Anemia and iron deficiency in infants aged 6-12 months in the city of Necochea: Prevalence and determinants

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ABSTRACT

Introduction. Anemia in the first years of life leads to severe psychomotor, social, and financial effects. The objective of this study was to determine its prevalence, causes, and risk and preventive factors among infants in the city of Necochea.

Population and methods. Observational, descriptive, and cross-sectional study. Healthy infants aged 6-12 months who attended a spontaneous health checkup in a public and/or private facility in the district of Necochea during 2017 were assessed. An informed consent was obtained; a social and nutrition survey was administered; dietary and medicinal iron intake was assessed; and a physical examination and lab tests were done.

Results. A total of 239 participants were included; 50.6 % had anemia and 47.3 %, iron deficiency. Mean and median hemoglobin levels were both 10.9 g/dL, (reference mean: 12.5 mg/dL). Among anemia patients, 54.4 % had iron deficiency; iron intake was inadequate in 61.7 %; and 44.3 % had not received iron supplementation the previous day. Among these, 24.5 % had not received a medical indication for it, and 9.1 % did not find iron supplementation available at their primary health care center or hospital. An adequate iron intake was a protective factor against iron deficiency (relative risk [RR]: 0.78 [95 % confidence interval {CI}: 0.6-0.9]), but not against the development of anemia (RR: 1.08; [95 % CI: 0.8-1.3]).

Conclusions. In the city of Necochea, anemia and iron deficiency are highly prevalent conditions; dietary iron intake is insufficient and supplementation is under-prescribed.

Key words: *anemia, iron deficiency anemia.*

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INTRODUCTION

Anemia is defined as a reduced hemoglobin (Hb) level below 2 standard deviations (SDs) for sex and age, and its most common cause is iron deficiency (ID).[1-3] Anemia is considered a marker of social inequality and a severe public health problem. If not detected early, it causes severe neurological disorders, including a lower intelligence quotient, poor reading and writing skills and math performance, a higher school repetition index, and a deficient socio-affective development;[2,5-9] it also leads to impaired development, immune answer, and physical and work performance, among other consequences.[1-3]

ID is caused by a persistently negative balance,[3,5] which mainly depends on the deposits acquired towards the end of gestation and iron bioavailability in the type of milk consumed. Then, it will depend on intestinal absorption from diet, nutritional status, still immature regulatory factors, and their relation to absorption facilitators, such as vitamin C, fructose, citric acid, and lactic acid, or inhibitors, like phosphates, phytates (bread), calcium (dairy), fibers, polyphenols, and tannins (coffee, tea, chocolate).[1-3,6,10,11] The greatest iron bioavailability is found in meat.

The following are risk factors for ID and anemia: early umbilical cord clamping, twin pregnancy, preterm birth, maternal anemia, inadequate or untimely complementary feeding, non-fortified milk intake, parasitic disease, and intestinal mucosa irritation; and also social conditions, such as low income, low educational environment, malnutrition, undernutrition, and unmet basic needs (UBNs).[1,12-15] According to the National Survey on Nutrition and Health (*Encuesta Nacional de Nutrición y Salud*, ENNyS),[12-14] anemia prevalence showed a great inter-regional variation, from 16.5 % among children younger than 5 years to 34.1 % among those aged 6-24 months and 47.6 % among 6-12-month-old infants. Among these children with anemia, 54 % had ID.

At 1 year old, in Argentina, 72 % of children are still breastfed[16] and 3 out of 4 of those who are not breastfed are exclusively fed with non-fortified milk; of these, 50 % do not meet the minimum iron requirements. As of 6 months old, many infants receive food with a poor iron and calorie intake;[17] only 40 % refer meat intake the previous day, and more than half eat low quality meats.

The Argentine Society of Pediatrics (*Sociedad Argentina de Pediatría*, SAP), the World Health Organization (WHO), and the American Academy of Pediatrics (AAP) recommend iron administration as of 4 months old to exclusively and partially breastfed infants until highly bioavailable iron sources are introduced.[1-3,6,18] The REMEDIAR + REDES program provides free medicinal iron, like ferrous sulfate, at a national level.[20] However, only 33 % of infants aged 6-11 months and 9 % of children aged 12-23 months receive it, and a higher use is observed among households without UBNs.[10]

Both the SAP and the AAP recommend a universal screening for Hb levels at 9 months old,[1,3,18] but such requirement is not systematically met.[19,22] There are regulations and consensuses in relation to anemia detection, screening, prevention, and management, as well as social assistance programs and a legal framework that establishes iron fortification of milk and flour;[24] however, the prevalence of anemia is still high.

In 2000, a study done in Necochea about timely umbilical cord clamping showed the benefits for iron deficiency anemia (IDA) prevention, but the long-term follow-up was not completed.[25] No local studies have been done on the prevalence of IDA, ID, and risk factors or on the perspective of this condition among health care staff and families.

The purpose of this study was to clarify the local situation in the 6 to 12-month-old population. The objective of this study was to determine the prevalence of anemia and ID and its relation to dietary and medicinal iron intake, and the reason why iron supplementation is sometimes not administered.

MATERIAL AND METHODS

This was an observational, descriptive, and cross-sectional study. It included all healthy infants aged 6-12 months who attended a spontaneous health checkup in a public and/or private facility in the city of Necochea between February and December 2017. This was an attempt to prevent a selection bias. Children with an acute infectious disease were excluded. The sample size was estimated with the openEpi software, version 3.03, considering that 50 % of average annual births (1496 neonates)[29] would be between 6 and 11 months old for a disease with an hypothetical frequency of 45 % ± 5[13] and an expected confidence interval (CI) of at least 95 %.

The pediatrician that assessed each infant requested the informed consent from their parent/legal guardian and administered the survey (*Annex*), performed the physical examination, and requested the lab tests. For anemia diagnosis, Hb levels were assessed considering anemia a level below 11 g/dL (-2 SDs); ID was defined based on serum ferritin (SF) levels below 10 ng/mL; the values published by the 2017 SAP guidelines were used as reference. Blood iron levels and transferrin saturation were ruled out given their high pre-analytical variability. All lab tests were done at the Department of Hematology of Hospital Dr. E. Ferreyra, in Necochea, using a Mindray 2300® counter for Hb and a Metrolab 950 ELISA reader for SF.

Outcome measures were divided into 5 modules (*Table 1*). The first 2 modules included demographic outcome measures (age and sex) and perinatal outcome measures (birth weight, gestational age, and type of delivery) and described the characteristics of the study population. The other 3 modules allowed to establish indices for a better result interpretation.

The third module described the socioeconomic situation and established the educational environment index and the UBN index. The average number of years of completed education by the parents or the total years completed by the adult in charge of a single-parent household was obtained and classified into high (more than 13 years), middle (10-12 years), low (6-9 years), and very low (less than 6 years).[13] The UBN index was established when at least one of the outcome measures required for adequate housing conditions was not met.

The outcome measures in the fourth module allowed to establish the iron intake index. These included the type of milk consumed and divided it based on iron bioavailability into adequate (breast milk or fortified milk) or scarce (non-fortified milk); meat intake the previous day and its association with facilitators or inhibitors of absorption; and medicinal iron intake and, if negative, the reason for it. Iron intake was defined as adequate if it included breastfeeding or fortified milk, food of animal origin, and medicinal iron administration. The absence of any of these 3 requirements was considered an inadequate intake.

The fifth module includes the lab tests used to assess iron metabolism (Hb and SF) and reflects the presence or absence of anemia and ID. The EpiInfo™ software, version 7.2, was used for statistical analysis. Measures of frequency and association were obtained, including relative risk (RR) with a 95 % CI and a χ^2 test to establish an association for polytomous variables. The protocol was approved by the hospital's Board and Ethics Committee.

RESULTS

A total of 245 infants aged 6-12 months were included; 6 patients were excluded because they had an infectious disease at the time of the blood sample collection. The characteristics of the study population are presented in *Table 2*.

Anemia was observed in 50.6 %. The mean Hb level was 10.9 g/dL (SD ± 0.94), with a total range of 7.1-14 g/dL (range in the anemia population: 7.1-10.9 g/dL). Out of all children, 47.3 % had ID, with a total ferritin range of 0.6-247 ng/dL (range in the ID population: 0.6-9.7 ng/dL) and a mean of 12.7 ng/dL (SD ± 29.9).

Among all children with anemia, 54.4 % had ID. In addition, among children without anemia, 43.3 % had ID. *Table 3* shows the comparative results of the different indices in relation to

Table 2. *Characteristics of the study population (N: 239)*

		Total	Percentage
Educational environment	High	94	39.3
	Middle	79	33.0
	Low	44	18.4
	Very low	3	1.2
	ND	19	7.9
UBNs	Yes	47	19.6
	No	174	72.8
	ND	18	7.5
Birth	Preterm	10	4.2
	Term	211	88.3
	ND	18	7.5
Sex	Female	133	55.6
	Male	109	44.4
Age	6 mo	12	5.0
	7 mo	82	34.3
	8 mo	52	21.7
	9 mo	32	13.4
	10 mo	29	12.1
	11 mo	32	13.4
Delivery	Vaginal	103	43.0
	C-section	116	48.5
	ND	20	8.7

UBNs: unmet basic needs; ND: no data.

Table 1. *Outcome measure modules and indices obtained*

Demographic	Perinatal	Socioeconomic	Feeding	Hematological profile
☐ Age	☐ Type of delivery	☐ Maternal education	☐ Type of milk consumed the previous day	☐ Hb
☐ Sex	☐ Birth weight	☐ Paternal education	☐ Meat intake the previous day	☐ Ferritin
	☐ Gestational age	☐ INDEX: Educational environment	☐ Facilitators	☐ INDEX: Anemia
		☐ Overcrowding	☐ Inhibitors	☐ INDEX: Iron deficiency
		☐ School attendance	☐ Medicinal iron	
		☐ Sewer system	☐ No iron intake	
		☐ Brick house	☐ INDEX: Iron intake	
		☐ Running water		
		☐ INDEX: UBNs		

Hb: hemoglobin; UBNs: unmet basic needs.

anemia and ID, and their corresponding RR.

Regarding the characteristics of the study population, age showed a little association with the development of anemia (χ^2: 3.2 [*p*: 0.6]), but a more clear one with ID (χ^2: 9.7 [*p*: 0.08]). As age increased, the probability of ID was higher. Also, as age increased, iron intake decreased (χ^2: 12.2 [*p*: 0.03]). No differences were observed in the sex outcome measure in terms of anemia or ID prevalence (RR: 1.17 [95 % CI: 0.9-1.5]). Of all assessed infants, 4.5 % had been born prematurely, and all of these had anemia and ID. An adequate birth weight was a protective factor against ID (RR: 0.16 [95 % CI: 0.02-0.9]), but not against anemia (RR: 0.4 [95 % CI: 0.1-1.3]). Finally, the type of delivery was not found to be a determinant of anemia (RR: 1.2 [95 % CI: 0.9-1.6]) or of ID (RR: 1 [95 % CI: 0.8-1.3]).

In relation to sociodemographic outcome measures, the presence of UBNs did not affect the development of anemia (RR: 1.2 [95 % CI: 0.8-1.8]) or of ID (RR: 1 [95 % CI: 0.7-1.3]). The household educational environment showed a strong association with the presence of anemia (χ^2: 7.9 [*p*: 0.04]), but such association was not so clear with ID (χ^2: 3 [*p*: 0.4]), and demonstrated that a higher educational environment led to a lower probability of anemia.

An adequate iron intake did not affect the development of anemia (RR: 0.8 [95 % CI: 0.8-1.4]), but it was a protective factor against ID (RR: 0.7 [95 % CI: 0.5-0.9]). Iron intake was inadequate in 61.7 % of children. Of them, 70 % had ID and 48.3 %, anemia. The breakdown of this index shows that 44.4 % of surveyed participants did not receive medicinal iron. The reasons for this included forgetfulness (n: 33), no medical indication (n: 24), stomachache (n: 19), unavailability at the health care center (n: 9), considered unnecessary (n: 9), and other reasons (n: 4). Also, 81 % of infants were breastfed and only 4.5 % received non-fortified milk. Lastly,

Table 3. *Comparative results of anemia and iron deficiency*

			Anemia			Iron deficiency		
		n	**Yes %n**	**No %n**	**RR (95 % CI)**	**Yes %n**	**No %n**	**RR (95 % CI)**
Total		239	50.6			47.3		
Sex	Female	130	46.1 (60)	53.9 (70)	1.17 (0.9-1.5)	45.5 (59)	54.5 (71)	1.08 (0.8-1.3)
	Male	109	45 (49)	55 (60)		49.5 (54)	50.5 (55)	
Delivery	C-section	116	55.6 (65)	44.4 (51)	1.29 (0.9-1.7)	44 (51)	56 (65)	1.06 (0.8-1.4)
	Vaginal	103	43.3 (44)	56.9 (59)		47.5 (49)	52.5 (54)	
	ND	20						
Age	6 months	12	50 (6)	50 (6)		50 (6)	50 (6)	
	7 months	82	58.8 (48)	41.2 (34)		36.2 (30)	63.8 (52)	
	8 months	52	48 (25)	52 (27)		44.2 (23)	55.8 (29)	
	9 months	32	56.2 (18)	43.8 (14)		47 (15)	53 (17)	
	10 months	29	51.7 (15)	48.3 (14)		62 (18)	38 (11)	
	11 months	32	56.2 (18)	43.8 (14)		62.5 (20)	37.5 (12)	
UBNs	Yes	47	58.7 (27)	41.3 (20)	1.23 (0.8-1.7)	46.6 (22)	53.3 (25)	1.02 (0.7-1.4)
	No	174	49.1 (86)	50.9 (88)		54.6 (95)	45.4 (79)	
	ND	18						
Educational environment	High	94	43 (40)	57 (54)		40.2 (38)	59.8 (56)	
	Middle	79	59.5 (47)	40.5 (32)		51.9 (41)	48.1 (38)	
	Low	44	50 (22)	50 (22)		45.5 (20)	54.5 (24)	
	Very low	3	100 (3)	0 (0)		67 (2)	33 (1)	
	ND	19						
Gestational age	Preterm	10	100 (10)	0 (0)		100 (10)	0 (0)	
	Term	211	48.3 (102)	51.7 (109)		43.3 (91)	56.7 (120)	
	ND	18						
Adequate intake	Yes	85	54.1 (46)	45.9 (39)	1.1 (0.8-1.4)	35.2 (30)	64.8 (55)	0.75 (0.6-0.9)
	No	137	48.2 (66)	51.8 (71)		51.8 (71)	48.2 (66)	
	ND	17						

ND: no data; UBNs: unmet basic needs; RR: relative risk; CI: confidence interval.

42 % had not consumed any type of food with a high iron bioavailability (meat) the previous day. In addition, 50.3 % referred the intake of food that facilitated absorption, like citrus fruits, but only 15 % did so in association with meat consumption.

DISCUSSION

Having full knowledge of all the effects caused by anemia on an individual's development, analyzing its status, and establishing that 1 in every 2 infants (50.6 %) aged 6-12 months has anemia should force us to seriously reconsider our duty as pediatricians. Some conditions are beyond our control. This is the case of the impact of the educational environment: anemia and ID were less common in households where caregivers had completed secondary school; however, it is clear that our professional background allows us to make many contributions based on an interdisciplinary work plan.

However, other outcomes observed in this study force us to have a self-critical approach. Namely, the small level of medicinal iron supplementation resulting from a lack of medical indication (1 in every 4 infants), insufficient supplies (1 in every 10 infants) or poor guidance (stomachache or forgetfulness in 1 in every 2 infants); this is similar to what has been described in other studies.[15,19] A future challenge would be to analyze this topic specifically given the relevance of anemia and ID prevention. In this context, it is also valid to raise the need to assess other local strategies in relation to the type of supplementation selected in an attempt to improve iron intake.

As age increased, iron intake decreased; but at an older age, iron requirements were high and breastfeeding was not enough to meet them, as reflected by the higher prevalence of ID. The assessment of dietary iron intake showed that a high rate of children (2 in every 5) had not received food with a high iron bioavailability; of them, only 1 in every 6 infants consumed this food in association with facilitators of iron absorption. This study sought to approach the situation in this regard, but a deeper analysis is required, taking specific studies as reference.[28]

In relation to the type of milk consumed, more than 95 % of infants received milk with a high iron bioavailability, and only 1 in every 20 infants received only non-fortified milk. This study was not aimed at assessing the breastfeeding index; however, results are not far from those obtained in the ENNyS or the National Breastfeeding Survey (*Encuesta Nacional de Lactancia Materna*, ENaLac).[16] Exclusive breastfeeding did not have an effect on anemia and/or ID development. This is consistent with other studies.[4] Most likely, this is due to iron fortification of infant formula, which has a smaller intestinal absorption but a higher iron concentration, which in the end achieves an adequate bioavailability.

As observed in other studies,[4] the type of delivery did not have an effect on outcomes. In turn, a low birth weight was a risk factor for ID. All preterm infants had anemia and ID, but many of them received follow-up at the Department of Neonatology, so they could not be selected for inclusion in this study; this was probably a bias in the assessment of these two outcome measures. In addition, no differences were observed in the prevalence of anemia and/or ID based on sex or presence of UBNs.

Drake and Bernztein demonstrated a positive cost-benefit ratio in the prevention of ID, where for each dollar invested, 33.4 dollars were saved in economic losses resulting from anemia-associated conditions.[22] With our support, government authorities should become aware of such knowledge and develop policies to that effect.

Although the SAP and the AAP recommend screening for anemia and ID before 12 months old, such practice is not generally reflected. This was introduced as an additional comment to the survey, so it should be analyzed in future studies.

For all these reasons, it is unavoidable to recognize the actual significance and importance of anemia in children and the society in general. In turn, it is necessary to have local information that can be compared to better adapt regulations and guide community efforts. Only this way it will be possible to strengthen known strategies and develop new ones to eradicate such unfair disease. This study describes several problems that should be further investigated.

CONCLUSION

The prevalence of anemia and iron deficiency in infants aged 6-12 months in the city of Necochea is high and even exceeds the national mean prevalence. ID is the main cause. A high educational environment and exogenous iron intake were protective factors against ID. This study showed that a high rate of children did not receive an adequate dietary or medicinal iron intake and that more than half of participating families had a middle or low educational environment.

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ANNEX

1) IDENTIFICATION: ______________________________(Write the initials of first and last names).
SEX: F M AGE:__________months old.

2) PERINATAL HISTORY:
Birth weight: __________g. Gestational age: _______weeks. Type of delivery:_________.

3) FAMILY AND SOCIOECONOMIC HISTORY:
Maternal education (in completed years): _____________________________.
Paternal education (in completed years): _____________________________.
No. of household members: ___________________. No. of rooms: _______.
School attendance (school-age household member who does NOT attend school): YES. __ NO. __
House: Bricks._________ Metal sheets.__________ Excreta disposal: Sewer system.________
Cesspit._____ Water: Running. _______ Well. _______

4) FEEDING
Current breastfeeding: YES._____ NO. ___
Breastfeeding up to ___________months old (only if the child is not currently breastfed).
Regarding consumption the previous day (ask what the infant consumed yesterday):

I. Breast milk only	IV. Breast milk and cow's milk.
II. Cow's milk only	V. Breast milk and fortified milk.
III. Fortified milk only	VI. Cow's milk and fortified milk.

Did the child eat meat yesterday (cow, chicken, fish, blood sausage, liver)?
No.______ Yes. ________
Did the child eat meat last week? (Only if the previous answer was No).
No.______ Yes. _______
Did the child eat citrus fruits yesterday?
No.______ Yes. ________
Did the child have any infusion yesterday (tea, coffee, mate, mate infusion, chocolate milk)?
No.______ Yes. _________
Did the child combine meat and infusions yesterday? (Ask only if the child ate meat the previous day).
No.______ Yes. _________
Did the child combine meat and citrus fruits yesterday? (Ask only if the child ate meat the previous day).
No. _____ Yes._________
Did the child receive iron yesterday?
No.______ Yes. _________
If Yes: How long has the child been taking iron?_ months.
How many drops do you administer?___ drops.
If the child did not receive iron:
I. The doctor did not indicate it.________
II. You did not consider it necessary.___________
III. It was not available at the hospital, primary health care center or pharmacy._________
IV. It gave the child a stomachache. ___________
V. You usually forget it.______________
VI. Other reason.______________

5) WEIGHT:__________kg. W/A: pctl_________. W/H: pctl____. Height:_______cm. H/A: pctl_______

6) LAB TESTS
Hb: _____mg/dL. Blood iron: ____μg/dL.
Hct: ____%. Serum ferritin: ___________ng/mL.
Transferrin sat.: _______%.