**Available online at: http://www.iajps.com**          *Research Article*

# PREVALENCE OF ANEMIA AND ASSOCIATED FACTORS AMONG CHILDREN IN KSA: A CROSS-SECTIONAL STUDY

**Nafisa Mohamed Badawi[1], Najya Abdullah Attia[2], Rayan Hasan Alzahrani[3], Noura Abdullah AlAtwi[3], Mshary Ali Alqahtani[4], Riyadh Abdullah Alalyani[4], Samar Othman Alnashri[4], Joud Mahmoud Hashash[4], Shahad khalid balbaid[4], Reema Ashraf Howidi[5], Mohammed Mosad Elkholy[6], Mohamed Abdullah Assiri[7], Rahmah Ali Almagadi[7], Rowaida Talal Fadhel[7] and Ibrahim Musaad Alhoshan[8]**

[1] General Pediatric Consultant, Abha, KSA Nafisabadawi@hotmail.com
[2] Assistant Professor & Consultant of Pediatric, Department of pediatrics, king Abdulaziz Medical City, Jeddah, KSA. dr_najya.attia@yahoo.com
[3] Pediatric Resident, Saudi Board, KSA.
[4] Medical Service Doctor, MBBS, KSA.
[5] Post Graduate Medical, MBBS, KSA
[6] Post Graduate Medical, MBBS, Egypt
[7] Medical Intern, MBBS, KSA.
[8] Medical Student, MBBS, KSA.

**Abstract:**
*Objective: To determine the prevalence of anemia among children aged 12 years and less in the Saudi population*
*Methods: This study employs a cross-sectional design to assess the prevalence of anemia and its associated factors among children aged 12 years or less in the Kingdom of Saudi Arabia (KSA). A cross-sectional approach allows for the collection of data at a single point in time from a diverse group of participants.*
*Results: The study included 587 participants. The most frequent gender among them was Male (n= 316, 53.8%) followed by Female (n= 271, 46%). The most frequent BMI among study participants was normal 5-85 kg/m² (n= 570, 97.1%), followed by obese more than 95 kg/m² (n= 15, 2.6%). The most frequent age value among study participants was 4-6 years (n= 296, 50%) followed by 10-12 years (n= 166, 28%). The most frequent anemia level among them was non-anemia (n= 308, 52%), followed by Moderate anemia (n= 126, 21%). Participants were asked about their parents' educational level. The most frequent education for fathers among study participants was university (n= 395, 67.3%), followed by school (n= 159, 27.1%). The most frequent education for mothers among study participants was university (n= 383, 65.2%), followed by school (n= 144, 24.5%). Participants were asked about their eating if they eat red meat; the most frequent answer was yes (n= 380, 64.7%); other hands answered no (n= 207, 35.3%), and about eating green vegetables, yes (n=267, 45.5%), in other hands no (n=320, 54.5%). The eating citrus consumption the most answered yes (n=345, 58.8%), followed by no (242, 41.2%). The most frequently were not exposed to smoking (n=454, 77.3%), exposed to smoking (n=133, 22.6%).*
*Conclusion: The results of the study showed that most of the children are male and the most of there weight was normal according to their BMI. Most of them were children of university-educated fathers and mothers. Most children have not been exposed to smoking. Most of them relied on eating red meat and Citrus consumption, in addition to drinking milk. Most study participants had good communication.*

**Corresponding author:**

**Nafisa Mohamed Badawi,**
*General Pediatric Consultant,*
*Abha, KSA Nafisabadawi@hotmail.com*

## INTRODUCTION:

Anemia is a medical illness characterized by a decrease in the total number of red blood cells in circulation or a deficiency in the red blood cells' ability to transport oxygen, resulting in an inadequate supply to fulfill the body's physiological requirements (1). Anemia is often diagnosed by assessing low levels of hemoglobin (Hb) or hematocrit concentrations (2). However, other diagnostic methods include evaluating variations in blood reticulocyte count, mean corpuscular volume, blood film analysis, or Hb electrophoresis (3). However, considering the population size and limitations of clinical practice, the measurement of Hb concentration is often used as the primary hematological examination for the determination of anemia (4). Anemia has a significant worldwide incidence and has the potential to manifest at any point in the lifespan, with a specific propensity for occurrence in preschool-aged children (5). As per the established criteria set by the World Health Organization (WHO), anemia is characterized by a hemoglobin concentration below 11 g/dL in females and below 12 g/dL in boys (6). It is worth mentioning that anemia has the potential to impact mental health, cognitive abilities, and concentration skills (6).

Iron deficiency is widely recognized as the primary etiology of anemia. Extensive clinical and epidemiological investigations have consistently revealed a substantial correlation between iron deficiency anemia (IDA) and an elevated susceptibility to various psychiatric conditions, including unipolar depressive disorder, bipolar disease, anxiety disorder, attention deficit-hyperactivity disorder, delayed development, and mental retardation, across different age groups (7).

Africa has the greatest worldwide incidence of anemia at 47.5%, with South-East Asia following closely behind at 35.7% (8). Furthermore, the prevalence of this condition is estimated to be about 17.8% in the Americas, 14% in the United Arab Emirates, 11% in Egypt, and greater than 40% in the Syrian Arab Republic and Oman among women who are of reproductive age (8). A number of research studies conducted in Saudi Arabia have focused on the prevalence of anemia in preschool children under the age of six, with a particular emphasis on their nutritional condition (8-10). The objective of this investigation was to ascertain the prevalence of anemia in Saudi Arabia, with a focus on age demographics, as well as the classification and severity of anemia.

## METHODS:

Study design
This study employs a cross-sectional design to assess the prevalence of anemia and its associated factors among children aged 12 years or less in the Kingdom of Saudi Arabia (KSA). A cross-sectional approach allows for the collection of data at a single point in time from a diverse group of participants.

Study approach
The study will be conducted across various regions within the Kingdom of Saudi Arabia, encompassing urban, suburban, and rural settings to ensure representation of the broader population.

Study population
The target population consists of children aged 12 years or less residing in Saudi Arabia.

Study sample
A representative sample will be drawn from the target population using a multistage sampling technique. In the first stage, different regions will be randomly selected. Within each region, clusters such as schools, community centers, and healthcare facilities will be identified. From these clusters, participants will be randomly selected to achieve an appropriate sample of children.

Study tool
For the current study, a questionnaire was adopted for data collection, also categorized as a study tool.

Data collection

Data will be collected through structured interviews and physical examinations. Trained research personnel will administer questionnaires to parents or guardians of the children to gather demographic, socioeconomic, and dietary information. Additionally, blood samples will be collected from participants to assess hemoglobin levels.

Data analysis

Descriptive statistics will be used to calculate the prevalence of anemia and its severity distribution. Inferential statistics, such as chi-square tests and logistic regression, will be employed to analyze the association between anemia prevalence and demographic or socioeconomic factors.

Ethical considerations

Ethical approval will be obtained from [Specify the relevant ethics committee or institutional review board]. Informed consent will be obtained from parents or guardians of participating children. Confidentiality of participants' information and their right to withdraw from the study at any point will be ensured.

RESULTS:

The study included 587 participants. The most frequent gender among them was Male (n= 316, 53.8%) followed by Female (n= 271, 46%). Figure 1 shows the gender distribution among study participants. The most frequent BMI among study participants was normal 5-85 kg/m$^2$ (n= 570, 97.1%), followed by obese more than 95 kg/m$^2$ (n= 15, 2.6%). Figure 2 shows the BMI distribution among study participants. The most frequent age value among study participants was 4-6 years (n= 296, 50%) followed by 10-12 years (n= 166, 28%). Figure 3 shows the distribution of age among study participants.
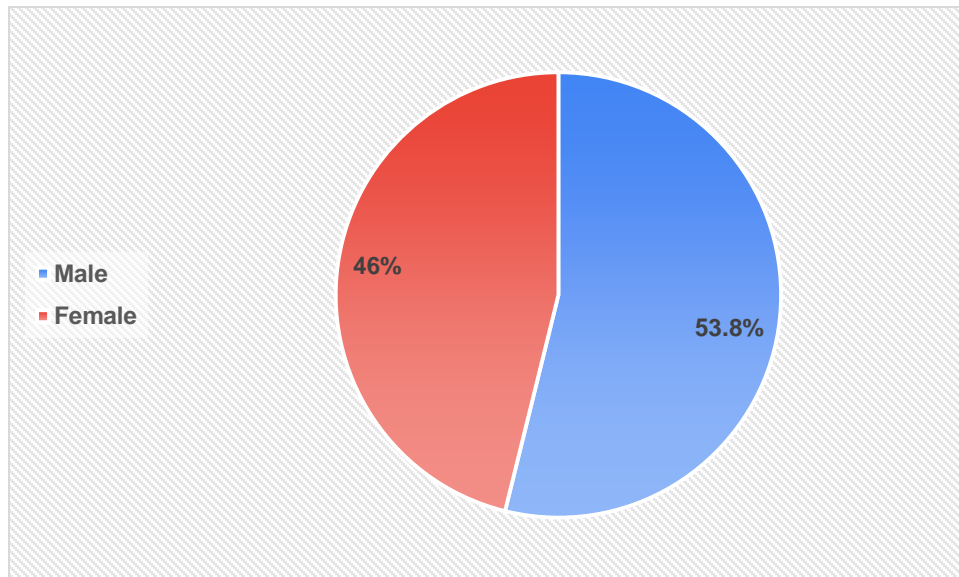


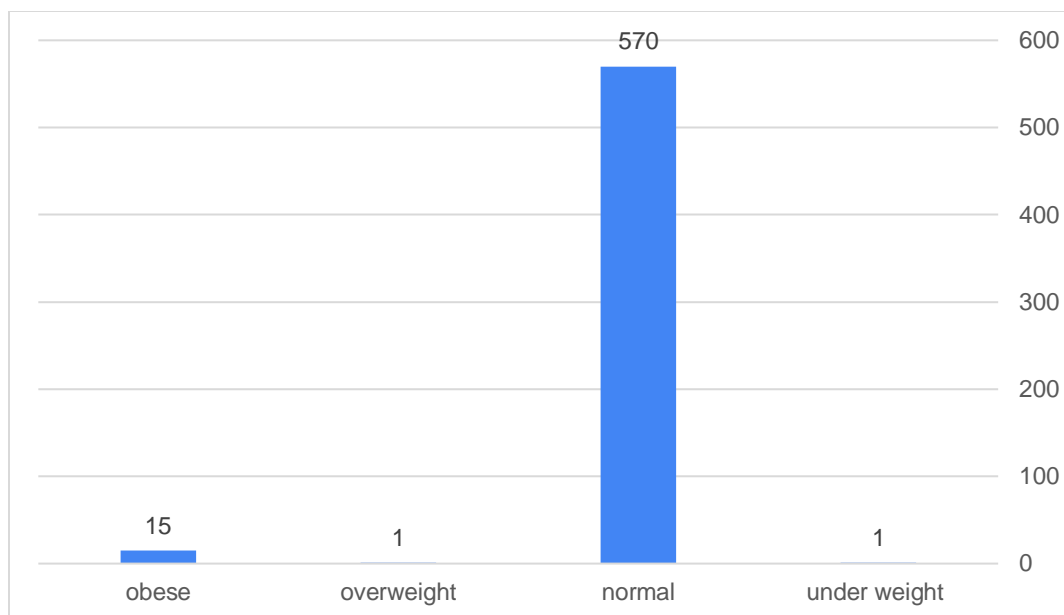**Figure 1: gender distribution among study participants**

**Figure 2: BMI distribution among study participants**
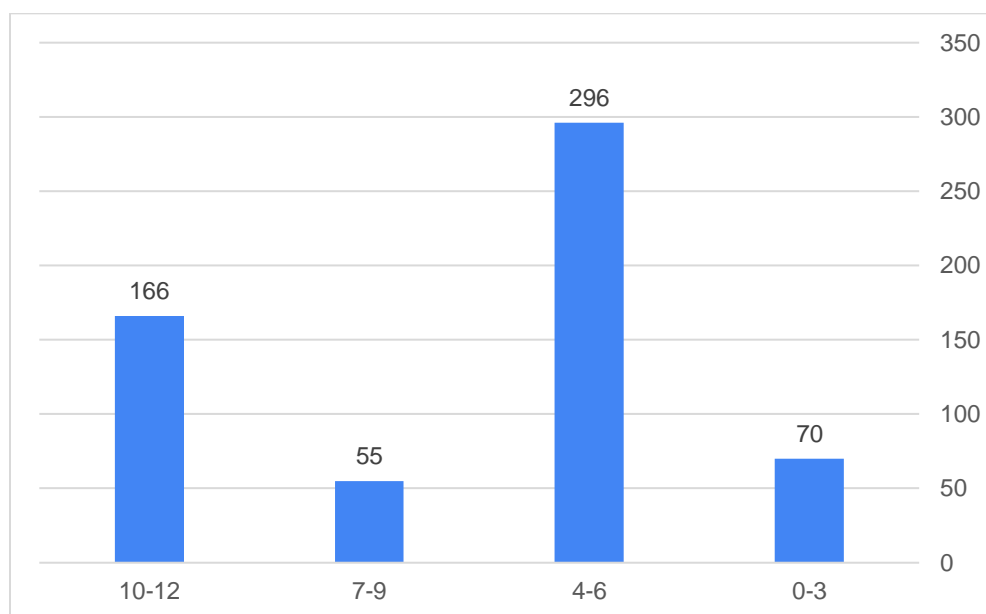
**Figure 3: Age distribution among study participants**

The most frequent anemia level among them was non-anemia (n= 308, 52%), followed by Moderate anemia (n= 126, 21%). Figure 4 shows the anemia level distribution among study participants.
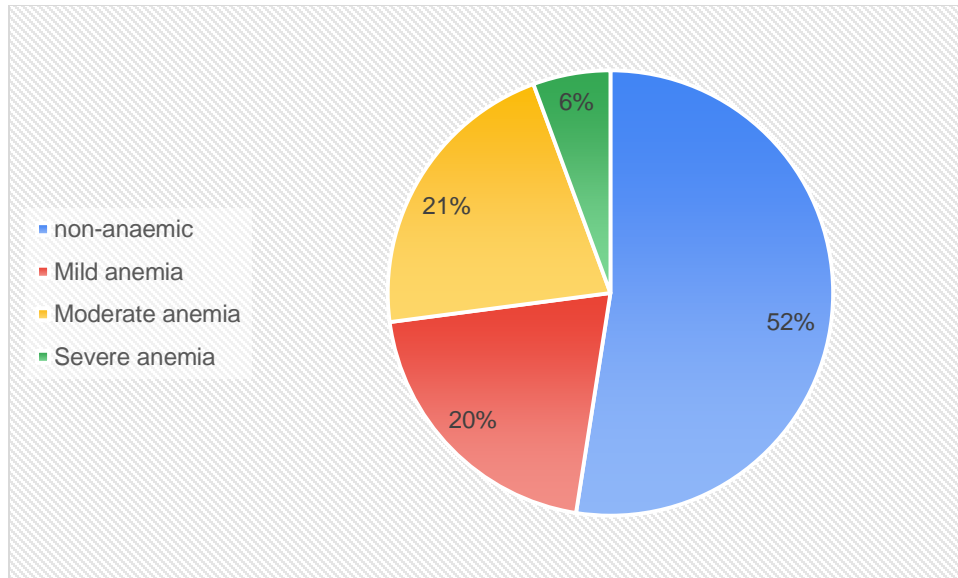
**Figure 4 shows the anemia level distribution among study participants.**

Participants were asked about their parents' educational level. The most frequent education for fathers among study participants was university (n= 395, 67.3%), followed by school (n= 159, 27.1%). The most frequent education for mothers among study participants was university (n= 383, 65.2%), followed by school (n= 144, 24.5%). Perceived the educational level of parents is presented in Figure 5.
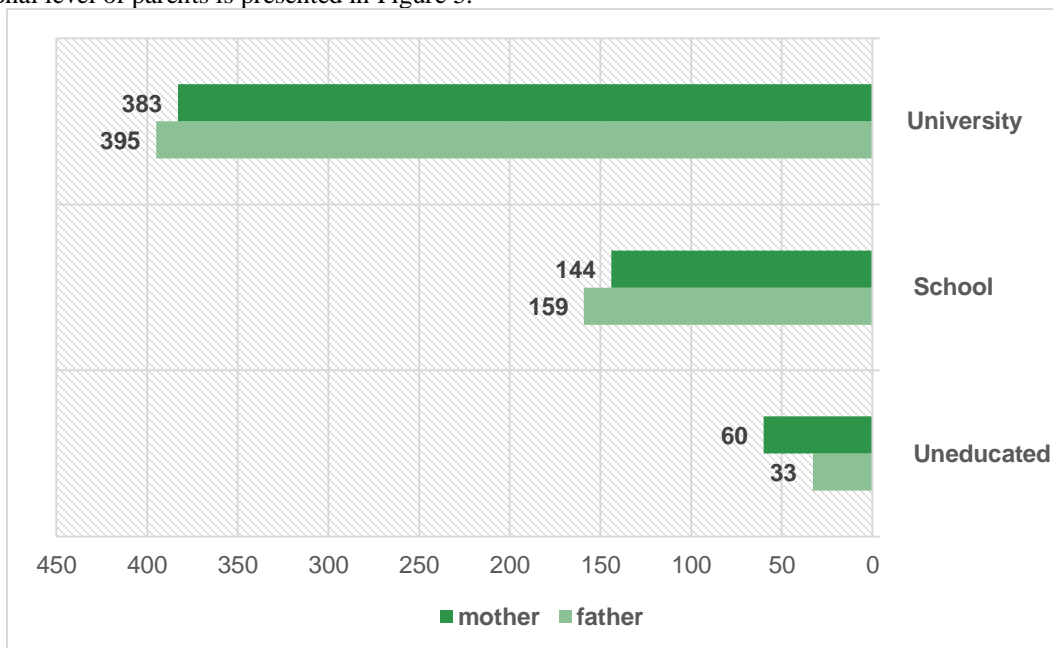


**Figure 5: educational of parents among study participants**

Participants were asked to assess if they had diseases. Their responses and results are presented in Table 1.

|  | yes | no |
|---|---|---|
| Do you have a troll? | 91 (15.5%) | 496 (84.5%) |
| Do you have extreme thinness? | 218 (37.1%) | 369 (62.9%) |
| Do you have an Intestinal parasitic infection? | 135 (23%) | 452 (77%) |

Participants were asked about their eating if they eat red meat; the most frequent answer was yes (n= 380, 64.7%); other hands answered no (n= 207, 35.3%), and about eating green vegetables, yes (n=267, 45.5%), in other hands no (n=320, 54.5%). The eating citrus consumption the most answered yes (n=345, 58.8%), followed by no (242, 41.2%). Figure 6 shows participants if they are exposed to smoking. The most frequently were not exposed to smoking (n=454, 77.3%), exposed to smoking (n=133, 22.6%).
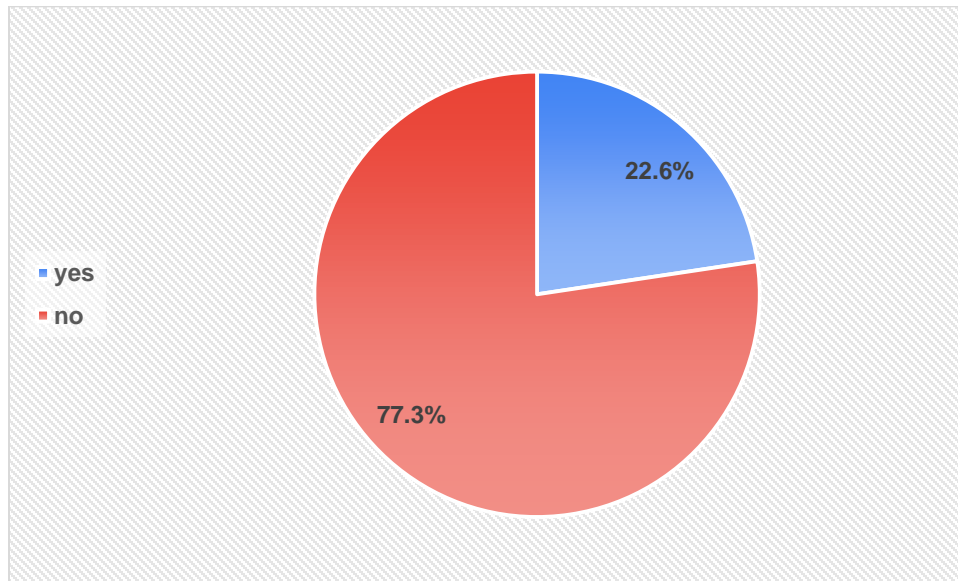


**Figure 6: Participants exposed to smoking**

## DISCUSSION:

The World Health Organization (WHO), ranking in the top ten most critical health issues (1), recognizes anemia as a significant global health concern. Anemia, a condition characterized by a hemoglobin level below 11.0 g/dl, is often encountered in infants between the ages of 6 and 59 months, as well as in pregnant women who are considered the most susceptible population (1, 2). Anemia is characterized by a deficiency in red blood cells or impaired hemoglobin function, resulting in an inadequate supply of oxygen to meet the organism's physiological requirements. According to the World Health Organization (WHO, 2011), an estimated 273.2 million children between the ages of 6 and 59 months worldwide were afflicted with anemia, resulting in an overall prevalence rate of 42.6%. Nevertheless, this phenomenon has a disproportionate impact on several global locations. Sub-Saharan Africa, an area with a prevalence rate of 62.3%, provides shelter to roughly 84.5 million

children aged 6-59 months who are afflicted with anemia.

The early management of anemia and its elimination are objectives in the field of public health, as well as significant challenges faced by educational institutions, since they have the potential to enhance both physical development and cognitive abilities in children (3). Undoubtedly, the ramifications of anemia among preschool-aged children are of significant concern (4,5,6,7). These consequences encompass a range of adverse effects, such as compromised cognitive function, hindered motor development and growth, diminished academic performance, reduced immune function leading to heightened susceptibility to infections, decreased responsiveness and activity levels, and increased fatigue. These factors have the potential to significantly impede the long-term growth and development of a kid in an irreversible manner. The scenario has sparked significant attention on both a domestic and global scale, resulting in the initiation

of preventive initiatives such as the fortification of food and the provision of intermittent iron supplements (8, 9). Since the most common anemia among children is iron deficiency, the review will focus on that.

**CONCLUSION:**

The results of the study showed that most of the children are male and the most of there weight was normal according to their BMI. Most of them were children of university-educated fathers and mothers. Most children have not been exposed to smoking. Most of them relied on eating red meat and Citrus consumption, in addition to drinking milk. Most study participants had good communication.

**REFERENCES:**

1. Sanou D, Turgeon-O'Brien H, Desrosiers T. Prévalence et déterminants non alimentaires de l'anémie et de la carence en fer chez des orphelins et enfants vulnérables d'âge préscolaire du Burkina-Faso. Nutr Clin Métabolisme. 2008;22(1):10–9.
2. WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization 2011.
   (WHO/NMH/NHD/MNM/11.1 http://www.who.int/vmnis/indicators/haemoglobin.pdf) (accessed 26 August 2023).
3. Grantham-McGregor S, Ani C. A review of studies on the effect of iron deficiency on cognitive development in children. J Nutr. 2001;131(2):649S–68S.
4. Beard JL. Iron biology in immune function, muscle metabolism and neuronal functioning. J Nutr. 2001;131(2):568S–80S.
5. Lozoff B, Smith JB, Clark KM, Gloria Perales C, Rivera F, Castillo M. Home intervention improves cognitive and social-emotional scores in Iron-deficient anemic infants. PEDIATRICS. 2010;126(4):e884–94.
6. McCann JC, Ames BN. An overview of evidence for a causal relation between iron deficiency during development and deficits in cognitive or behavioral function. Am J Clin Nutr. 2007;85(4):931–45.
7. Stoltzfus RJ. Iron interventions for women and children in low-income countries. J Nutr. 2011;141(4):756S–62S.
8. OMS. Directive: utilisation d'associations de micronutriments en poudre pour l'enrichissement à domicile de l'alimentation des nourrissons et des enfants de 6 à 23 mois. 2012.
9. Sylvetsky AC, Jefferds MED, De-Regil LM, Dowswell T. Intermittent iron supplementation for improving nutrition and developmental outcomes in children. In: The Cochrane Collaboration, editor. Cochrane Database of Systematic Reviews. Chichester: John Wiley & Sons, Ltd; 2011.
10. Diouf S, Folquet M, Mbofung K, Ndiaye O, Brou K, Dupont C, et al. Prévalence et déterminants de l'anémie chez le jeune enfant en Afrique francophone – Implication de la carence en fer. Arch Pédiatrie. 2015;22(11):1188–97.
11. Mangosongo B, Kalokola FM, Munubhi EK, et al. Iron deficiency in sickle cell anaemia patients in Dar es Salaam. Tanzania Med J 2004;19:5-8.
12. Fajolu IB, Grange OA, Renner JK, et al. Prevalence of iron deficiency in children 6-24 months in Lagos. Nig Q J Hosp Med 2007;17:97-100.
13. Beard JL. Iron biology in immune function, muscle metabolism and neuronal functioning. J Nutr 2001;131:568S-579S.
14. Hurrell RF, Reddy MB, Juillerat M, et al. Meat protein fractions enhance nonheme iron absorption in humans. J Nutr 2006;136:2808-12.
15. Reddy MB, Hurrell RF, Cook JD. Meat consumption in a varied diet marginally influences nonheme iron absorption in normal individuals. J Nutr 2006;136:576-81.
16. Cowin I, Emond A, Emmett PALSPAC Study Group. Association between composition of the diet and haemoglobin and ferritin levels in 18-month-old children. Eur J Clin Nutr 2001;55:278-86.
17. Thorisdottir AV, Ramel A, Palsson GI, et al. Iron status of one-year-olds and association with breast milk, cow's milk or formula in late infancy. Eur J Nutr 2013;52:1661-8.
18. Domellöf M, Thorsdottir I, Thorstensen K. Health effects of different dietary iron intakes: a systematic literature review for the 5th Nordic Nutrition Recommendations. Food Nutr Res 2013;
19. Thankachan P, Walczyk T, Muthayya S, et al. Iron absorption in young Indian women: the interaction of iron status with the influence of tea and ascorbic acid. Am J Clin Nutr 2008;87:881-6.
20. Kapsokefalou M, Miller DD. Lean beef and beef fat interact to enhance nonheme iron absorption in rats. J Nutr 1993;123:1429-34.
21. Cook JD, Reddy MB. Effect of ascorbic acid intake on nonheme-iron absorption from a complete diet. Am J Clin Nutr 2001;73:93-8.

22. Hallberg L, Brune M, Rossander L. The role of vitamin C in iron absorption. Int J Vitam Nutr Res Suppl 1989;30:103-8.

23. Dorea JG. Iron and copper in human milk. Nutrition 2000;16:209-20.

24. Feeley RM, Eitenmiller RR, Jones JB, et al. Copper, iron, and zinc contents of human milk at early stages of lactation. Am J Clin Nutr 1983;37:443-8.

25. Hicks PD, Zavaleta N, Chen Z. Iron deficiency, but not anemia, upregulates iron absorption in breast-fed Peruvian infants. J Nutr 2006;136:2435-8.

26. Onur CB, Sipahi T, Tavil B, et al. Diagnosing iron deficiency in cyanotic heart disease. Indian J Pediatr 2003;70:29-31.

27. Fernandes SMR, de Morais MB, Amancio OMS. Intestinal Blood Loss as an aggravating Factor of Iron Deficiency in Infants Aged 9 to 12 Months Fed Whole cow's Milk. J Clin Gastroenterol 2008;42:152-6.

28. Muñoz M, Villar I, García-Erce JA. An update on iron physiology. World J Gastroenterol 2009;15:4617-26.

29. Zimmermann MB, Hurrell RF. Nutritional iron deficiency. Lancet 2007;370:511-20.

30. Ganz T, Nemeth E. Regulation of iron acquisition and iron distribution in mammals. Biochim Biophys Acta 2006;1763:690-9.

31. el Hage Chahine JM, Pakdaman R. Transferrin, a mechanism for iron release. Eur J Biochem 1995;230:1102-10.

32. Ponka P, Lok CN. The transferrin receptor: role in health and disease. Int J Biochem Cell Biol 1999;31:1111-37.

33. Andrews NC. Forging a field: the golden age of iron biology. Blood 2008;112:219-30.

34. Baker E, Morgan EH. Iron transport. In: Brock JH, Halliday JW, Pippard MJ, et al. editors. Iron metabolism in health and disease. London: WB Saunders, 1994:63-95.

35. Jelkmann W. Regulation of erythropoietin production. J Physiol 2011;589:1251-8.

36. Frazer DM, Anderson GJ. Iron imports. I. Intestinal iron absorption and its regulation. Am J Physiol Gastrointest Liver Physiol 2005;289:G631-5.

37. Breda L, Gardenghi S, Guy E, et al. Exploring the Role of Hepcidin, an Antimicrobial and Iron Regulatory Peptide, in Increased Iron Absorption in Thalassemia. Ann N Y Acad Sci 2005;1054:417-22.

38. Ganz T, Nemeth E. Hepcidin and iron homeostasis. Biochim Biophys Acta 2012;1823:1434-43.

39. Cook JD. Diagnosis and management of iron-deficiency anaemia. Best Pract Res Clin Haematol 2005;18:319-32.

40. Thompson RB, Proctor SJ. Iron metabolism: Iron deficiency: Iron overload. In: A Short Textbook of Haematology 6th ed. Hong Kong: Longman Group, 1984:153-87

41. Rao R, Georgieff MK. Iron in fetal and neonatal nutrition. Semin Fetal Neonatal Med 2007;12:54-63.

42. Siddappa AM, Rao R, Long JD, et al. The assessment of newborn iron stores at birth: a review of the literature and standards for ferritin concentrations. Neonatology 2007;92:73-82.

43. Beard J, deRegnier RA, Shaw MD, et al. Diagnosis of iron deficiency in infants. Lab Med 2007;38:103-8.

44. Oski FA. Iron deficiency in infancy and childhood. N Engl J Med 1993;329:190-3.

45. Domellöf M, Braegger C, Campoy C, et al. Iron Requirements of Infants and Toddlers. J Pediatr Gastroenterol Nutr 2014;58:119-29.

46. Sturgeon P. Studies of iron requirements in infants and children. Pediatrics 1954;13:107-25.

47. Mesías M, Seiquer I, Navarro MP. Iron nutrition in adolescence. Crit Rev Food Sci Nutr 2013;53:1226-37.

48. Alton I. Iron deficiency anemia, prevalence of iron deficiency and iron deficiency anemia in adolescent males and nonpregnant females. In: Stang J, Story MT. editors. Guidelines for adolescent nutrition services. Minneapolis: Center for Leadership, Education and Training in Maternal and Child Nutrition, 2005.

49. Scientific Opinion on Dietary Reference Values for iron. EFSA J 2015;13:4254.

50. Brotanek JM, Gosz J, Weitzman M, et al. Iron Deficiency in Early Childhood in the United States: Risk Factors and Racial/Ethnic Disparities. Pediatrics 2007;120:568-75.

51. Muñoz Pérez MA, García Vera C, Galve Royo F, et al. Is general screening for anemia and iron deficiency justified in nursing infants? Aten Primaria 1995;15:446-8.

52. Vendt N, Grünberg H, Leedo S, et al. Prevalence and causes of iron deficiency anemias in infants aged 9 to 12 months in Estonia. Medicina 2007;43:947-52.

53. Vieira AC, Diniz AS, Cabral PC, et al. Nutritional assessment of iron status and anemia in children under 5 years old at public daycare centers. J Pediatr (Rio J) 2007;83:370-6.

54. Kisiangani I, Mbakaya C, Makokha A, et al. Assessment of iron status among preschool children (6 to 59 months) with and without

malaria in Western Province, Kenya. Pan Afr Med J 2015;21:62.

55. Hlatswayo BPS, Ntshangase S, de Villiers FPR. The effects of iron deficiency and anaemia on primary school learners' scholastic performance. S Afr J Child Health 2016;10:111-5.

56. Sikosana PL, Bhebhe S, Katuli S. A prevalence survey of iron deficiency and iron deficiency anaemia in pregnant and lactating women, adult males and pre-school children in Zimbabwe. Cent Afr J Med 1998;44:297-305.

57. Nigeria Food Consumption and Nutrition Survey. 2001. Available online: http://pdf.usaid.gov/pdf_docs/PNADC880

58. Akodu OS, Disu EA, Njokanma OF, et al. Iron deficiency anaemia among apparently healthy pre-school children in Lagos, Nigeria. Afr Health Sci 2016;16:61-8.

59. Jeremiah ZA, Buseri FI, Uko EK. Iron deficiency anaemia and evaluation of the utility of iron deficiency indicators among healthy Nigerian children. Hematology 2007;12:249-53.

60. Osazuwa F, Ayo OM, Imade P. A significant association between intestinal helminth infection and anaemia burden in children in rural communities of Edo state, Nigeria. N Am J Med Sci 2011;3:30-4.

61. Ekwochi U, Odetunde O, Maduka I, et al. Iron deficiency among non-anemic under-five children in enugu, South-East, Nigeria. Ann Med Health Sci Res 2013;3:402-6.

62. Soliman AT, Al Dabbagh MM, Habboub AH, et al. Linear Growth in Children with Iron Deficiency Anemia Before and After Treatment. J Trop Pediatr 2009;55:324-7.

63. Ferlin MLS, Jorge SM, Ricco RG, et al. Prematurity anemia: effect of iron supplementation. Nutr Res 2001;21:149-58.

64. Drossos C, Thanapoulos B, Papadimitrou T, et al. Incidence of anaemia in congenital heart diseases (author's transl). Pediatr Med Chir 1981;3:309-12.

65. Torre M, Rodriguez AR, Saura-Calixto F. Effects of dietary fiber and phytic acid on mineral availability. Crit Rev Food Sci Nutr 1991;30:1-22.

66. Onimawo IA, Ukegbu PO, Asumugha VU, et al. Assessment of anaemia and iron status of school age children (aged 7-12 years) in rural communities of Abia state, Nigeria. Afr J Food Agric Nutr Dev 2010;10:2570-86.

67. Barr F, Brabin L, Agbaje S, et al. Reducing iron deficiency anaemia due to heavy menstrual blood loss in Nigerian rural adolescents. Public Health Nutr 1998;1:249-57.

68. Moschonis G, Papandreou D, Mavrogianni C, et al. Association of iron depletion with menstruation and dietary intake indices in pubertal girls: the healthy growth study. Biomed Res Int 2013;2013:423263

69. Adinma ED, Adinma JI. Menstrual characteristics amongst south-eastern Nigerian adolescent school girls. West Afr J Med 2009;28:110-3.

70. Hotez PJ, Molyneux DH, Sylla K, et al. Tropical Anemia: One of Africa's Great Killers and a Rationale for Linking Malaria and Neglected Tropical Disease Control to Achieve a Common Goal. PLoS Negl Trop Dis 2008;2:e270

71. Odebunmi JF, Adefioye OA, Adeyeba OA. Hookworm Infection among School Children in Vom, Plateau State, Nigeria. American-Eurasian Journal of Scientific Research 2007;2:39-42.

72. de Silva NR, Brooker S, Hotez PJ, et al. Soil-transmitted helminth infections: updating the global picture. Trends Parasitol 2003;19:547-51.

73. Stoltzfus RJ, Albonico M, Chwaya HM, et al. Hemoquant determination of hookworm-related blood loss and its role in iron deficiency in African children. Am J Trop Med Hyg 1996;55:399-404.

74. Agbolade OM, Agu NC, Adesanya OO, et al. Intestinal helminthiases and schistosomiasis among school children in an urban center and some rural communities in southwest Nigeria. Korean J Parasitol 2007;45:233-8.

75. Nmorsi OPG, Isaac C, Aashikpelokhai IS, et al. Geohelminthiasis among Nigerian preschool age children. International Journal of Medicine and Medical Sciences 2009;1:407-11.

76. Schuftan C, Ramalingaswami V, Levinson FJ. Micronutrient deficiencies and protein-energy malnutrition. Lancet 1998;351:1812.

77. Gasche C, Lomer MCE, Cavill I, et al. Iron, anaemia, and inflammatory bowel diseases. Gut 2004;53:1190-7.

78. Stevens AR, Pirzio-Biroli G, Harkins HN, et al. Iron Metabolism in Patients After Partial Gastrectomy. Ann Surg 1959;149:534-8.

79. Andrews NC. Iron homeostasis: insights from genetics and animal models. Nat Rev Genet 2000;1:208-17.

80. Lozoff B, Klein NK, Nelson EC, et al. Behavior of infants with iron-deficiency anemia. Child Dev 1998;69:24-36.

81. Tay ELW, Peset A, Papaphylactou M, et al. Replacement therapy for iron deficiency improves exercise capacity and quality of life in patients with cyanotic congenital heart disease and/or the Eisenmenger syndrome. Int J Cardiol 2011;151:307-12.

82. Pourcelot E, Lénon M, Mobilia N, et al. Iron for proliferation of cell lines and hematopoietic progenitors: Nailing down the intracellular functional iron concentration. Biochim Biophys Acta 2015;1853:1596-605.

83. Arslan MT, Ozcetin M, Ozyurek R, et al. Rate of Abnormal Coagulation Test Results in Patients with Congenital Heart Disease. J Contemp Med 2011;1:6-10.

84. Ekiz C, Agaoglu L, Karakas Z, et al. The effect of iron deficiency anemia on the function of the immune system. Hematol J 2005;5:579-83.

85. Macdougall LG, Anderson R, McNab GM, et al. The immune response in iron-deficient children: Impaired cellular defense mechanisms with altered humoral components. J Pediatr 1975;86:833-43.

86. Carlson ES, Tkac I, Magid R, et al. Iron is essential for neuron development and memory function in mouse hippocampus. J Nutr 2009;139:672-9.

87. Jáuregui-Lobera I. Iron deficiency and cognitive functions. Neuropsychiatr Dis Treat 2014;10:2087-95.

88. Wang B, Zhan S, Gong T, et al. Iron therapy for improving psychomotor development and cognitive function in children under the age of three with iron deficiency anaemia. In: Lee L. editor. Cochrane Database of Systematic Reviews. Chichester, UK: John Wiley & Sons, Ltd., 2013.

89. Grantham-McGregor S, Ani C. A review of studies on the effect of iron deficiency on cognitive development in children. J Nutr 2001;131:649S-666S.

90. Haas JD, Brownlie T. Iron deficiency and reduced work capacity: a critical review of the research to determine a causal relationship. J Nutr 2001;131:676S-688S.

91. Bogdanis GC. Effects of physical activity and inactivity on muscle fatigue. Front Physiol 2012;3:142.

92. Hurrell RF, Lynch SR, Trinidad TP, et al. Iron absorption in humans as influenced by bovine milk proteins. Am J Clin Nutr 1989;49:546-52.

93. Addison GM, Beamish MR, Hales CN, et al. An immunoradiometric assay for ferritin in the serum of normal subjects and patients with iron deficiency and iron overload. J Clin Pathol 1972;25:326-9.

94. Finch CA, Bellotti V, Stray S, et al. Plasma ferritin determination as a diagnostic tool. West J Med 1986;145:657-63.

95. Guyatt GH, Oxman AD, Ali M, et al. Laboratory diagnosis of iron-deficiency anemia: an overview. J Gen Intern Med 1992;7:145-53. Erratum in: J Gen Intern Med 1992 Jul-Aug;7(4):423.

96. Mast AE, Blinder MA, Gronowski AM, et al. Clinical utility of the soluble transferrin receptor and comparison with serum ferritin in several populations. Clin Chem 1998;44:45-51.

97. Khan AS, Shah SA. Iron deficient children and significance of serum ferritin. J Pak Med Assoc 2005;55:420-3.

98. Marnell L, Mold C, Du Clos TW. C-reactive protein: Ligands, receptors and role in inflammation. Clin Immunol 2005;117:104-11.

99. Beard JL, Murray-Kolb LE, Rosales FJ, et al. Interpretation of serum ferritin concentrations as indicators of total-body iron stores in survey populations: the role of biomarkers for the acute phase response. Am J Clin Nutr 2006;84:1498-505.

100. Gershov D, Kim S, Brot N, et al. C-Reactive protein binds to apoptotic cells, protects the cells from assembly of the terminal complement components, and sustains an antiinflammatory innate immune response: implications for systemic autoimmunity. J Exp Med 2000;192:1353-64.

101. C-reactive concentrations as a marker of inflammation or infection for interpreting biomarkers of micronutrient status. Available online: http://apps.who.int/iris/bitstream/10665/133708/1/WHO_NMH_NHD_EPG_14.7_eng.pdf

102. McDonnell SM, Witte D. Hereditary hemochromatosis. Preventing chronic effects of this underdiagnosed disorder. Postgrad Med 1997;102:83-5, 88-91, 94.

103. Johnson-Wimbley TD, Graham DY. Diagnosis and management of iron deficiency anemia in the 21st century. Therap Adv Gastroenterol 2011;4:177-84.

104. Beutler E. the red cell indices in the diagnosis of iron-deficiency anemia. Ann Intern Med 1959;50:313.

105. Aulakh R, Sohi I, Singh T, et al. Red cell distribution width (RDW) in the diagnosis of iron deficiency with microcytic hypochromic anemia. Indian J Pediatr 2009;76:265-8.

106. Bessman JD, Gilmer PR, Gardner FH. Improved classification of anemias by MCV and RDW. Am J Clin Pathol 1983;80:322-6.

107. Margolis HS, Hardison HH, Bender TR, et al. Iron deficiency in children: the relationship between pretreatment laboratory tests and subsequent hemoglobin response to iron therapy. Am J Clin Nutr 1981;34:2158-68.

108. Serdar MA, Sarici SU, Kurt I, et al. The role of erythrocyte protoporphyrin in the diagnosis of

iron deficiency anemia of children. J Trop Pediatr 2000;46:323-6.

109. Siegel RM, LaGrone DH. The use of zinc protoporphyrin in screening young children for iron deficiency. Clin Pediatr (Phila) 1994;33:473-9.

110. Parsons PJ, Reilly AA, Hussain A. Observational study of erythrocyte protoporphyrin screening test for detecting low lead exposure in children: impact of lowering the blood lead action threshold. Clin Chem 1991;37:216-25.

111. Jayaranee S, Sthaneshwar P. Serum soluble transferrin receptor in hypochromic microcytic anaemia. Singapore Med J 2006;47:138-42.

112. Wish JB. Assessing Iron Status: Beyond Serum Ferritin and Transferrin Saturation. Clin J Am Soc Nephrol 2006;1:S4-8.

113. Yoon SH, Kim DS, Yu ST, et al. The usefulness of soluble transferrin receptor in the diagnosis and treatment of iron deficiency anemia in children. Korean J Pediatr 2015;58:15-9.

114. Nadeem S, Shah S, Iqbal T, et al. Serum transferrin receptor, serum ferritin and serum transferrin receptor-ferritin index in adults with iron deficiency anaemia. J Ayub Med Coll Abbottabad 2011;23:44-6.

115. Allen J, Backstrom KR, Cooper JA, et al. Measurement of soluble transferrin receptor in serum of healthy adults. Clin Chem 1998;44:35-9.

116. Phiri KS, Calis JCJ, Kachala D, et al. Improved method for assessing iron stores in the bone marrow. J Clin Pathol 2009;62:685-9.

117. Fairbanks VF. Is the peripheral blood film reliable for the diagnosis of iron deficiency anemia? Am J Clin Pathol 1971;55:447-51.

118. Zhu A, Kaneshiro M, Kaunitz JD. Evaluation and treatment of iron deficiency anemia: a gastroenterological perspective. Dig Dis Sci 2010;55:548-59.

119. Hay W, Levin M, Sondheimer JM. Haematologic disorders. In: Hay WW Jr, Hayward AR, Levin MJ, et al. Current Paediatrics Diagnosis and Treatment. 16th edition. McGraw-Hill Companies, 1903:843.

120. Perloff JK, Rosove MH, Child JS, et al. Adults with cyanotic congenital heart disease: hematologic management. Ann Intern Med 1988;109:406-13.

121. Baumgartner H, Bonhoeffer P, De Groot NMS, et al. ESC Guidelines for the management of grown-up congenital heart disease. Eur Heart J 2010;31:2915-57.

**ANNEX 1: DATA COLLECTION TOOL**

1. Are you exposed to smoking?
   - Yes
   - No

2. What is the father's education level?
   - Uneducated
   - School
   - University

3. What is the mother's education level?
   - Uneducated
   - School
   - University

4. What is the result of Cell analysis (cell shape)?
   - Small size
   - Normal size
   - Large size
   - Don't know

5. What is the result of Cell analysis (cell color)?
   - Faded color
   - Natural color
   - Don't know

6. Do you have a troll?
   - Yes
   - No

7. Do you have extreme thinness?
   - Yes
   - No

8. Do you have an Intestinal parasitic infection?
   - Yes
   - No

9. Do you eat leafy green vegetables?
   - Yes
   - No

10. Do you Eat lots of green leafy vegetables?
    - Daily
    - More than once a week
    - Once a week
    - Doesn't eat

11. Do you eat Citrus consumption?
    - Yes
    - No

12.  Do you Eat Frequent consumption of citrus fruits?
- Daily
- More than once a week
- Once a week
- Doesn't eat

13.  Do you eat red meat?
- Yes
- No

14.  Do you Eat lots of red meat?
- Daily
- More than once a week
- Once a week
- Doesn't eat

15.  Do you drink milk?
- Yes
- No

16.  Do you drink a lot of milk?
- Daily
- More than once a week
- Once a week
- Doesn't eat

17.  Did you Use milk supplements?
- Yes
- No

**APPENDIX 2: Participants responses to scale items**

|  | yes | no |
|---|---|---|
| Do you eat leafy green vegetables? | 267 (45.5%) | 320 (54.5%) |
| Do you eat Citrus consumption? | 345 (58.8%) | 242 (41.2%) |
| Do you eat Red meat? | 380 (64.7%) | 207 (35.3%) |
| Do you drink milk? | 484 (82.5%) | 103 (17.5%) |
| Did you use milk supplements? | 138 (23.5%) | 449 (76.5%) |

|  | Daily | More than once a week | Once a week | Doesn't eat |
|---|---|---|---|---|
| Do you eat a lot of leafy green vegetables? | 62 (10.6%) | 144 (24.5%) | 178 (30.5%) | 203 (34.6%) |
| Do you eat a lot of Citrus consumption? | 71 (12.1%) | 175 (29.8%) | 201 (34.2%) | 140 (23.9%) |
| Do you eat a lot of red meat? | 65 (11.1%) | 201 (34.2%) | 209 (35.6%) | 112 (19.1%) |
| Do you drink lot of milk? | 207(35.3%) | 221(3 7.6%) | 90 (15.3%) | 69 (11.8%) |

SPSS

**age**

|  | Frequency | percent |
|---|---|---|
| 0-3 | 70 | 12% |
| 4-6 | 296 | 50% |
| 7-9 | 55 | 9% |
| 10-12 | 166 | 28% |
| Total | 587 | 100% |

**gender**

|  | Frequency | Percent |
|---|---|---|
| Male | 316 | 53.8% |
| Female | 271 | 46% |
| Total | 587 | 100% |

**exposed to smoking**

|  | Frequency | Percent |
|---|---|---|
| yes | 133 | 22.6% |
| no | 454 | 77.3% |
| Total | 587 | 100% |

**father's education**

|  | Frequency | Percent |
|---|---|---|
| Uneducated | 33 | 5.6% |
| School | 159 | 27.1% |
| University | 395 | 67.3% |
| Total | 587 | 100% |

**mother's education**

|  | Frequency | Percent |
|---|---|---|
| Uneducated | 60 | 10.2% |
| School | 144 | 24.5% |
| University | 383 | 65.2% |
| Total | 587 | 100% |

**BMI level**

|  | Frequency | Percent |
|---|---|---|
| underweight ( < 5) | 1 | 0.2% |
| Normal (5-85) | 570 | 97.1% |
| Overweight (85-95) | 1 | 0.2% |
| Obese ( >95) | 15 | 2.6% |
| Total | 587 | 100% |

**Cell analysis (cell shape)**

|  | Frequency | Percent |
|---|---|---|
| Small size | 55 | 9.4% |
| Normal size | 251 | 42.8% |
| Large size | 3 | 0.5% |
| Don't know | 278 | 47.4% |
| Total | 587 | 100.0% |

**Cell analysis (cell color)**

|  | Frequency | Percent |
|---|---|---|
| Faded color | 74 | 13% |
| Natural color | 209 | 36% |
| Don't know | 304 | 52% |
| Total | 587 | 100% |

**Hemoglobin (anemia)**

|  | Frequency | Percent |
|---|---|---|
| non-anemic ( 12< ) | 308 | 52% |
| Mild anemia (10-11) | 120 | 20% |
| Moderate anemia (7-9.9) | 126 | 21% |
| Severe anemia ( <7) | 33 | 6% |
| Total | 587 | 100% |

Logistic regression

**Case Processing Summary**

|  |  | N | Marginal Percentage |
|---|---|---|---|
| Hemoglobin | non-anemic | 308 | 52.5% |
|  | Mild anemia | 120 | 20.4% |
|  | Moderate anemia | 126 | 21.5% |
|  | Severe anemia | 33 | 5.6% |
| Valid |  | 587 | 100.0% |
| Missing |  | 0 |  |
| Total |  | 587 |  |
| Subpopulation |  | 378[a] |  |

**Model Fitting Information**

| Model | Model Fitting Criteria | Likelihood Ratio Tests | | |
|---|---|---|---|---|
|  | -2 Log Likelihood | Chi-Square | df | Sig. |
| Intercept Only | 1165.885 |  |  |  |
| Final | 1009.974 | 155.911 | 36 | .000 |

**Likelihood Ratio Tests**

| Effect | Model Fitting Criteria | Likelihood Ratio Tests | | |
|---|---|---|---|---|
| | -2 Log Likelihood of Reduced Model | Chi-Square | df | Sig. |
| Intercept | 1055.993 | 46.019 | 3 | .000 |
| gender | 1010.691 | .717 | 3 | .869 |
| BMI level | 1012.183 | 2.209 | 3 | .530 |
| age | 1011.453 | 1.479 | 3 | .687 |
| exposed to smoking | 1019.904 | 9.930 | 3 | .019 |
| cell shape | 1010.896 | .922 | 3 | .820 |
| cell color | 1015.306 | 5.331 | 3 | .149 |
| troll | 1016.808 | 6.833 | 3 | .077 |
| Extreme thinness | 1025.483 | 15.509 | 3 | .001 |
| Intestinal parasitic infection | 1028.324 | 18.350 | 3 | .000 |
| father's education | 1011.985 | 2.011 | 3 | .570 |
| mother's education | 1013.102 | 3.128 | 3 | .372 |
| Milk supplement | 1021.424 | 11.450 | 3 | .010 |

**Parameter Estimates**

| Hemoglobin[a] | | B | Std. Error | Wald | df | Sig. | Exp(B) | 95% Confidence Interval for Exp(B) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Lower Bound | Upper Bound |
| Mild anemia | Intercept | 2.091 | 1.329 | 2.477 | 1 | .116 | | | |
| | gender | .175 | .224 | .609 | 1 | .435 | 1.191 | .767 | 1.850 |
| | BMI level | .188 | .319 | .347 | 1 | .556 | 1.206 | .646 | 2.252 |
| | age | -.078- | .110 | .507 | 1 | .476 | .925 | .746 | 1.147 |
| | exposed to smoking | -.731- | .287 | 6.462 | 1 | .011 | .482 | .274 | .846 |
| | cell shape | .055 | .137 | .163 | 1 | .686 | 1.057 | .808 | 1.381 |
| | cell color | -.201- | .234 | .740 | 1 | .390 | .818 | .517 | 1.293 |
| | troll | .286 | .422 | .459 | 1 | .498 | 1.330 | .582 | 3.040 |
| | Extreme thinness | -.865- | .253 | 11.693 | 1 | .001 | .421 | .257 | .691 |
| | Intestinal parasitic infection | .403 | .349 | 1.333 | 1 | .248 | 1.497 | .755 | 2.968 |
| | father's education | -.168- | .231 | .526 | 1 | .468 | .846 | .537 | 1.330 |
| | mother's education | -.225- | .202 | 1.239 | 1 | .266 | .798 | .537 | 1.187 |
| | Milk supplement | -.359- | .273 | 1.733 | 1 | .188 | .698 | .409 | 1.192 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Moderate anemia | Intercept | 8.243 | 1.451 | 32.264 | 1 | .000 | | | |
| | gender | -.013- | .241 | .003 | 1 | .957 | .987 | .615 | 1.584 |
| | BMI level | -.426- | .502 | .720 | 1 | .396 | .653 | .244 | 1.748 |
| | age | .075 | .117 | .412 | 1 | .521 | 1.078 | .857 | 1.355 |
| | exposed to smoking | -.760- | .300 | 6.401 | 1 | .011 | .468 | .259 | .843 |
| | cell shape | .044 | .138 | .101 | 1 | .750 | 1.045 | .797 | 1.370 |
| | cell color | -.357- | .222 | 2.592 | 1 | .107 | .700 | .453 | 1.081 |
| | troll | -.628- | .346 | 3.288 | 1 | .070 | .534 | .271 | 1.052 |
| | Extreme thinness | -.798- | .274 | 8.479 | 1 | .004 | .450 | .263 | .770 |
| | Intestinal parasitic infection | -1.015- | .303 | 11.206 | 1 | .001 | .363 | .200 | .657 |
| | father's education | -.091- | .241 | .143 | 1 | .705 | .913 | .570 | 1.463 |
| | mother's education | -.341- | .213 | 2.562 | 1 | .109 | .711 | .468 | 1.080 |
| | Milk supplement | -.647- | .272 | 5.658 | 1 | .017 | .524 | .307 | .892 |
| Severe anemia | Intercept | 5.794 | 1.791 | 10.470 | 1 | .001 | | | |
| | gender | .080 | .389 | .043 | 1 | .836 | 1.084 | .506 | 2.321 |
| | BMI level | .372 | .482 | .595 | 1 | .441 | 1.450 | .564 | 3.727 |
| | age | -.067- | .193 | .122 | 1 | .727 | .935 | .641 | 1.364 |
| | exposed to smoking | -.773- | .469 | 2.719 | 1 | .099 | .462 | .184 | 1.157 |
| | Cell shape | .205 | .220 | .871 | 1 | .351 | 1.228 | .798 | 1.890 |
| | cell color | -.697- | .334 | 4.363 | 1 | .037 | .498 | .259 | .958 |
| | troll | -.718- | .527 | 1.860 | 1 | .173 | .488 | .174 | 1.369 |
| | Extreme thinness | -.561- | .439 | 1.635 | 1 | .201 | .571 | .241 | 1.349 |
| | Intestinal parasitic infection | -.401- | .472 | .722 | 1 | .396 | .670 | .266 | 1.688 |
| | father's education | -.497- | .368 | 1.823 | 1 | .177 | .609 | .296 | 1.251 |
| | mother's education | -.012- | .355 | .001 | 1 | .972 | .988 | .492 | 1.982 |
| | Milk supplement | -1.218- | .403 | 9.133 | 1 | .003 | .296 | .134 | .652 |

a. The reference category is: non-anemic.