ORIGINAL ARTICLE

Outcome of Iron Deficiency on the Global School Performance of the Children: A case study from Nowshera, Pakistan

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ABSTRACT

Aim: This study was accompanied to decipher the influence of Vitamin A deficiency and Iron Deficiency with and without anemia on the academic performance of school going children, aged 6-14 years, of District Nowshera, KPK, Pakistan.

Methods: A Cross Sectional descriptive study was designed to ponder population of children, appearing in the government schools in the District Nowshera, KPK, to evaluate their nutritional status and its impact on their activities. Blood sample of 5cc was taken, Hemoglobin level was assessed by colorimetric method, the serum Ferritin level and Vitamin A levels were estimated by the commercially available Bio-Check kit and ABO Switzerland ELISA kit, respectively. Children having hemoglobin levels below age specific cutoff value, of 11.5g/dl, were considered anemic while those having ferritin levels <15µg/L were considered having iron deficiency and those with below cutoff value for both Hemoglobin and ferritin were considered as Iron deficient and anemic.

Results: Vitamin A deficiency do not have any effect on cognition of children while iron deficiency with anemia and even without anemia has a significant effect on intellectual activities of children beside lethargy and inability of these children to accomplish physical tasks. Most affected areas of cognition are memory, conceptualization, concentration and non-verbal intellectual activities resulting in low global school performance of these children in Math's and English $r = 0.5$ and $p < 0.05$ respectively.

Conclusion: It is concluded from this study that iron deficiency with or without anemia has a significant correlation with intellectual activities and school performance of the children. Although these effects are more adverse in cases where children are subjected to infant age malnutrition but can be reverse with nutritional supplementary programs and adequate check on dietary habits of the children.

Keywords: Anemia among children, Iron deficiency, Vitamin A deficiency, Cognition,

INTRODUCTION

Micronutrient deficiencies are most rampant deficiencies among developing countries as compared to rest of the world and are contributing to high rates of impermanence[1]. Vitamin A, Iron, Iodine and Zinc are contributing most rigorously to morbidities, especially in pre-school children, by reducing immune and non-immune defenses and by disturbing normal development and cognitive functions of school going children[2].

Twenty one percent of children are suffering from Vitamin A deficiency worldwide, of which 7% belongs to the school age population, that leads to vision impairment and blindness and can even lead to death[3]. Iron deficiency with and without anemia is also common among children. About 2 billion people are suffering from iron deficiency anemia and the number of iron deficient without anemia is much higher, whereas, about 800,000 deaths are globally ascribed to Iron deficiency[4]. Beside all other consequences micronutrient deficiency also results in distress, reduced brain development and thus leads to impairment of academic performance of school-going children[5].

Former studies in the area have not found a direct relation between Vitamin A deficiency and intellectual accomplishment of children, but Iron deficiency and iron deficiency anemia affect cognitive functioning of school going children significantly[6]. Behavioral and motor developmental changes among Iron deficient children can be attributed to depleted iron stores of the body which leads to failure of functioning of iron dependent enzymes and develop fatigue and general ailing state due to short oxygen supply in the body[7].

Iron deficiency has strong influence on four areas of cognitive functioning among school age children it affects memory, conceptualization, concentration and intellectual activities of children and also result in below average scores in academic performance of anemic children as compared to normal for their age[8]. Beside cognitive functioning Iron Deficiency can also lead to anemia, lethargy and

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functional impairment of small bowel, especially in adolescents[9].

Iron deficiency could be an outcome of poor dietary intake or chronic infection, it may also be an indication of celiac diseases, however, infections like malaria, diarrhea and measles could also lead to anemia among children[10].

This study was, got onto compare upshots of Vitamin A deficiency and Iron deficiency with and without anemia on the intellectual outcome of school aged children in district Nowshera of KPK, Pakistan. About 353 students, aged 6-14 Years, enrolled at local schools were registered for the cross sectional descriptive study and contained groups of children with vitamin A deficiency, iron deficiency, iron deficiency with anemia and normal group having none of these impairments, for comparison of average test scores and below average test score achievers.

SUBJECT AND METHODS

In conducting this study an ethical approval was obtained from Shaikh Zayed Postgraduate Medical Institute (SZPGMI) Institutional Review Board (IRB) and Permission for the survey from the District Coordination Officer (DCO) Nowshera and EDO education Nowshera was procured. Education development officer (EDO) identified different schools in district Nowshera in the survey, selection of the schools was done on the basis of availability of school children aged 6-14 years at the time of the survey. Consents were taken from the head of participating schools as well as from the parents or guardians of the children who were supposed to be a part of this survey. Parents/guardians were interviewed to fill up questionnaire, school teachers also acted as translator where required. About 5ml blood was drawn from each child. 1 ml blood was transferred in EDTA tube for estimation of hemoglobin level and 4ml in a red top vacutainer tube for estimation ferritin and vitamin A. Serum was separated by centrifugation at 4000 RPM for 10 minutes and stored at -20^{o}C.

RESULTS

Assessment of Iron Deficiency and Anemia: Hemoglobin of each participant was determined by colorimetric method on the same day of sample collection in the temporary settled laboratory in Nowshera. Hemoglobin cutoff 11.5g/dl as recommended by WHO[11] was used for assessment of anemia for children 8-11 years and a 12.0 g/dl for children 11-14 years. Children with hemoglobin below the age specific cutoff were interpreted as “Anemic”.

Levels of serum ferritin was determined using commercial kits from Bio-Check, Inc. Children in the age group 6-14 years who had serum ferritin less than the cutoff level of<15µg/L were considered iron deficient according to WHO guidelines (2001). Whereas children with both ferritin and hemoglobin below cutoff value were referred to as Iron deficient with anemia.

Assessment of Vitamin A Deficiency: Serum vitamin A levels were estimated using commercially available ELISA kits from ABO Switzerland Co., Ltd. Enrolled study participants with cutoff levels of vitamin A <349nmol/L were considered deficient those with 349-698nmol/L with low and > 698nmol/L were referred as normal.

Assessment of School performance: Class teachers of enrolled children were trained to evaluate the class performance of child and record information’s on already provided evaluation chart. Class teachers were trained to note the average test scores of Mathematics, English, and Urdu, General knowledge and also co-curricular activities and participation in sports. Teachers also recorded intellectual development in the academic survey with the help of guide provided. Four areas of academic growth were evaluated by recording their attention, concentration, memory, conceptualization and anticipation during class for one month. After one month teachers evaluated each child and noted the scores on evaluation chart and posted to NHRC by courier service.

The sum of test scores in each subject evaluated and scores obtained in four areas of intellectual development provided the “Global School Performance (GSP)”. Mean GSPs of the study groups were compared with the iron, vitamin A and hemoglobin status.

Data Entry & Analysis: Data for analysis was entered in IBM STATISTICS 20.0. Initially 360 children were registered for the survey. Data on school performance of 7 children was not reported by school teachers, therefore data of 353 children were analyzed.

Effect of Micronutrient Deficiency on School Performance

Anemia vs Global School Performance: The children selected for survey (n=353) the hemoglobin status of those who were either anemic or non-anemic, it was seen among the non-anemic children (n=222), the Global School Performance was excellent in 49(22.1%), good in 94(42.3%), average in 65(29.3%) and below average in 5(14.3%), whereas among anemic children (n=131) the Global School Performance was excellent in 27(20.6%), good in 44(33.6%), average in 38(29%) and below average in 22(16.8%) respectively. High percentage

of average and below average global school performance was prominent in anemic children when compared with non anemic, presenting a strong relationship between anemia and Global School Performance (χ^2= 10.584, p= 0.017) (Fig. 1).

Test scores of children obtained in different subjects were dichotomized into an above or below average score to compare the percentage of children scoring below average for each category of hemoglobin status (anemic/non-anemic). It was estimated that among children who scored below average test scores in Math's, English, Urdu, & sports, percentage of anemia was significantly higher than those students who obtained higher scores. Subjects in which performance of students was considerably affected by anemia were Math's, English, Urdu and sports (p = 0.010, 0.015, 0.010, & 0.028, respectively). However, it was observed that there is no significant association of anemia with below average scores in general knowledge and co-curricular activities (p = 0.505 & 0.279 respectively). (Table 1)

Iron deficiency vs Global School Performance:

It was seen in children (n=353) among them the ones with normal iron status (n=132), the Global School Performance was excellent in 30(22.8%) good in 52(39.4%), average in 37(28%) and below average in 13(9.8%) respectively, whereas among the children (n=221) who were deficient in iron status, the Global School Performance was excellent in 46 (20.8%), good in 86 (38.9%), average in 66(29.8%) and below average in 23(10.4%) respectively. No correlation was observed between iron deficiency and Global School Performance of enrolled children (χ^2= 0.266, p= 0.966) (Fig. 2).

Above and below average test scores of children secured in different subjects were compared amongst children with respect to iron deficiency and normal iron status. It was assessed that among children who had below average test scores in Maths and English, percentage of iron deficiency was substantially higher than those students who obtained higher scores (p = 0.003 & 0.033) respectively. While iron deficiency posed no effect on below average scores in Urdu, general knowledge, co-curricular activities and sports (p=0.241, 0.148, 1.000 and 0.418) respectively (Table 2).

Iron deficiency with Anemia vs Global School Performance: Among enrolled children (n=353) those with iron deficiency and anemia, it was observed 22(21.5%) scored excellent, 38(37.5%) scored good, 26 (25.5%) scored average and 16(15.7%) scored below average. Whereas, among 111 children with normal iron and hemoglobin levels, it was observed that scores were excellent of 22(19.8%), good in 47(42.3%), average of 33 (29.7%) and below average of 9(8.9%) respectively. It was seen the percentage of children secured below average GSP scores were higher among iron and hemoglobin status. This association was not found statistically significant (χ2=3.369 p=0. 338) (Fig.3).

Further the above and below average test scores secured by children in different subjects were compared according to the combined status of iron and hemoglobin (normal iron with normal hemoglobin and iron deficiency with anemia). It was observed, among children who scored below average test scores in Math's and English, percentage of iron deficiency with anemia was considerably higher than those who obtained higher scores in the same subjects (p = 0.038 & 0.031) respectively. While iron deficiency and anemia showed no effect on below average scores in Urdu, general knowledge and co-curricular activities and sports (p = 0.353, 0.516, 0.649 and 0.590) respectively (Table 3).

Fig. 1: Association of Anemia with Global School Performance χ^2= 10.584, p= 0.017

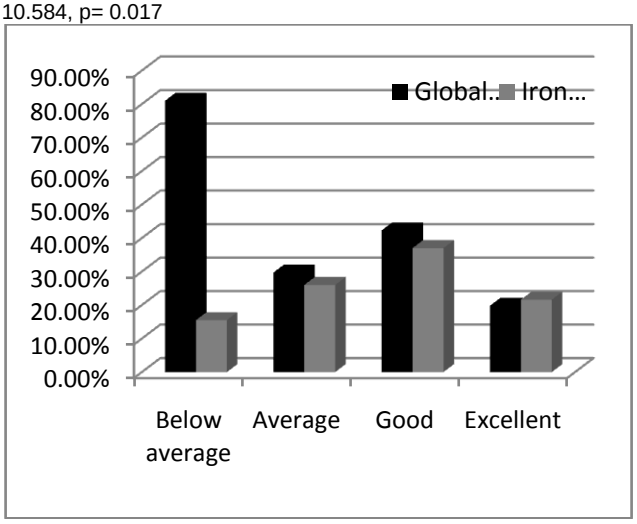

Table 1: Association of Anemia with subject scores

Subjects	χ^2	df	P value
Maths	6.066	1	0.010
English	5.274	1	0.015
Urdu	6.230	1	0.010
General Knowledge	0.502	1	0.505
Co-curricular Activities	0.140	1	0.279
Sports	4.145	1	0.028

Table 2: Association of iron status with subject scores

Subjects	χ^2	df	P value
Math's	8.768	1	0.003
English	4.525	1	0.033
Urdu	1.706	1	0.241
General Knowledge	2.459	1	0.148
Co-curricular Activities	0.011	1	1.000
Sports	0.900	1	0.418

Fig. 2: Association of Iron status with Global School Performance χ^2= 0.266, p= 0.966

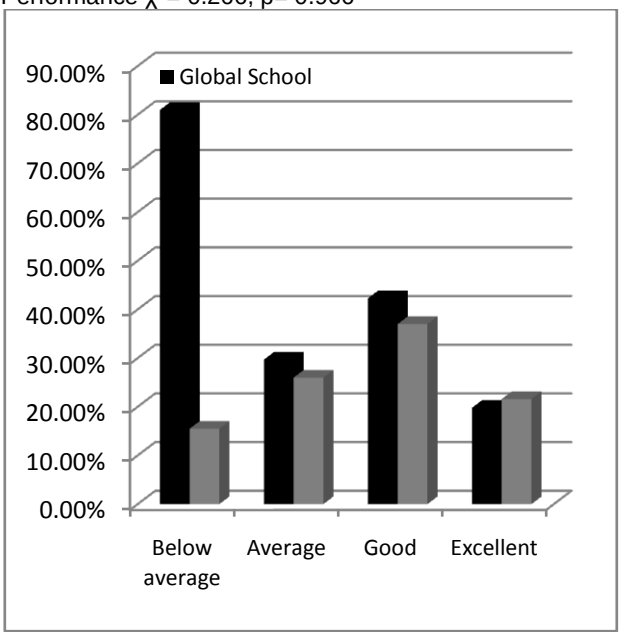

Fig. 3: Association of Iron deficiency with anemia and Global School Performance χ^2= 3.369, p= 0.338

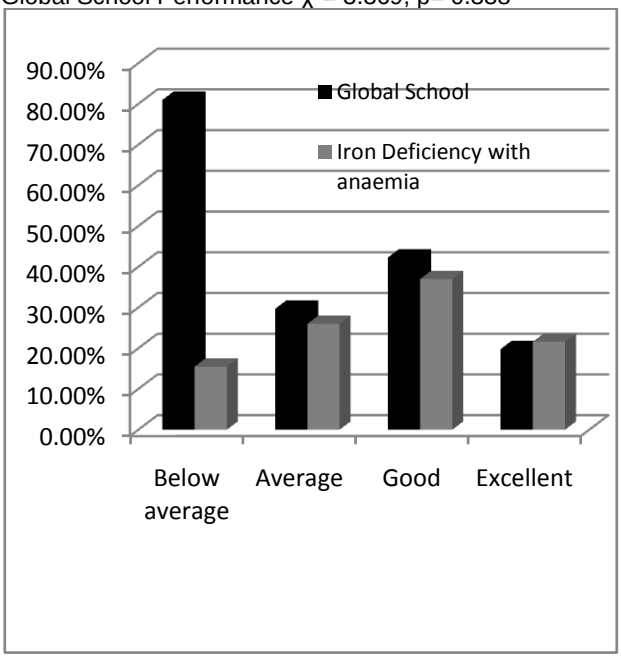

Table 3: Association of Iron deficiency with anemia and below average subject scores

Subjects	χ^2	df	P value
Maths	4.312	1	0.038
English	4.656	1	0.031
Urdu	1.196	1	0.353
General Knowledge	0.636	1	0.516
Co-curricular Activities	0.375	1	0.649
Sports	0.501	1	0.590

DISCUSSION

Iron deficiency, one of the most common malnutrition, affects certain biological functions of the affected population, like physiological and motor activities. It was also the verdicts ofthe former studies in the research area, Kanani et al, reported adversarial effects of iron deficiency on physical and motor activities of adolescent Indian girls facing drop outs at a much higher rate than normal adolescent girls and anemic and non-anemic boys of the same age-group[12]. Abalkhail and Shawky also found an effect of anemia on failure of school examination performance of affected children older than age 12 and uppermost ratio was of pubescent girls than the same age-grouped male students. They also indicated nutritional routines of these adolescents and stated a significant combined effect of skipping breakfast and anemia on the meagre intellectual performance of affected children in schools[13], similar results were also confirmed by Rausch et al[14].

This study was commenced to state the effect of iron deficiency, with and without anemia,on cognition of the school going population of district Nowshera aged 6-14yrs in Pakistan. In this study, a noteworthy effect was observed by Iron deficiency and low Hemoglobin status of the children who were scoring below average global school performances than those who were normal. Similar results have also been reported by Gupta et al., who reported a slight increase in percentage, of Iron deficiency and anemia among children in the United states, is associated with behavioral changes in children[14]. A significant impact of iron deficiency and anemia on the intellect and temperament of children had also reported[15].

It was found in our study, notably, that the children's showing iron deficiency with or without anemia secured below average score in Math's, English and Urdu along with week memory and concentration. It has also confirmed by other researchers of the area that low level of iron even without anemia is responsible for weak memory and reduced mental activities in affected children[16]. The affected children were also not very good at sports and other extracurricular activities. The most plausible effect of impairment of physiological and motor function among anemic children is depleted store of iron in the body, as iron is requisite to produce a number of neurotransmitters such as dopamine, vital for normal functioning of the brain. Moreover, deficiency of oxygen to the tissues causes exhaustion and lethargy and inability to perform subsidiary activities[7,17].

Those children who have a high Iron deficiency and low hemoglobin status showed below average scores in their academic performance, especially in

the subjects related to critical thinking like Mathematics and English r=0.5 and p<0.05. Concentration and memory were the two most affected areas of cognition among anemic children as compared to control group (children with normal hemoglobin status), p 0.045 and 0.049 respectively. It has also been reported by Falkinghamet that iron deficient children have low scores in global performance and impaired cognition, and an improved cognitive response has been observed with iron supplement intake on a regular basis[18].

Same consequences were also reported by Halterman et al, who took school aged children and adolescents, as samples in his Nationwide study, to demonstrate effect of low hemoglobin and anemia on cognition of these participants and recorded direct effect of low hemoglobin and anemia on low standardized Math's score even in those children and adolescents which have iron deficiency without anemia. In another observational study, conducted by NHANES III survey in the United States, direct impact of iron status was demonstrated on academic performance of 5398 children aged 6-16 years involved in the study[19]. Most probable cause of impairment of cognition in iron deficient children is the cerebral cortex part of the brain, which becomes fatigued due to short supply of oxygen and iron for proper functioning of this part, and it starts even before red blood cell production is disrupted and anemia develops. As most of the complex functions of brain like memory, anticipation, language skills and healthy physical activities are under the control of cerebral cortex, so affected individuals are prone to instability of corporeal and motor activities[20], as it is also observed in this study, children with a high iron deficiency, even without anemia, were most indolent and accomplishing low grade scores in subjects related to critical thinking.

Nader et al, also found an irrevocable outcome of Iron deficiency on intellectual, physical and Co-curricular activities of school aged female participants, and notified more severe causes in cases where iron deficiency developed in infancy than in adulthood[21]. Adulthood and school-age, anemia can also be recuperated by nutritional supplementation programs as reported by Nokes et al, but the effects established during infancy are irrevocable and lead to poor neurodevelopment and consistent pitiable cognition in the future[22]. Other studies are also in support of impaired neurodevelopment related to iron deficiency among children and long term effect on intellectual activities of the children unless provided them with iron supplements to avoid adverse and irreversible effects[23]. Bobonis et al, in their study, conveyed s

ubstantial weight gain and repossession from baseline anemia in 2-6 years old children, after administration of iron supplements and de-worming drugs to those who were affected by intestinal infections in the slums of Dehli, India. They also found an incredible decrease in absentees and an amended tendency toward cognitive accomplishments of the convalesced children[24].

Diaz et al., found a notable influence of iron deficiency and other poverty factors on neurodevelopment and physical and rational accomplishments of children 2 years to 6 years aged and suggested a substantial loss of non-verbal intellectual activities with the development of anemia. In developing countries, where most of the population is depleted and deprived of the upkeep, spending national budgets on such supplementation programs is grim to accomplish, instead there should be an ample supply of sustenance during pregnancy and infancy to circumvent far ahead effects on children.

CONCLUSION

It is concluded, that iron deficiency, with or without anemia, has a significant correlation with intellectual activities and school performance of the children. The most credible root of these outcomes is the inaccessibility of iron in body tissues and iron dependent enzymes of cerebral cortex that leads to impairment of physical and motor activities along with cognition. Although these effects are more adverse in cases where children are subjected to infant-aged malnutrition, but can be reversed with nutritional supplementary programs and adequate check on the dietary habits of the children.

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