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Original Article

The Correlation Between Blood Lead Levels And Iron Deficiency Anaemia In Paediatric Population

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ABSTRACT

Objective: To determine a correlation between blood lead levels and iron deficiency anemia among the primary school-aged kids of Pakistan.

Study Design: Cross-sectional Analytical Study.

Place and Duration of Study: Military Hospital Rawalpindi, Pakistan from Jan 2019 to Dec 2019.

Methodology: Venous Blood samples were drawn for estimating Iron, Ferritin, Lead levels and otherhematological parameters as well. Anemia was further stratified into mild, moderate, and severe by correlating it with lead levels.

Results: 300 cases were enrolled in with a mean age of 8.39±2.09 years. Two groups were formulated-e with Blood Lead Levels <10 µg/dl in 110(36.6%) and >10 µg/dl in 190(63.4%). The blood iron and ferritin levels were recorded lower (49.1±19.1 and 51.5 ± 24.5respectively) ((*p*-value <0.05), in cases with blood lead levels ≥10 µg/dl whereas mean values for iron and ferritin in group with blood lead levels <10 µg/dl were 61.02±21.31 and 78.61±24.68 respectively. The severity of anemia was proportionate with the blood levels of lead with 5(4.5%) and 40(21.1%) in <10 µg/dl and ≥10 µg/dl groups respectively (*p*-value <0.001).

Conclusion: Lead poisoning is becoming a major cause of iron deficiency anemia and other hematological problems. Due to this recognition, we want to establish a protocol in our hospital for early detection of lead levels in case of iron deficiency and highlight this issue so that departmentsof Pakistan should implement effective reforms to combat this nutritional and environmental hazard.

Keywords: Anemia, Deficiency, Iron, Lead.

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INTRODUCTION

Leaded petrol and gasoline are the prime sources of environmental pollution. Drinking from lead pipes is also another cause. Intake of old leaded paint, pigments and glazes whichare used in pottery lead to exposure at home. Informal disposal of goods containing lead may pollute soil, especially in cityareas. All these lead to systemic manifestations (such as renal, hematological, neurological, and cardiovascular dysfunction).[1,2]

The United States and developed countries seriously pursued hazards associated with elevated lead levels consequently achieving a reduction of lead levels by 80% in the pediatric population since the 1970s.But this dilemma is consistent in developing countries such as Pakistan.[3] As per analysis carried out from 1989 -94 on blood lead levels, mean values of 38.2 µg/dl were reported from Karachi as compared to 2.3 µg/dl in Islamabad owing to the variability of environmental pollution and traffic density. Even within the city population children belonging to higher traffic zone presented with higher mean values (16.46 µg/dl) as compared to less density zone (12.0 µg/dl) in Karachi. Furthermore, mean values of 16.5 µg/dl and 10.8 µg/dl among school-going children and newborns respectively were reported. In Pakistan, efforts in hand were established to make in 1988 to label raised lead levels as a matter of environmental and public health concern therefore attention was paid to phasing out lead from petrol in 2001.[4,5]

The World Health Organization defined hemoglobin levels < 11 g/dl as anemia. Hypo chromic microcytic anemia due to low iron reserves instigate lead absorption and resultantly decreases hemoglobin, thus initiating a vicious cycle. Lead is a competitive inhibitor of iron absorption and disrupts heme synthesis. Thereby adversely affecting cognition and intellectual abilities of children adding to mortality and morbidity.[6,7]

The Centre for Diseases Control and Prevention gave guidelines in 1991 according to which lead poisoning in children defined as having blood lead level of ≥10µg/dl,[8] whereas the United States

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Environmental Protection Agency marked a level of 20–40 µg/dl asa threshold level of anemia in children.[9]

The rationale of this study is to determine the correlation between blood lead levels and iron deficiency anemia in the pediatric population of Pakistan due to the high pervasiveness of lead pollution.Due to increased environmental hazards, lead levels are consistently on the rise with adverse impact on hematological parameters as quoted by literature consequently retarding mental and physical growth of pediatric age group.[10]

METHODOLOGY

The Cross-sectional Study was executed at Military Hospital Rawalpindi, Pakistan over a period of 01 year from Jan 2019to Dec 2019 after taking consent from ethical review board (IERB EC/386). Sample size calculated was286. Prevalence ofsevere anemia in relation with lead levels was projected to be 75.3%with a confidence level of 95% and 5% margin of error as reported byJain *et al*.[11] With non-probability consecutive sampling, a total of 300 participants were enrolled in the study.

Inclusion Criteria: Healthy children of age range 6 – 12years, school going ,whose parentsprovided informed written consent were included in the study.

Exclusion Criteria: Children whose parents did not provide consent, with chronic diseases and hematological disorders (such as thalassemia, hemoglobinopathies) were excluded.

Literacy levels, Socio-demographic and socio economic profileswere obtained from the accompanying mother or father. Participants were divided into two groups <10 µg/dl and ≥10 µg/dl on the basisof serum lead level. They were further segregated into batches of mild (10-10.9g/dl), moderate (8- 9.9g/dl), and severe (< 8g/dl) anemia based on hemoglobin levels. Sterile disposable 5ml syringeswere used to draw three venous blood samples to determine complete blood counts (Ethylenediaminetetraacetic acid sample bottle), serum lead levels (Heparin sample bottle),and serum ferritin/iron levels.Celttacauto-analyzer was used to estimate. Hematological parameters like Hemoglobin, Hematocrit, Red blood cell count, Mean corpuscular hemoglobin Mean corpuscular volume, Mean corpuscular hemoglobin concentration. HGA graphite furnace atomic absorption spectrophotometer was used to analyze lead levels.

Data was entered and analyzed with Statistical Package for the social sciences (SPSS) version 23.00. Frequency and percentage were offered asthe descriptive statistics for the categorical variable while the mean and standard deviation was reported for continuous variables;independent sample t-test was tooled for comparative analysis.Chi-square test was used to compare the categorical groups.A significance value of ≤0.05 was considered significant.

RESULTS

A total of 300 patients enrolled in the study with a mean age of 8.39±2.09 years (6 to12 years). The cohort was divided into two groups based on lead levels with Blood Lead Levels <10 µg/dl in 110(36.6%) and ≥10 µg/dl in 190(63.4%) participants. A greater number of participants in age group >9 years old,urban areas, and males deciphered higher blood lead levels but were not statistically noteworthy (*p*-value > 0.05) as enumerated in (Table-I).The severity of anemia was proportionate with the blood levels of lead with 5(4.5%) and 40(21.1%) in <10 µg/dl and ≥10 µg/dl groups respectively (Table-II).The blood iron and ferritin levels were recorded lower (49.08±19.09 and 51.54±24.49 respectively), in children with blood lead levels ≥10 µg/dl whereas mean values reported in a group with blood lead levels <10 µg/dl were 61.02±21.31 and 78.61±24.68 for iron and ferritin respectively (Table-4).

Table-I: Socio-demographic Characteristics

		Blood Lead Levels (<10 µg/dl) n=110	Blood Lead Levels (≥10 µg/dl) n=190
Age	≥9years	45(41.0%)	100(52.6%)
	≤9years old	65(59.0%)	90(47.4%)
Sex	Male	45(41.0%)	115(60.5%)
	Female	65(59.0%)	75(39.5%)
Residential Profile	Urban	60(54.5%)	100(52.6%)
	Rural	50(45.5%)	90(47.4%)

Table-II: Association of Anemia with Blood Lead Levels

Hemoglobin Profile	Blood Lead Levels (<10 µg/dl) n=110	Blood Lead Levels (≥10 µg/dl) n=190	*p*-value
No anemia (≥10.9 g/dl)	80(72.7%)	70(36.8%)	<0.001
Mild anemia (>9.9-10.9 g/dl)	5(4.6%)	55(28.91%)	
Moderate anemia(8-9.9 g/dl)	20(18.23%)	25(13.12%)	
Severe anemia: (< 8 g/dl)	5(4.54%)	40(21%)	

Table-III: Hematological Parameters

	Blood Lead Levels (<10 µg/dl) n=110	Blood Lead Levels (≥10 µg/dl) n=190	*p*-value
RBC (×106 mm3)	4.1 ± 0.5	4.2 ± 0.3	0.08
Hemoglobin (g/dl)	9.0 ± 0.9	12.2 ± 0.4	<0.001
Hematocrit	28.6± 2.3	36.6 ± 2.0	<0.001
Mean corpuscular volume(µ3)	70.1 ± 14.8	81.5 ± 6.7	<0.001
Mean corpuscular hemoglobin	21.8± 3.2	27.1 ± 1.2	<0.001
Mean corpuscular hemoglobin concentration	31.4 ± 1.9	33.6 ± 1.9	<0.001

Table-IV: Comparison of Serum Iron and Ferritin Mean Values with Blood Lead Levels

	Blood Lead Levels (<10 µg/dl) Mean ± SD	Blood Lead Levels (≥10 µg/dl) Mean ± SD	*p*-value
Serum Iron (µg/dl)	64.66±10.25	44.74±9.27	0.000
Ferritin (ng/ml)	82.46±12.64	51.49±11.90	0.000

DISCUSSION

This study elucidated that a greater number of participants in age group >9 years old, urban areas, and males deciphered higher blood lead levels all etiological factors supporting the negative impact of traffic density and exposure to the polluted environment on the health of children.

Jain NB *et al* studied Indian children< 5 years old and analyzed relation between blood lead levels and anemia. He found correlation due to similar traffic, population, and developmental dilemmas of South Asian countries. Children had 1.3 and 1.7 times greater probability to develop moderate and severe anemia if their blood lead levels are≥10 µg/dl) as compared to children with blood lead levels (<10 µg/dl).[11]

Hegazy et al did a slightly different study in which he enumerated a correlation of anemia with blood level of other metals (lead, copper, zinc, and iron) among children. Findings of this study warrants the need for more extended research as compared to this study to derive possible correlation.63.33% of the study participants had blood lead levels ≥ 10 µg/dl with greater preponderance for anemia and lower iron and ferritin levels. Findings consistent with this study as the blood iron and ferritin levels were recorded lower (49.08±19.09 and 51.54±24.49 respectively), in children with blood lead levels ≥10 µg/dl whereas mean values reported in a group with blood lead levels less than 10 µg/dl were 61.02±21.31 and 78.61±24.68 for iron and ferritin respectively.[12]

Shah F et al. conducted a cross-sectional study to estimate the association of environmental exposure of lead and iron deficit anemia preschool children primarily attending the pediatric patient department of Karachi. The blood lead levels prevalent in severely anemic (53%) children were (100-200µg/L). The significant negative correlations of blood lead level with hemoglobin percent and ferritin/iron content (*p*-value <0.001) were recorded in anemic children.[13]

Iron deficiency and lead poisoning areone of the most prevalent scenarios in developing countries owing to urbanization, leaded fuels, etc. which retard growth of children during their growing period due to disproportionate demand and consumption profile of iron thus leading to mental, cognitive, and physical growth retardation. However, the aim can be achieved with iron supplementation.[14]

Keramati MR et al. conducted study on 223 Iranian children with blood lead concentrationsof 57.1±25.3 µg/dl and 57±20.4 µg/dl in control and cases grouprespectively in order to find the correlation between blood lead concentration and iron deficiency.However they failed to find any significance andrelationship between blood lead levels and anemia (*p*-value 0.17), These findings areconflicting to this study where a significant association was derived (*p*-value <0.001).[15]

Rondó PH et al did study on Brazilian pediatric population aged 2-11 yearsliving near a lead-manipulating industry, and analyzed iron deficiency anemia and blood lead concentrations. He concluded negative associations between blood lead levels and home distance from the industry(*p*-value <0.001), hemoglobin(*p*-value 0.019), and ferritin ((*p*-value 0.023).[16]

Zareifar S *et al* investigated the association between blood lead level and microcytic hypochromic anemia in children with normal and deficient ferritin levels. He was not able to define the threshold of blood lead levels responsible for anemia in the pediatric population.[17]

Hershko *et al*. evaluated iron stores depletion and blood lead levels in the Israeli population. Their report was also not supportive to this study and stated a lack of association between blood iron and lead levels.[18]

It is too essential toeducate parents about the implications of iron deficiency and lead poisoning.

Meticulous efforts, diligent measures and surveillance of affecteeare required for judicious prescription of iron supplements. Enhanced population screening and referral programs should be incorporated in addition to mass awareness campaigns. Legislative authorities should ponder on this consequential subject to eliminate lead from materials such as petrol, paint, food cans, etc.[19]

CONCLUSION

Lead poisoning is becoming a major cause of iron deficiency anemia and other hematological problems. Due to this recognition, we want to establish a protocol in our hospital for early detection of lead levels in case of iron deficiency and highlight this issue so that departments of Pakistan should implement effective reforms to combat this nutritional and environmental hazard.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

HA: & AR: Study design, drafting the manuscript, data interpretation, critical review, approval of the final version to be published.

MF: & KZ: Data acquisition, data analysis, approval of the final version to be published.

UA: & ZG: Critical review, concept, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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