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Iron deficiency and child psychomotor development in a rural region of Chota, Peru, 2022

Deficiencia de hierro y desarrollo psicomotor infantil en una zona rural de Chota, Perú 2022

Deficiência de ferro e desenvolvimento psicomotor infantil em uma área rural de Chota, Peru 2022

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Abstract

Introduction: Iron deficiency and psychomotor developmental delay are two public health problems that cause high childhood morbidity and mortality worldwide, which can be related to social, economic, cultural and health factors that affect the environment where children and their family live. **Objective:** To determine the relationship between iron deficiency anemia and psychomotor development in children aged 2 to 4 years treated at the Cuyumalca Clinic, Chota. **Materials and methods:** Relational, cross-sectional study conducted on 48 children, who underwent hemoglobin testing through a portable hemoglobinometer and were subjected to the Psychomotor Development Test. **Results:** 31.2% of the children displayed some type of anemia, with the most common being moderate anemia (17.7%). On average, 10.9% showed some type of psychomotor developmental delay, including coordination (6.3%), language (8.4%), motor skills (16.7%), and overall development (12.5%). 4.2% of the children who had minor to moderate anemia showed developmental delay risks in the three assessed areas as well as in their overall development. **Conclusion:** There is no statistically significant relationship between iron deficiency anemia and several domains of psychomotor development, including coordination, language, motor skills as well as overall development.

Keywords: Anemia, Iron-deficiency; iron deficiencies; child development. (Source: DeCS, Bireme).

Resumen

Introducción: La deficiencia de hierro y las alteraciones en el desarrollo psicomotor son dos problemas de salud pública que causan una alta morbimortalidad infantil alrededor del mundo. Los estudios apuntan a que esto se relaciona con los factores sociales, económicos, culturales y sanitarios en los que el niño y su familia vive. **Objetivo:** Determinar la relación entre anemia ferropénica y desarrollo psicomotor en niños de 2 a 4 años atendidos en el Puesto de Salud de Cuyumalca, Chota. **Materiales y métodos:** Estudio relacional, transversal, desarrollado con 48 niños a quienes se les realizó un dosaje de hemoglobina con hemoglobinómetro portátil y se les aplicó el Test de Desarrollo Psicomotor. **Resultados:** El 31,2% de niños presentaron algún tipo de anemia, siendo la anemia moderada la más frecuente (16,7%); en promedio 10,9% evidenciaron alguna alteración en el desarrollo psicomotor en coordinación (6,3%), lenguaje (8,4%), motricidad (16,7%) y desarrollo global (12,5%). El 4,2% de niños con riesgo para el desarrollo presentaron anemia leve o moderada en las tres áreas evaluadas, al igual que en el desarrollo global. **Conclusión:** No existe relación estadística significativa entre anemia ferropénica y desarrollo psicomotor para las áreas de coordinación, lenguaje y motricidad; además del desarrollo global.

Palabras clave: Anemia ferropénica; deficiencia de hierro; desarrollo infantil. (Fuente: DeCS, Bireme).

Resumo

Introdução: A deficiência de ferro e as alterações no desenvolvimento psicomotor são dois problemas de saúde pública que causam elevada morbidade e mortalidade infantil em todo o mundo. Estudos sugerem que isso está relacionado aos fatores sociais, econômicos, culturais e de saúde em que vivem a criança e sua família. **Objetivo:** Determinar a relação entre anemia ferropriva e desenvolvimento psicomotor em crianças de 2 a 4 anos atendidas no Posto de Saúde Cuyumalca, Chota. **Materiais e métodos:** Estudo relacional, transversal, desenvolvido com 48 crianças que realizaram dosagem de hemoglobina com hemoglobinômetro portátil e foi aplicado o Teste de Desenvolvimento Psicomotor. **Resultados:** 31,2% das crianças apresentaram algum tipo de anemia, sendo a anemia moderada a mais frequente (16,7%); em média, 10,9% apresentaram alguma alteração no desenvolvimento psicomotor na coordenação (6,3%), linguagem (8,4%), motricidade (16,7%) e desenvolvimento global (12,5%). 4,2% das crianças em risco de desenvolvimento apresentaram anemia leve ou moderada nas três áreas avaliadas, bem como no desenvolvimento global. **Conclusão:** Não há relação estatística significativa entre anemia ferropriva e desenvolvimento psicomotor para as áreas de coordenação, linguagem e motricidade; bem como o desenvolvimento global.

Palavras chave: Anemia ferropriva; deficiências de ferro; desenvolvimento infantil. (Fonte: DeCS, Bireme).

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Introduction

Currently, Peru and the world face three child malnutrition burdens: 1) food deficit that causes shortness in height; 2) poor intake of iron-rich foods, which leads to iron deficiency anemia; and 3) excessive eating that results in children being overweight and obese[1,2]. This situation has caused nutritional deficiencies and psychomotor developmental delays in children[3,4].

The World Health Organization (OMS) has defined iron deficiency as the morbid state of blood hemoglobin concentration below the accepted levels according to age, sex, and geographical altitude[5]. The largest number of cases occurs within the first three years[6], which results in physical, psychological, and socio-emotional changes as well as developmental disorders[7,8]. The insufficient intake of foods rich in iron has become one of the most urgent nutritional and public health problems to face due to the growth and developmental delays that this deficiency may cause. It is a problem that needs to be addressed since the Food and Agriculture Organization of the United Nations (FAO) has acknowledged that the number of nutritional disorders such as iron deficiency anemia (IDA) has increased due to a low budget allocation and the lack of effective health policies[9].

Worldwide, nearly a quarter of the population has iron deficiency, of which 42% are under five years of age[10]. Furthermore, according to the UNICEF (United Nations International Children's Emergency Fund)[11] almost half (48%) of the children between 2 to 5 years old and 41% of children under 3 years old have IDA. In Peru, iron deficiency reached 40% in children aged between 6 and 35 months in 2020 (4.3 percentage points lower than in 2018). 48.4% of these cases were located in rural areas (five regions showed prevalence rates higher than 50%). In the Cajamarca region and the Chota province, 33.8% and 33% of infants displayed iron deficiency, respectively[12]. This situation indicates that the problem is worsening, especially among the poor and extremely poor sectors of the population, which have been the most hardly affected by the COVID-19 health emergency.

Nutritional (low weight, acute malnutrition, short height, being overweight, etc.) and iron deficiency problems have negative consequences on the growth and development of children, also causing physical, psychological, and social damages as well as increasing child morbidity and mortality rates[3,11,13,14]. In addition, iron deficiency has short and long term consequences, which are critical for the child's health status as it increases the risk of psychomotor developmental delays. In this regard, the Spanish Association of Pediatrics[4], has identified that deficient nutritional states such as anemia cause a decrease in physical abilities as well as an increase in the risk of delaying the development of psychomotor (language, motor skills, and coordination) and cognitive skills.

Psychomotor development is any dynamic process of acquisition and organization of the child's biopsychosocial skills, which results from the neuro-maturation required to achieve progressive autonomy of the infant in areas such as coordination, language, and motor skills[15,16]. Piaget[17] from his Cognitive Development theory, states that intellectual development is built from the experiences that each child has in his/her environment. Thus, this construction involves the development of sensorial and psychomotor abilities, which are achieved during the first two years, as well as the development of the symbolic function and language (oral/written), reached between the 2 and 7 years of age. However, iron deficiency not only leads to psychomotor developmental disorders in areas such as coordination, language, and motor skills but also causes problems at cognitive (learning and intelligence) and socio-emotional levels, which manifest in the short and long term[18,19].

Based on the UNICEF reports[18], 32% of the worldwide population of children under five years old are developmentally delayed, whereas 43% are at risk of psychomotor developmental delay. These figures are a result of an increase in both poverty and chronic malnutrition. In Peru, the mother-child emotional bond in children under one year old reached 48%, with women and rural areas being affected with percentages of 51% and 52%, respectively[20]. Likewise, 50% of children aged under three years know how to express correctly their emotions (verbal communication). In this regard, the results were more negative for both being male (46%) and living in mountainous areas (48%)[12].

In this context and for an efficient approach to the problem, it is essential to recognize that iron deficiency is a disorder that affects children's psychomotor development during their first years of life, with a greater prevalence in poor populations and those that lack access to basic services (health, education, water, sanitation, etc.). In addition, the developmental disorder and its risk can be the result of the lack of knowledge and inadequate practices in terms of early stimulation at maternal and familial level. This problematic situation, together with the lack of local and regional studies, was the basis to carry out this study.

Materials and methods

Type, design and population of the study

Relational, cross-sectional study conducted between the months of March and April, 2022. The population included 48 children aged 2 – 4 years old, who were treated at the Cuyumalca Clinic. A population-based sample (48=48) was chosen through a non-randomized convenience sampling protocol. The participants were children of both genders who lived in the Centro Poblado neighborhood of Cuyumalca. Children with a diagnosis of mental disability, premature birth, intrauterine growth delay, and multiple births were excluded.

Data collection techniques and instruments

Hemoglobin levels were assessed with a HemoCue® Hb201+ portable hemoglobinometer[21], which was used to analyze a capillary blood sample obtained from the tip of the child's index finger, through a cyanomethemoglobin method. Hemoglobin concentration was classified following the WHO parameters for children aged between six months to five years old[5], as follows: normal (≥11.0 g/dl), mild anemia (10.0–10.9g/dl), moderate anemia (7.0–9.9

g/dl), and severe anemia (<7.0 g/dl). This is a safe, accurate and user-friendly method to be used by trained personnel, which has also been internationally standardized by the WHO for hemoglobin testing[5,22].

Psychomotor development was assessed through the Psychomotor Development Test (PDT) for 2-5 years old children and the 1985 Haeusssler and Marchand questionnaire[16] y utilizado por el Ministerio de Salud de Perú dentro de su normativa para la evaluación del desarrollo psicomotor infantil which is used by the Ministry of Health to assess infant psychomotor development[13,19]. The PDT test is applied to characterize the child's performance in multiple areas, including coordination, language and motor skills and provides a global/general development profile. The test includes 52 items (coordination=16; language=24; and motor skills=12), which are quantified as normal (score=01) or disorder (score=00). Likewise, the child's performance is determined through the total T score obtained in either the total test or the Subsets, where: normal T score≥40 points , risk T score= 30-39 points, and delay T score<29 ponts[19].

The PDT test was validated through a study on 540 children organized in 6 age groups. The reliability of its psychometric properties included: (i) the discriminate test-item score (p>0.003); internal concordance: Total Test (KR-20=0.94) and Subtests Coordination (KR-20=0.89), Language (KR-20=0.94) and Motor Skills (KR-20=0.82); and (iii) concurrent validity: *Stanford Binet Test* evaluated with Pearson r (coordination r=0.73 and language r=0.73) and the Denver Test (Total test=0.85, language=0.84, and motor skills=0.71)[16].

Procedure for data collection

Data collection required documented authorization from the Head of the Cuyumalca Health Clinic and the Nursing professional responsible for the growth and development service. The training of the participants was done in the hours of 8:00 am to 5:00 pm through an invitation letter. The hemoglobin level was assessed in the growth and development clinic office and the application of the PDT test was conducted in the early intervention area of this clinic. The equipment (hemoglobinometer) and materials (PDT test battery, procedure manual and PDT format and registry) used were standardize by the WHO and the Peruvian Ministry of Health[5,19].

Before the start of data collection, the researchers received training in the portable hemoglobinometer and PDT Test use. This activity was done by the Nursing professional of the clinic.

Ethical criteria

The study was approved by the scientific committee of the Health Sciences Department of the National Autonoma University of Chota, through the department resolution No. 035-2022-FCCSS-UNACH/C, issued on February 23, 2022. The ethical criteria were upheld during the entire process. The mothers who agreed voluntarily to participate in the study signed informed consents prior to the collection of information.

Statistical analysis

The collected information was uploaded in a data matrix designed through SPSS.V.25.0 software. The descriptive statistical analysis applied absolute and relative frequencies. The inferential analysis used Chi-square (X2), adjusted with Fisher's exact test in frequencies lower than 5, considering a significant p-value<0.05.

Results

The study was done with 48 children from 2 to 5 years of age, from both genders, treated at the Cuyumalca Health Clinic. The average age was 32.6 months, 39.6% were between 2 years 0 months 0 days and 2 years 11 months 29 days, and 52.1% were male (Table 1).

Table 1. Demographic characteristics in children aged 2 to 5 years from the Cuyumalca Health Clinic, Chota

Caracteristics	N (48)	% [IC = 95%]
Age		
2 years	19	39.6 [25.8;53.4]
3 years	13	27.1 [14.5;39.7]
4 years	16	33.3 [20.0;46.6]
Gender		
Male	25	52.1 [38.0;66.2]
Female	23	47.9 [33.8;62.0]

31.2% of the children exhibited some type of anemiz, with moderate anemia being the most frequent (16.7%) (Table 2).

Table 2. Hemoglobin levels in children from 2 to 5 years from the Cuyumalca Health Clinic, Chota.

Hemoglobin levels	N(48)	% [IC = 95%]
Without anemia	33	68.8 [55.7;81.9]
Mild anemia	7	14.5 [4.5;24.5]
Moderate anemia	8	16.7 [6.1;27.3]

In average, 10.9% of participating children displayed some level of psychomotor developmental disorder, specifically in coordination (6.3%), language (8.4%), and motor skills (16.7%), as well as global development (12.5%) (Table 3).

There are no statistical differences between iron deficiency anemia and psychomotor development in children from 2 to 5 years of age [p>0.05] (Table 4).

Table 3. Psychomotor development in children from 2 to 5 years from the Cuyumalca Health Clinic, Chota.

Developmental areas	N(48)	%[IC = 95%]
Coordination area		
Normal	45	93.7 [86.8;100.6]
Risk	2	4.2 [-1.5;9.9]
Delay	1	2.1 [-2.0;6.2]
Language area		
Normal	44	91.6 [83.8;99.4]
Risk	3	6.3 [-0.6;13.2]
Delay	1	2.1 [-2.0;6.2]
Motor skills area		
Normal	40	83.3 [72.7;93.9]
Risk	7	14.6 [4.6;24.6]
Delay	1	2.1 [-2.0;6.2]
Global development		
Normal	42	87.5 [78.1;96.9]
Risk	4	8.3 [0.5;16.1]
Delay	2	4.2 [-1.5;9.9]

Source: Psychomotor Development Test (PDT).

Table 4. Relationship between iron deficiency anemia and psychomotor development in children from 2 to 5 years from the Cuyumalca Health Clinic, Chota.

Psychomotor Development	Mild anemia			Moderate anemia			X2	*Fisher's* exact test
	N(7)	%(100.0)	[IC=95%]	N(8)	%(100.0)	[IC=95%]		
Coordination area								
Normal	6	12.5	[3.1;21.9]	8	16.7	[6.1;27.3]	0.611*	0.506 – 0.526
Risk	1	2.1	[-2.0;6.2]	0	0.0	---		
Language area								
Normal	7	14.6	[4.6;24.6]	7	14.6	[4.6;24.6]	0.833*	0.779 – 0.795
Risk	0	0.0	---	1	2.1	[-2.0;6.2]		
Motor skills area								
Normal	7	14.6	[4.6;24.6]	7	14.6	[4.6;24.6]	0.713*	0.692 – 0.709
Risk	0	0.0	---	1	2.1	[-2.0;6.2]		
Global development								
Normal	6	12.5	[3.1;21.9]	7	14.6	[46;24.6]	0.812*	0.703 – 0.72
Risk	1	2.1	[-2.0;6.2]	1	2.1	[-2.0;6.2]		

*X2=p>0.05.
Source: Psychomotor Development Test (PDT).

Discussion

The demographic composition of the sample is similar to the characteristics shown by children less than five years of age in the study by Nampijja *et al.*[23] in Uganda, where 50.4% were male, with an average age of 34.6 months, 26.3% had a delay in growth, and 6.5% lived in poverty conditions. Similarly, the Peruvian studies conducted by Chura and Arestegui[24], showed that 52.5% of the children were male and ranged between two to three years of age. Burga[25] reported that 56% were male, and of these 36% were four years old, while Bravo[26] reported 58% were male. Likewise, the result coincide with those reported by the National Institute of Statistics and Computer Sciences (NISCS) in 2020[19,27], where of the more than 500,000 births, 296,000 were male and 248,000 were female. This is related to the descending demographics in birth, mortality, and marriage rates, which have been registered in Peru during the last two decades. The demographic findings are used to characterize the children and contextualize the social and physical space where they live in, which helps to understand the situations which are causing the morbid nutritional states, such as anemia and psychomotor developmental disorders[28]. These public health problems had the highest incidence in certain ages and contexts[29.30].

Nearly one third of the children showed some degree of anemia, with moderate anemia being the most frequent. These figures may be reflecting the impact that COVID-19 is having on infant health services, as well as the lack of knowledge and nutritional habits of mothers, the adherence to food supplementation, or the limited efficiency of the iron food supplements and other micronutrients provided by the government[1,9]. This may be due to the interruption of the health services worldwide because of the COVID-19 pandemic, which caused the closing of first level health services (for the first 8 months of the pandemic in Peru), as well as the redistribution of resources towards the clinical assistance for COVID-19, which could have affected the follow up and

treatment of childhood anemia. Moreover, the limited access to health services caused by the confinement restrictions and the worry about exposure to the virus made it difficult for families to access health services, which could have led to a small number of visits to children health services, including diagnosis and treatment of anemia.

The iron deficiency results coincide with those of diverse studies, which showed that mild and moderate anemia are the most frequent but differ in terms of frequencies. To this respect, Kazakhstan, Pivina *et al.*[31] showed that more and 50% of children younger than 5 years of age presented with iron deficiency anemia; while Luciano *et al.*[32] in Italy, found that close to 30% of one year old children had iron deficiency anemia. Also, Zhang *et al.*[33] showed higher than 35% figures in China. However, Uganda Nampijja *et al.*[23] reported that 75.8% and 47.1% of children from Uganda had mild and moderate anemia, respectively. In Peru, Burga[25]. revealed that over half of the children had either mild or moderate anemia, Gómez[34] found that 59% had mild anemia and 41% had moderate anemia, Tume[35] reported that 48% had moderate anemia and 35% had mild anemia, and Chura y Arestegui[24] observed that 50% had moderate anemia and 35% had mild anemia. The reported iron deficiency figures may be affecting the cognitive, social, motor, language, and coordination growth and development of children[22]. This is the reason why the government health institutions must increase financial resources to strengthen strategies focused on prevention of iron deficiency anemia[36,37].

The diverse proportions of anemia shown by the discussed studies could be related to the socioeconomic and cultural context where they were conducted, since they have demonstrated that this iron deficiency disorder is more common in rural and marginal urban areas as well as in poor and under 5 years old populations[26.34]. In addition, the problem may be exacerbated by the limited access to health services (nutritional guidance, preventive and therapeutic management of anemia, antiparasitic treatment, etc.) during the COVID-19 pandemic. The observed iron deficiency may also be the consequence of the lack of knowledge and inadequate nutritional practices provided by the mother, which affect the nutritional state and psychomotor development of the child[38].

The observed higher frequency of the risk for psychomotor development may be associated with iron deficiency, since Farreras-Rozman[39] has shown that this disorder leads to deficient myelination and neuronal deficit, which causes alterations in neurotransmitter function and future psychomotor developmental problems. In addition to causing changes in the homeostasis of neurotransmitter, iron deficiency also alters synaptogenesis and decreases basal ganglia functionin[31].

The reported psychomotor development figures are significantly lower than those shown previously. Studies from Studies from Uganda[23], Kazakhstan[31], Italy[32], and China[33] showed that nearly one third of participating children had some degree of developmental delay. Likewise, in Peru, Rojas[40] found that on average 62.5% of children were at risk in the developmental areas and global development which were evaluated. Tume[35] reported a risk of 53% and an 8% of global developmental delay and an average of 36% in the areas of coordination, language and motor skills. Similarly, Burga[25] identified an 8% risk, 2% of delay in global development, and a risk average of 18% for development of coordination and language. These figures alter the acquisition and organization of biopsychosocial abilities in children (neural maturation of the central nervous system and interaction with their environment), thereby limiting the progressive autonomy in the distinct areas of development[15,16,41-43].

In reference to the relationship between anemia and psychomotor development, the findings and similar to those reported by Bravo[26] y Chura[24] who determined the relationship between anemia severity, developmental areas, and global development was not significant [p>0.05]. Likewise, the study by Nampijja *et al.*[23] in Uganda did not find a significant relationship between iron deficiency anemia and the development of the language (p=0.22), motor skills (p=0.25), and social (p=0.67) areas. In contrast, these observations differ from findings from a Chinese study done by Zhang *et al.*[33] in which a significant association was reported between variables (p=0.007); as well as in Peruvian studies from Gómez[34], Tume[35] y Burga[25]. who reported a statistically significant relationship (p<0.05) between three areas of development and iron deficiency anemia. This may be caused by the higher severity of anemia and the higher prevalence of risk and developmental delay in participating children, which shows that as anemia worsens it alters the process of psychomotor development[42,44], causes nutritional disorders which leads to irreversible impacts on the central nervous system (oligodendrocytes require iron to synthesize fatty acids and cholesterol, which are essential for myelination and fast neuronal response to stimuli)[28,40] and affect the neurolinguistic functions of the child[43].

Finally, the government policies must be focused not only in health services to counteract anemia and developmental delays through iron supplements and early intervention for development, but the multicausal problems that this represents must also be considered since once present in the child, they will lead to short-term and long-term developmental problems. This is why strategies in the first level of health intervention that are focused on addressing the multicausal factors such as: lack of iron supplements, low adherence to supplementation programs, shortage of effective nutritional guidance, inadequate therapeutic management of anemia, non-existent or scare early stimulation and early intervention programs, etc.

Conclusions

Moderate anemia was the most frequent. The risk for psychomotor development was the more common developmental disorder. There is no statistically significant relationship between iron deficiency anemia and psychomotor development in the coordination, language, and motor skills areas as well as in global development. The strengthening of intervention strategies in first level health services

would help social agencies to reduce iron deficiency anemia and psychomotor development disorders. The identification of social, demographic, economic, cultural and environmental factors that are associated with iron deficiency and children developmental disorders is required.

Conflict of interests: None declared by the authors.

Clarifications: This article is the result of the undergraduate dissertation called "Iron deficiency and psychomotor development in children between 2 to 4 years of age treated at the Cuyumalca Health Clinic, Chota, 2022."

References

1. Organización Mundial de la Salud (OMS). Informe de la nutrición mundial: arrojar luz sobre la nutrición para inspirar nuevas iniciativas [Internet]. 2018. Available from: https://globalnutritionreport.org/documents/427/GNR_2018_ES_Web_res_JP5Is8Y.pdf
2. Instituto Nacional de Salud. Desnutrición, anemia y obesidad son los principales problemas de malnutrición infantil en el Perú [Internet]. Lima (PER): Centro Nacional de Alimentación y Nutrición; 2019. Available from: https://observateperu.ins.gob.pe/noticias/278-desnutricion-anemia-y-obesidad-son-los-principales-problemas-de-malnutricion-infantil-en-el-peru
3. Organización Mundial de la Salud (OMS). WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for height and body mass index-for-age: methods and development [Internet]. 2006. Available from: https://www.who.int/publications/i/item/924154693X
4. Asociación Española De Pediatría, Moro M, Málaga S, Madero L. Tratado de pediatría. 11th ed. (ESP): Editorial Médica Panamericana; 2014. Available from: https://dialnet.unirioja.es/servlet/libro?codigo=700184
5. Organización Mundial de la Salud (OMS). Concentraciones de hemoglobina para diagnosticar la anemia y evaluar su gravedad: Indicadores de Micronutrientes del VMNIS/Sistema de Información Nutricional sobre Vitaminas y Minerales [Internet]. 2011. Available from: https://apps.who.int/iris/handle/10665/85842
6. Gonzales GF, Olavegoya P, Vásquez-Velásquez C, Alarcón-Yaquetto DE. Uso de hemoglobina (Hb) para definir anemia por deficiencia de hierro. Rev Peru Investig Materno Perinatal [Internet]. 2019;7(1):37-54. DOI: 10.33421/inmp.2018108
7. Gonçalves T, Tavares A, Chagas K, Izze da Silva E, Lima C, Pereira M, et al. Prevalence and factors associated with anemia in children enrolled in daycare centers: a hierarchical analysis. Rev Paul Pediatr [Internet]. 2017;35(3):281-288. DOI: 10.1590/1984-0462/;2017;35;3;00008
8. Klotz CR, Osório MM, Taconeli CA, Schmidt ST, Corrêa da Silva BH, Bettega CC. Prevalence and risk factors of anemia in children. J Pediatr [Internet]. 2016;92(4):353-360. DOI: 10.1016/j.jped.2015.09.007
9. Organización de las Naciones Unidas para la Alimentación y la Agricultura. Panorama de la seguridad alimentaria y nutricional en américa latina y el caribe: Desigualdad y sistemas alimentarios [Internet]. 2018. Available from: http://www.fao.org/3/CA2127ES/CA2127ES.pdf
10. Organización Mundial de la Salud. Anemia [Internet]. 2018. Available from: https://www.who.int/es/health-topics/anaemia#tab=tab_1
11. Fondo de las Naciones Unidas para la Infancia (UNICEF). El estado mundial de la infancia 2019 Niños, alimentos y nutrición: Crecer bien en un mundo en transformación [Internet]. 2019. Available from: https://www.unicef.org/peru/media/6366/file/Estado%20Mundial%20de%20la%20Infancia%202019%20Resumen%20Ejecutivo.pdf
12. Instituto Nacional de Estadística e Informática. Perú: Encuesta Demográfica y de Salud Familiar–ENDES 2020 [Internet]. Lima (PER); 2021. Available from: https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1656/index1.html
13. Ministerio de Salud del Perú. Resolución Ministerial 537-2017-MINSA: Norma Técnica de Salud para el Control de Crecimiento y Desarrollo de la niña y el niño Menor de Cinco Años [Internet]. Perú; 2017. Available from: https://www.gob.pe/institucion/minsa/normas-legales/190581-537-2017-minsa
14. Palma A. Malnutrición en niños y niñas en América Latina y el Caribe [Internet]. 2018. Available from: https://www.cepal.org/es/enfoques/malnutricion-ninos-ninas-america-latina-caribe
15. Cobos Álvarez P. El desarrollo psicomotor y sus alteraciones: Manual práctico para evaluarlo y favorecerlo. Madrid (ESP): Ediciones Pirámide; 2007. Available from: https://www.edicionespiramide.es/libro.php?id=1708970
16. Haeussler IM, Marchant T. TEPSI: Test de desarrollo psicomotor 2-5 años. 16th ed. Santiago de Chile (CHL): Ediciones Universidad Católica de Chile; 2014. Available from: https://biblioteca.ipchile.cl/cgi-bin/koha/opac-detail.pl?biblionumber=5608&shelfbrowse_itemnumber=9240
17. Piaget J. El nacimiento de la inteligencia en el niño. Barcelona (ESP): Crítica; 1999. Available from: https://www.casadellibro.com.co/libro-el-nacimiento-de-la-inteligencia-en-el-nino/9788498922271/1854675
18. Fondo de las Naciones Unidas para la Infancia (UNICEF). La primera infancia importa para cada niño [Internet]. 2019. Available from: https://www.unicef.org/peru/sites/unicef.org.peru/files/2019-01/La_primera_infancia_importa_para_cada_nino_UNICEF.pdf
19. Ministerio de Salud del Perú. TEPSI: Test de desarrollo psicomotor. Dos a cinco años [Internet]. Lima (PER); 1995. Available from: https://www.gob.pe/institucion/minsa/informes-publicaciones/285027-tepsi-test-de-desarrollo-psicomotor-dos-a-cinco-anos
20. Ministerio de Desarrollo e Inclusion Social del Perú. Desarrollo infantil temprano: en niñas y niños menores de 6 años de edad [Internet]. Lima (PER): Instituto Nacional de Estadística e Informática; 2019. Available from: https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1674/libro.pdf
21. HemoCue® Hb 201+. Operating Manual [Internet]. California (USA): HemoCue AB – Hemocue, Inc. Available from: https://www.cliawaived.com/web/items/pdf/HMC-111716_201_Operating_Manual~2068file3.pdf
22. Ministerio de Salud del Perú. Resolución Ministerial 250-2017-MINSA: Norma Tecnica de Salud para el Manejo terapéutico y preventivo de la anemia en niños, adolescentes, mujeres gestantes y puérperas [Internet]. Lima (PER). 2017. Available from: https://anemia.ins.gob.pe/rm-ndeg-250-2017-minsa
23. Nampijja M, Mutua AM, Elliott AM, Muriuki JM, Abubakar A, Webb EL, et al. Low Hemoglobin Levels Are Associated with Reduced Psychomotor and Language Abilities in Young Ugandan Children. Nutrients [Internet]. 2022;14(7):1452. Available from: https://pubmed.ncbi.nlm.nih.gov/35406065
24. Chura Huanca V, Arestegui Calcina F. Anemia relacionado con el Desarrollo Psicomotor en niños de 3 a 5 años de la Institución Educativa Inicial 319 Taparachi, Juliaca - 2017 [Tesis de Licenciatura]. Juliaca (PER): Universidad Peruana Unión; 2018. Available from: https://repositorio.upeu.edu.pe/handle/20.500.12840/1827
25. Burga Rodríguez ME. Anemia y desarrollo psicomotriz en niños y niñas de 4 y 5 años que asisten a la Institución Educativa N° 99- Santa Rosa la Tulpuna, Cajamarca - 2019 [Tesis de Licenciatura]. Cajamarca (PER): Universidad Nacional de Cajamarca; 2019. Available from: https://repositorio.unc.edu.pe/handle/20.500.14074/3574
26. Bravo Mascaro EY. La anemia y el desarrollo psicomotor en niños de 2 a 5 años de un colegio del distrito de La Victoria; Lima – 2019 [Tesis de Licenciatura]. Lima (PER): Universidad Nacional Mayor de San Marcos; 2020. Available from: https://cybertesis.unmsm.edu.pe/bitstream/handle/20.500.12672/15607/Bravo_me.pdf
27. Instituto Nacional de Estadística e Informática. Perú: Natalidad, mortalidad y nupcialidad 2019 (departamento, provincia y distrito) [Internet]. Lima (PER): INEI; 2019. Available from: https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1766/libro.pdf
28. Carrero CM, Oróstegui MA, Ruiz Escorcia L, Barros Arrieta D. Anemia infantil: desarrollo cognitivo y rendimiento

académico. AVFT [Internet]. 2018;37(4):411-426. Available from: https://www.revistaavft.com/images/revistas/2018/avft_4_2018/19_anemia_infantil.pdf
29. Quesada P, Gallego AM, Reyes M. Caracterización de pacientes en edad pediátrica con anemia ferropénica. Rev Electr Dr Zoilo E Marinello Vidaurreta [Internet]. 2017;42(3). Available from: http://revzoilomarinello.sld.cu/index.php/zmv/article/view/1076/pdf_405
30. Román Sacón J, Calle Contreras P. Estado de desarrollo psicomotor en niños sanos que asisten a un Centro Infantil en Santo Domingo, Ecuador. Enfermería (Montevideo) [Internet]. 2017;6(2):39-44. Available from: https://revistas.ucu.edu.uy/index.php/enfermeriacuidadoshumanizados/article/view/1467
31. Pivina L, Semenova Y, Doşa MD, Dauletyarova M, Bjørklund G. Iron Deficiency, Cognitive Functions, and Neurobehavioral Disorders in Children. J Mol Neurosci [Internet]. 2019;68(1):1-10. Available from: https://pubmed.ncbi.nlm.nih.gov/30778834
32. Luciano R, Romeo DM, Mancini G, Sivo S, Dolci C, Velli C, et al. Neurological development and iron supplementation in healthy late-preterm neonates: a randomized double-blind controlled trial. Eur J Pediatr [Internet]. 2022;181(1):295-302. Available from: https://pubmed.ncbi.nlm.nih.gov/34291331
33. Zhang YL, Zheng SS, Zhu LY, Ji C, Angulo-Barroso RM, Lozoff B, et al. Impact of iron deficiency in early life stages on children's motor development: a longitudinal follow-up. Zhonghua Er Ke Za Zhi [Internet]. 2019;57(3):194-199. Available from: https://pubmed.ncbi.nlm.nih.gov/30818896
34. Gómez Tone LE. Niveles de hemoglobina y su incidencia en el desarrollo psicomotriz en niños menores de un año de la Red Asistencial Juliaca Essalud, 2018 [Tesis de Maestría]. Juliaca (PER): Universidad Andina; 2019. Available from: https://revistas.uancv.edu.pe/index.php/RCIA/article/view/800
35. Tume Flores W. Desarrollo psicomotor asociado al nivel de hemoglobina en niños y niñas de 2 a 5 años de edad, Centro de Salud Cabana – 2018 [Tesis de Licenciatura]. Puno (PER): Universidad Nacional del Altiplano; 2019. Available from: https://repositorioslatinoamericanos.uchile.cl/handle/2250/3277996
36. Dávila Aliaga CR, Paucar-Zegarra R, Quispe AM. Anemia infantil. Rev Peru Investig Matern Perinat [Internet]. 2018;7(2):46-52. Available from: https://investigacionmaternoperinatal.inmp.gob.pe/index.php/rpinmp/article/view/118/123
37. Zavaleta N. Anemia infantil: retos y oportunidades al 2021. Rev Peru Med Exp Salud Publica [Internet]. 2017;34(4):588-589. Available from: http://www.scielo.org.pe/scielo.php?script=sci_arttext&pid=S1726-46342017000400002
38. Pender NJ. The Health Promotion Model [Internet]. 5th ed. (USA): Prentice Hall; 2006. Available from: https://www.amazon.com/-/es/N-J-al-Pender/dp/B008UBQPT6
39. Farreras P, Rozman C. Medicina Interna. 14th ed. (ESP): Ediciones Harcourt S.A; 2000. Available from: https://www.iberlibro.com/servlet/BookDetailsPL?bi=30274951983
40. Rojas Soto M. Desarrollo psicomotor en el preescolar con anemia del Centro de Salud Collique III Zona, Comas – 2019 [Tesis de Licenciatura]. Lima (PER): Universidad César Vallejo; 2019. Available from: https://repositorio.ucv.edu.pe/handle/20.500.12692/39804?locale-attribute=en
41. Sastre-Riba S, Ortiz T. Executive neurofunctionality: a comparative study in high intellectual abilities. Rev Neurol [Internet]. 2018;66(S01):S51-S56. Available from: https://pubmed.ncbi.nlm.nih.gov/29516453
42. Puelles-Díaz A, Illanes-González H, Órdenes Y, Gallardo E. Psychomotor development of children from Chilean and Haitian parents in kindergartens of the district of Coquimbo, Chile: A descriptive study. Medwave [Internet]. 2020;20(4):e7904. Available from: https://pubmed.ncbi.nlm.nih.gov/32469856
43. Aquino Canchari CR. Anemia infantil en el Perú: un problema aún no resuelto. Rev Cubana Pediatr [Internet]. 2021;93(1):e924. Available from: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0034-75312021000100018
44. Beltrán-Navarro B, Matute E, Vásquez-Garibay EM. Efecto de la deficiencia de hierro sobre el desarrollo neuropsicológico en lactantes. Interdisciplinaria [Internet]. 2019;36(2):129-150. Available from: https://www.redalyc.org/articulo.oa?id=18060566026