A. & As Part Of The Parsifal Study Team. (2014). Expression of genes related to anti-inflammatory pathways are modified among farmers' children. PloS one, 9(3), e91097 .

Yaqub, S. A., Rahamon, S. K., & Arinola, O. G. (2014). Haematological and immunological indices in Nigerian farmworkers occupationally exposed to organophosphate pesticides. European Journal of General Medicine, 11(2), 109-114.

Getu, S., Shiferaw, E., & Melku, M. (2020). Assessment of hematological parameters of petrol filling workers at petrol stations in Gondar town, Northwest Ethiopia: a comparative cross-sectional study. Environmental health and preventive medicine, 25, 1-9 .

Kent B.D., Mitchell P.D. and McNicholas W.T. (2011). Hypoxemia in patients with COPD: cause effects, and disease progression. International Journal of COPD, 6: 199–208 .

Teklu, G., Negash, M., Asefaw, T., Tesfay, F., Gebremariam, G., Teklehaimanot, G & Tsegaye, A. (2021). Effect of gasoline exposure on hematological parameters of gas station workers in Mekelle City, Tigray Region, Northern Ethiopia. Journal of blood medicine, 839-847 .

Mattia, G. D., Bravi, M. C., Laurenti, O., Luca, O. D., Palmeri, A., Sabatucci, A., & Ghiselli, A. (2004). Impairment of cell and plasma redox state in subjects professionally exposed to chromium. American journal of industrial medicine, 46(2), 120-125 .

Bono, R., Romanazzi, V., Pirro, V., Degan, R., Pignata, C., Suppo, E., & Vincenti, M. (2012). Formaldehyde and tobacco smoke as alkylating agents: the formation of N-methylenvaline in pathologists and in plastic laminate workers. Science of the Total Environment, 414, 701-707 .

Hayat, K., Afzal, M., Aqueel, M. A., Ali, S., Khan, Q. M., & Ashfaq, U. (2018). Determination of insecticide residues and their adverse effects on blood profile of occupationally exposed individuals. Ecotoxicology and Environmental Safety, 163, 382-390.

https://doi.org/10.58614/jahsm471

Nacira, D., Dhiaeddine, A., & Mondher, F. (2018). Contribution to Study of Paint Solvents' Toxicity Among Building Workers. International Journal of Pharmaceutical Research & Allied Sciences, 7(2).

Nynäs, P., Vilpas, S., Kankare, E., Karjalainen, J., Lehtimäki, L., Numminen, J. & Uitti, J. (2023, March). Laboratory Test Results in Patients with Workplace Moisture Damage Associated Symptoms—The SAMDAW Study. In Healthcare (Vol. 11, No. 7, p. 971). MDPI .

Akpinar-Elci, M., White, S. K., Siegel, P. D., Park, J. H., Visotcky, A., Kreiss, K., & Cox-Ganser, J. M. (2013). Markers of upper airway inflammation associated with microbial exposure and symptoms in occupants of a water-damaged building. American journal of industrial medicine, 56(5), 522-530.

Rezaei, N., Farhoudi, A., Pourpak, Z., Aghamohammadi, A., Moin, M., Gharagozlou, M. & Mahmoudi, M. (2004). Neutropenia in patients with primary antibody deficiency disorders. Iranian Journal of Allergy, Asthma and Immunology, 77-82.

Salama, L. A. M., Mahfouz, T. A. E. H., Sileem, A. E. S., & Said, M. W. (2022). Skin Prick Test Results and Total IgE Levels of Asthma Patients in Zagazig University Hospital (2015-2019). The Egyptian Journal of Hospital Medicine, 86(1), 707-713 .

Kumar, R., Sharan, N., Kumar, M., Bisht, I., & Gaur, S. N. (2012). Pattern of skin sensitivity to various aeroallergens in patients of bronchial asthma and/or allergic rhinitis in India. Indian Journal of Allergy, Asthma and Immunology, 26(2), 66-72 .

Rasdeed, E. M., & Al-Khazraji, S. M. (2018). Immunological Study in A Sample of Patients with Atopic Dermatitis in Baghdad. Iraqi Journal of Community Medicine, 31(3).

Yuqing Hu, Y., Liu, S., Liu, P., Mu, Z., & Zhang, J. (2020). Clinical relevance of eosinophils, basophils, serum total IgE level, allergen-specific IgE, and clinical features in atopic dermatitis. Journal of Clinical Laboratory Analysis, 34(6), e23214.

Tanei, R. (2015). Clinical characteristics, treatments, and prognosis of atopic eczema in the elderly. Journal of Clinical Medicine, 4(5), 979-997.

Seo, E., Yoon, J., Jung, S., Lee, J., Lee, B. H., & Yu, J. (2019). Phenotypes of atopic dermatitis identified by cluster analysis in early childhood. The Journal of dermatology, 46(2), 117-123 .

Al-asady, H. M. K., & Al-Rubaeaee, A. A. (2023). Determination Of The Level Of Vitamin D And White Blood Cell Count In Patients With Eczema. World Bulletin of Public Health, 21, 112-116 .

Piscazzi, F., Gargiulo, L., Ibba, L., Valenti, M., Facheris, P., Costanzo, A., & Narcisi, A. (2023). Upadacitinib for the treatment of atopic dermatitis in the elderly: an Italian case series of seven patients. Journal of Dermatological Treatment, 34(1), 2245510.

Hoxha, S., Fida, M., Malaj, R., & Vasili, E. (2020). Erythroderma: a manifestation of cutaneous and systemic diseases. EMJ Allergy Immunol, 1-8.

Su, W. J., Fang, S., Chen, A. J., & Shan, K. (2015). A case of crusted scabies combined with bullous scabies. Experimental and Therapeutic Medicine, 10(4), 1533-1535.

Dayag, D. B., Shaikh, N., Lee, P., & Granet, K. (2019). Dupilumab-associated acquired hemophilia a in an elderly male with severe eczema. Journal of Medical Cases, 10(7), 206-208.

Dogru, M., & Citli, R. (2017). The neutrophil-lymphocyte ratio in children with atopic dermatitis: a case-control study. Clin Ter, 168(4), e262-e265.

Brodin, P., Jojic, V., Gao, T., Bhattacharya, S., Angel, C. J. L., Furman, D. & Davis, M. M. (2015). Variation in the human immune system is largely driven by non-heritable influences. Cell, 160(1), 37-47.

Huang, P. W., Tseng, Y. H., & Tsai, T. F. (2020). Predictive value of NUDT15 variants on neutropenia among Han Chinese patients with dermatologic diseases: a single-center observational study. Dermatology and Therapy, 10, 263-271.

Inokuchi-Sakata, S., Ishiuji, Y., Katsuta, M., Kharma, B., Yasuda, K. I., Tominaga, M. & Asahina, A. (2021). Role of eosinophil relative count and neutrophil-to-lymphocyte ratio in the assessment of severity of atopic dermatitis. Acta Dermato-Venereologica, 101(7) .

Čelakovská, J., Čermáková, E., Boudková, P., Andrýs, C., & Krejsek, J. (2023). Evaluation of Leukocytes, B and T Lymphocytes, and expression of CD200 and CD23 on B lymphocytes in Patients with Atopic Dermatitis on Dupilumab Therapy—Pilot Study. Dermatology and Therapy, 13(5), 1171-1192 .

Brans, R., Hübner, A., Gediga, G., & John, S. M. (2015). Prevalence of foot eczema and associated occupational and non-occupational factors in patients with hand eczema. Contact Dermatitis, 73(2), 100-107.

Hollams, E. M., Hales, B. J., Bachert, C., Huvenne, W., Parsons, F., De Klerk, N. H., ... & Holt, P. G. (2010). Th2-associated immunity to bacteria in teenagers and susceptibility to asthma. European Respiratory Journal, 36(3), 509-516 .

Bozek, A., & Jarzab, J. (2013). Epidemiology of IgE-dependent allergic diseases in elderly patients in Poland. American journal of rhinology & allergy, 27(5), e140-e145.

Karmaus, W., Brooks, K. R., Nebe, T., Witten, J., Obi-Osius, N., & Kruse, H. (2005). Immune function biomarkers in children exposed to lead and organochlorine compounds: a cross-sectional study. Environmental Health, 4, 1-10 .

Kutluğ, Ş., Söğüt, A., Paksu, Ş., Sancak, R., Murat, N., Günbey, E., & Karli, R. (2021). The role of mean platelet volume as an inflammatory marker in children with allergic rhinitis. West Indian Medical Journal, 69(6) .

Van Den Heuvel, R. L., Koppen, G., Staessen, J. A., Hond, E. D., Verheyen, G., Nawrot, T. S., ... & Schoeters, G. E. (2002). Immunologic biomarkers in relation to exposure markers of PCBs and dioxins in Flemish adolescents (Belgium). Environmental Health Perspectives, 110(6), 595-600 .

Dananah, F. M., Ghafil, N. Y., & Al-Katib, S. R. (2020). Association of Hemoglobin Level with Clinical Severity and other Disease Markers in Patients with Allergic Rhinitis. Age (years), 30(10.95), 13-60 .

Sakashita, M., Hirota, T., Harada, M., Nakamichi, R., Tsunoda, T., Osawa, Y., & Fujieda, S. (2010). Prevalence of allergic rhinitis and sensitization to common aeroallergens in a Japanese population. International archives of allergy and immunology, 151(3), 255-261.

Tanaka, T., Narazaki, M., & Kishimoto, T. (2014). IL-6 in inflammation, immunity, and disease. Cold Spring Harbor perspectives in biology, 6(10), a016295 .

https://doi.org/10.58614/jahsm471

Niemeijer, N. R., & De Monchy, J. G. R. (1992). Age-dependency of sensitization to aero-allergens in asthmatics. Allergy, 47(4), 431-435.

Kim, S. H., Uuganbayar, U., Trinh, H. K. T., Le Pham, D., Kim, N., Kim, M., ... & Park, H. S. (2019). Evaluation of neutrophil activation status according to the phenotypes of adult asthma. Allergy, Asthma & Immunology Research, 11(3), 381.

Boskabady, M. H., Rezaiyan, M. K., Navabi, I., Shafiei, S., & Arab, S. S. (2010). Work-related respiratory symptoms and pulmonary function tests in northeast iranian (the city of Mashhad) carpenters. Clinics, 65, 1003-1007.

Silvestre-Roig, C., Hidalgo, A., & Soehnlein, O. (2016). Neutrophil heterogeneity: implications for homeostasis and pathogenesis. Blood, The Journal of the American Society of Hematology, 127(18), 2173-2181.