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ORIGINAL ARTICLE

Hemoglobin curves during pregnancy before and after fortification of flours with iron*

CURVAS DE HEMOGLOBINA AO LONGO DA GESTAÇÃO ANTES E APÓS A FORTIFICAÇÃO DE FARINHAS COM FERRO

CURVAS DE HEMOGLOBINA DURANTE EL EMBARAZO ANTES Y DESPUÉS DE LA FORTIFICACIÓN DE LA HARINA CON HIERRO

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ABSTRACT

Objective: To assess the level of hemoglobin-Hb during pregnancy before and after fortification of flours with iron. **Method:** A cross-sectional study with data from 12,119 pregnant women attended at a public prenatal from five macro regions of Brazil. The sample was divided into two groups: Before-fortification (birth before June/2004) and After-fortification (last menstruation after June/2005). Hb curves were compared with national and international references. Polynomial regression models were built, with a significance level of 5%. **Results:** Although the higher levels of Hb in all gestational months after-fortification, the polynomial regression did not show the fortification effect ($p=0.3$). Curves in the two groups were above the references in the first trimester, with following decrease and stabilization at the end of pregnancy. **Conclusion:** Although the fortification effect was not confirmed, the study presents variation of Hb levels during pregnancy, which is important for assistencial practice and evaluation of public policies.

DESCRIPTORS

Anemia, iron-deficiency
Pregnant women
Prenatal care
Maternal-child nursing
Food, fortified

RESUMO

Objetivo: Avaliar o nível de hemoglobina-Hb ao longo da gestação antes e após a fortificação de farinhas com ferro. **Método:** Estudo transversal com dados de 12.119 gestantes atendidas em pré-natal público de municípios das cinco macrorregiões do Brasil. Formaram-se dois grupos: Antes-fortificação (parto anterior a jun/2004) e Após-fortificação (última menstruação posterior a jun/2005). Curvas de Hb foram comparadas com referências nacional e internacional. Construíram-se modelos de regressão polinomial, com nível de significância de 5%. **Resultados:** Apesar dos níveis superiores de Hb em todos os meses gestacionais após-fortificação, a regressão polinomial não mostrou efeito da fortificação ($p=0,3$). As curvas dos dois grupos mostraram-se acima das referências no primeiro trimestre, com queda a seguir e estabilização no final da gestação. **Conclusão:** Apesar de não constatar efeito da fortificação, o estudo apresenta variação dos níveis de Hb durante a gravidez, importante para a prática assistencial e avaliação das políticas públicas.

DESCRITORES

Anemia ferropriva
Gestantes
Cuidado pré-natal
Enfermagem materno-infantil
Alimentos fortificados

RESUMEN

Objetivo: Evaluar el nivel de hemoglobina (Hb) durante el embarazo antes y después de la fortificación de la harina con hierro. **Método:** Estudio transversal con datos de 12.119 mujeres embarazadas que acuden a consultas prenatales públicas en municipios de las cinco macro-regiones de Brasil. Se formaron dos grupos: Antes de la Fortificación (parto antes de junio de 2004) y Después de la Fortificación (última menstruación después de junio de 2005). Las Curvas de Hb se compararon con referencias nacionales e internacionales. Se construyeron modelos de regresión polinomial, con nivel de significancia del 5%. **Resultados:** A pesar de altos niveles de Hb en todos los meses Después de la Fortificación, la regresión polinómica no mostró efecto de la fortificación ($p=0,3$). Las curvas de los dos grupos estaban por encima de las referencias en el primer trimestre, para luego caer y posteriormente estabilizarse al final del embarazo. **Conclusión:** Aunque no se observó efecto de la fortificación, el estudio muestra variaciones en los niveles de Hb durante el embarazo, lo que es importante para la práctica asistencial y la evaluación de las políticas públicas.

DESCRITORES

Anemia ferropénica
Mujeres embarazadas
Atención prenatal
Enfermería materno-infantil
Alimentos fortificados

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INTRODUCTION

Pregnancy is a particular moment in women lives, marked by innumerable physiological and anatomical adjustments in a short amount of time. The maternal plasmatic volume and the red cell mass expansion is necessary to produce fetal amniotic liquid, to increase the total capacity of blood connection with oxygen and to facilitate the distribution of oxygen in tissues⁽¹⁾. Besides that, this increase attend the uterus hypertrophied vascular system demands to protect the mom and fetus from deleterious effects of drops in cardiac output and, specially, to protect the mother from blood losses associated with birth and puerperium⁽²⁾.

In women with an adequate iron nutritional state, the hemoglobin level (Hb) starts to decline on the end of the first trimester and reaches the lowest value at the end of the second trimester (24th to 32nd weeks of pregnancy), with a discrete increase during the third trimester of pregnancy, explained by changes in plasmatic and red cell mass volume⁽³⁾. Due to the elevated demand of iron during pregnancy, the mineral drug supplement starting at the 20th week of pregnancy it is part of pregnant care activities⁽⁴⁾. However, anemia prevalence is still high, affecting about 30 to 40% of pregnant women, with great variability⁽⁵⁻⁶⁾, and depending on the gestational trimester⁽⁷⁾.

Maternal anemia increases the risk of premature birth and low birth weight. A review study showed that severe anemia is associated with low weight newborn, consequence of prematurity or growth restriction⁽⁸⁾. There is also evidence of early detection and efficient anemia treatment during pregnancy being associated to anemia and infant/adolescent malnutrition reduction and improvements in height at adulthood⁽⁹⁾. Thus, the importance to evaluate anemia in prenatal assistance is reinforced.

Aiming to contribute to the anemia control in the country, the Brazilian Health Ministry instituted the compulsory fortification of wheat and corn flours with iron starting in July of 2004⁽¹⁰⁾. The measure effect in Brazilian pregnant women pointed to significant decrease in anemia prevalence, with significantly higher means of Hb after the fortification⁽¹¹⁾, but the answer to this intervention was not analyzed, considering the physiological alterations during pregnancy and the increase of iron demands.

It is pertinent to evaluate the behavior of Hb levels during pregnancy months, before and after fortification of flours with iron, the objective of the present study.

METHOD

This study integrates a broad cross-sectional investigation conducted with retrospective data from records of 12,119 pregnant women attended in public prenatal

services of 13 cities from the five geographical regions of Brazil. Pregnant women were divided in two groups: Before-fortification of flours with iron (pregnant women who gave birth before June of 2004), and After-fortification (pregnant women with last date of menstruation posterior to June of 2005).

Data collection was conducted during 2006 to 2008 and included only low risk pregnant women, whose records had at least the date of the first prenatal consultation and from the last menstruation and the Hb dosage.

The dependent variable was the Hb level (g/dL) and the independent variables were: group (Before and After-fortification), geographical region, socio-demographic characteristics (age and relationship status), obstetric history (number of previous pregnancies and history of abortion) and prenatal characteristics (gestational age and nutritional state on the first prenatal consultation).

As the Hb data referred to the exam requested in the 1st prenatal consultation, the present study assumed that pregnant women, even those in the second or third trimester, for not being prenatal followed until then, did not receive guidance to use the supplement, recommended from the 20th week of pregnancy.

The levels of Hb in accordance with the gestational age were described through means, standard deviation and 95% Confidence Intervals. Hb curves following gestational age in months were built for the total pregnant women and stratified per fortification group. The Student t test was calculated to compare Hb means before and after fortification.

To adjust the Hb curves following the gestational month and the independent variables, polynomial regression models were built, being the dependent variable the level of Hb. The modelling was done by regression technique, from the linear model to third order form. The model choice was based in the descriptive level ($p < 0.05$) and in the residual analysis, to verify the model significance and the homoscedasticity assumption, respectively. The level of significance in all tests was 5%.

The Hb curves were compared to cut-off proposed by the World Health Organization (WHO)⁽¹²⁾ to identify anemia in pregnant women ($< 11.0 \text{g/dL}$) and with two curves, one international and one national. It was compared to the Centers for Diseases Control and Prevention (CDC) curve⁽¹³⁾, which propose specific cut-off (5th percentile) per gestational month for pregnant women supplemented with iron; and it was also compared to the Hb distribution model found in Szarfarc et al.⁽¹⁴⁻¹⁵⁾ studies with Brazilian pregnant women not supplemented with iron, using the 7th percentile to establish risk.

The study was approved by the Ethics in Research Committee (Process n^o 521/2006).

RESULTS

Table 1 presents the levels of Hb in accordance with gestational month and fortification group. It was verified an important drop in both groups from the first gestational

trimester. Levels of Hb were statistically more elevated in the After-fortification group ($p < 0.005$), in all months, except at the beginning ($< 3^{\text{rd}}$ month) and at the end (8^{th} month).

Table 1 – Mean, standard deviation and 95% CI of Hb levels in accordance with gestational month and Before and After fortification groups, Brazil, 2006 to 2008.

Month	Before-fortification			After-fortification			p-value*
	n	Mean (SD)	CI95%	n	Mean (SD)	CI95%	
<3	803	12.53(1.18)	12.45-12.61	980	12.54(1.12)	12.47-12.61	0.197
3	1406	12.21(1.14)	12.15-12.27	1575	12.30(1.17)	12.24-12.36	0.029
4	1235	11.76(1.18)	11.69-11.83	1284	11.90(1.14)	11.83-11.96	0.003
5	935	11.43(1.17)	11.36-11.51	869	11.56(1.11)	11.48-11.63	0.025
6	540	11.21(1.16)	11.11-11.31	495	11.36(1.12)	11.26-11.46	0.035
7	508	11.16(1.16)	11.06-11.26	380	11.32(1.12)	11.21-11.44	0.034
≥ 8	447	11.22(1.16)	11.11-11.33	330	11.33(1.19)	11.20-11.46	0.200

*The p-value is referred to Student t test.

Through a cubic polynomial regression model (Table 2), the Hb adjusted curve was estimated by gestational month (Figure 1). The fortification was found not statistically significant in the multiple model, independently of the geographical region, age, relationship status, BMI in the first prenatal consultation and number of previous pregnancies, variables significantly associated to Hb levels (Table 2).

Table 2 – Polynomial model parameter for mean levels of Hb in accordance with gestational month, fortification group, geographical region, age, relationship status, BMI and number of previous pregnancies, Brazil, 2006 to 2008.

Variables	Total	
	β	p-value
Gestational month	0.398	0.036
(Gestational month) ²	-0.181	<0.001
(Gestational month) ³	0.015	<0.001
Group		
Before-fortification	Reference	
After-fortification	0.03	0.316
Geographical region		
Northeast	Reference	
North	0.153	0.016
Midwest	0.062	0.401
Southeast	0.332	<0.001
South	0.813	<0.001
Age (years)	0.008	0.005
Relationship status		
With partner	Reference	
Without partner	-0.123	<0.001
BMI in the 1st consultation (kg/m²)	0.024	<0.001
Previous pregnancies		
<2	Reference	
≥ 2	-0.239	<0.001
Adjusted R²	0.223	
F (p-value)	121.280(<0.001)	

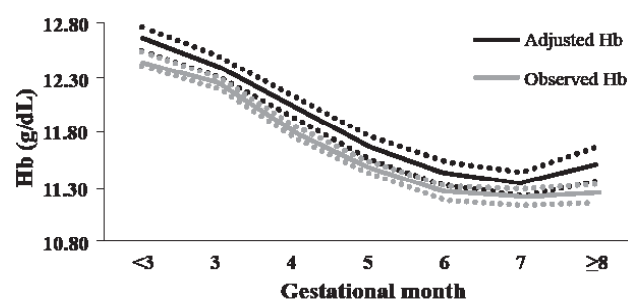


Figure 1 – Hb curves by gestational month, observed and adjusted for fortification group, geographical region, age, relationship status, BMI, previous pregnancies, Brazil, 2006 to 2008.

The Hb curve for the studied pregnant women was compared to the WHO cut-off and with the two curves, international (CDC) and national (Szarfarc et al.) (Figure 2).

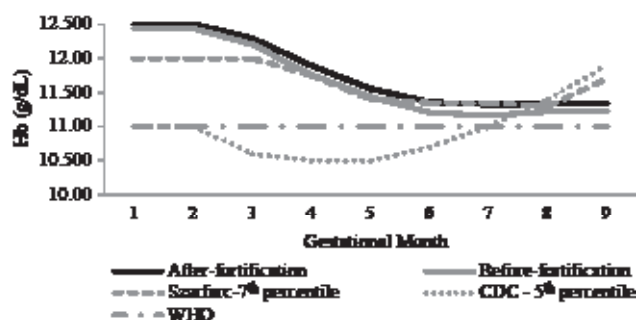


Figure 2 – Comparison of Hb curves before and after fortification with the five Szarfarc et al., CDC and WHO critical levels, Brazil – 2006 to 2008⁽¹²⁻¹⁴⁾.

Figure 2 shows that in the 1st gestational trimester both groups, Before and After-fortification presented superior Hb levels to the critical levels of reference curves. The Before-fortification group reached Szarfarc et al. critical levels at six months, and kept like that until the end of pregnancy. In the Before-fortification group, the drop in Hb levels reached Szarfarc et al. critical levels from the fifth month, but they kept higher than the WHO cut-off.

However, it is important to note that the levels of Hb from both studied groups did not follow the increase in Hb levels observed in the CDC curve from the 7th month, nor the Szarfarc et al. curve from the 8th month.

DISCUSSION

The results showed higher Hb levels in the After-fortification group in all gestational months, except at the beginning (<3rd month) and at the end (≥8th month), without statistically significant difference by the polynomial regression model, a result suggesting absence of effect from the fortification of flours with iron in the Hb level through the pregnancy of Brazilian women.

Although the food fortification is positively evaluated in many countries, this assertive is not clear for the iron fortification⁽¹⁶⁾. Besides, the real effects of this policy are not yet clear and must be considered, once declines in the anemia prevalence can result in structural changes in life conditions and, therefore, in the food offer, in eating patterns and in the improvement of access to health services.

It should be added the need for conjunct interventions to reduce iron deficiency anemia in the country, to recommend nutritional education, drug supplement and food fortification with iron.

A study conducted in United States of America (USA) aiming to quantify the potential effect of food fortification with iron, used models to build a simulation capable of separate the fortification effects from other variables, as the provision of food and eating habits, it was found that without the fortification, the iron deficiency anemia would increase from 2 to 5% between pre-schoolers, adolescent girls and women in reproductive age. Thus, it would not have effect in men, women or children of all other age groups⁽¹⁷⁾.

Brazilian studies presented two hypotheses for the low effectiveness of flour fortification in the country. The first refers to the low consumption of fortified food, reiterated in the Survey of Family Budgets POF (2004), especially within the low income population (<2 minimum wage/family). The second aspect is related to the low bio-availability of iron compounds that are being used in the fortification and its absorption suffers elevated influence of inhibitors for its utilization^(11,18).

To evaluate the levels of Hb through pregnancy is fundamental, once its difference in the anemia prevalence estimate can be a result of gestational age variability in the moment of the blood exam⁽¹⁹⁾.

The important drop in Hb levels observed from the first trimester of pregnancy is a behavior confirmed in other studies⁽²⁰⁻²²⁾, including in the Hb distribution model of Brazilian pregnant women⁽¹⁴⁾ and also in international level⁽¹³⁾. Those changes suggest for anemia diagnose to

consider specific Hb values in accordance with the gestational month^(3,13). Thus, a study with healthy Danish women pointed as Hb critical levels 11.0g/dL in the first trimester and 10.5g/dL in the second and third trimesters of pregnancy⁽²²⁾.

However, it is important to note that Hb levels in both studied groups did not follow the increase in Hb levels observed in the CDC curve from the 7th month, nor the Szarfarc et al. curve from the 8th month. This result could be explained by the fact that studied pregnant women did not receive ferrous sulfate, while the pregnant women composing the CDC curve were supplemented with iron. Besides, as the present study sample was scarce at the end of pregnancy, after the 8th month, an average of Hb levels was considered, a fact that possibly did not allow to identify an increase in the Hb level after the 8th month between the studies pregnant women, as observed in the literature⁽¹⁴⁻¹⁵⁾.

Thus, the results from the present study represented important information, once there is no nationwide research that present Hb curves along pregnancy. The available data refers only to estimates based in punctual studies. Therefore, although the present study sample was not randomized for all country, the obtained data from 12,119 pregnant women accurately represents changes in Hb levels during pregnancy of Brazilian women that can be considered for practical assistance.

Moreover, the study population was composed by women assisted in public health services, referred to a higher risk group of women regarding nutritional deficiencies and with health services restricted access in the Brazilian Unified Health System. The services demands and the availability of resources, limit many times, the number of consultations and the complete fulfillment of the protocol, as well as the careful reading of described data in the complete blood count. Besides, because this population is more vulnerable for presenting fragile socio-economic indicators, it is subjected to nutritional deficiencies as a whole and not only iron deficiency anemia, than those with access to private services, therefore, they have better socio-economic indicators.

Because anemia is conceptualized by Hb levels, this indicator is, especially within pregnant women, a fundamental parameter to investigate an intervention effect in the prevention and control.

The Brazilian health system guarantee prenatal coverage for all pregnant women and includes Hb dosage in the first prenatal consultation and also at the end of pregnancy⁽⁴⁾, allowing anemia control, which made possible this study based in medical records. Although the use of secondary data represents a limitation aspect due to the quality of information not always standardized, the use of those information allow to evaluate a high number of pregnant women.

As a modifiable risk factor, maternal nutritional state is fundamental in terms of primary care and therefore, should be integrated to prenatal assistance by health professional as prevention strategy of adverse outcomes in birth, particularly in developing countries⁽⁸⁾. In this scenario, the nurse as acting member in the prenatal assistance team⁽²³⁾ can effectively contribute to the prevention and treatment of anemia during pregnancy, as the nursing consultation is an important tool for anemia prevention, identification and control⁽²⁴⁾.

CONCLUSION

The Hb level presents an important drop from the first trimester in both groups, but the After-fortification curve kept above the Before-fortification group. The polynomial

regression, however, did not show significant effect for the fortification of flours with iron. Besides that, the Hb curves of both groups were above the national and international references in the first trimester, with a following drop and stabilization at the end of pregnancy which did not follow the increase in reference Hb levels.

Although the iron fortification effect in flours was not found, it is highlighted as a merit of the present study the importance to consider the variation in Hb levels along pregnancy. It is also presented a baseline of Hb levels by gestational month that can be used to evaluate levels of Hb in Brazilian pregnant women, once the Hb level varies during pregnancy as an answer to the high demand of iron. Moreover, the study provides subsidies for public policy evaluation of anemia control, contributing to the improvement and planning of new interventions.

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