CME

Anemia and Iron Deficiency in Children: Association With Red Meat and Poultry Consumption

*Galit Moshe, *Yona Amitai, †Gerard Korchia, Levana Korchia, ‡Ariel Tenenbaum, †Joseph Rosenblum, and †Avi Schechter

ABSTRACT

Objective: The aim of this study was to study the relative contribution of dietary sources of iron in children with high prevalence of anemia and iron deficiency (ID).

Methods: A cross-sectional study in 263 healthy, 1.5- to 6-year-old children in the Jewish sector of Jerusalem, Israel. Venous blood samples and a qualitative Food Frequency Questionnaire on iron-rich foods were obtained. Anemia was defined as hemoglobin <11 g/dL for children younger than 4 years and <11.5 g/dL for children older than 4 years; ID was defined as ferritin <12 μg/L.

Results: Anemia was found in 11.2%, ID in 22%, and iron-deficiency anemia in 3.7%. The prevalence of anemia was higher in toddlers ages 1.5 to 3 years compared with children ages 3 to 6 years (17.7% vs 7.3%, $P=0.01$). Children with extremely low red meat consumption (seldom) had 4-fold higher rates of ID than those who consumed ≥2 times per week (odds ratio 3.98; 95% confidence interval 1.21–13.03; $P=0.023$), whereas poultry consumption was not associated with ID. Soy consumption was inversely associated with ferritin (marginally significant, $r=-0.134$, $P=0.057$).

Conclusions: The high prevalence of anemia and ID found in this study, mainly in children 1.5 to 3 years old, is related to low red meat consumption. The characteristically high poultry consumption in the Israeli population was not protective. The shift toward reduced red meat consumption and higher poultry consumption in developed countries may result in increasing the risk of ID.

Key Words: anemia, iron deficiency, meat, poultry

(*JPGN* 2013;57: 722–727)

Anemia is a global public health problem in both developing and developed countries with major consequences for human health. In 2002, the World Health Organization (WHO) estimated that anemia, resulting from iron deficiency (ID), was among the most important contributing factors to the global burden of disease (1).

Received and accepted August 4, 2013.

From the *Department of Management, Health Systems Management Program, Bar Ilan University, Ramat Gan, the †Meuhedet Health Services, and the ‡Hadassah University Mt Scopus, Jerusalem, Israel.

Address correspondence and reprint requests to Yona Amitai, MD, MPH, Department of Management, Bar Ilan University, Ramat Gan 52900, Israel (e-mail: yonaamitai89@gmail.com).

This article has been developed as a Journal CME Activity by NASPGHAN. Visit *http://www.naspghan.org/wmspage.cfm?parm1=742* to view instructions, documentation, and the complete necessary steps to receive CME credit for reading this article.

This study was supported by a research grant from CTS Pharmaceutical Company, Israel.

The authors report no conflicts of interest.

DOI: 10.1097/MPG.0b013e3182a80c42

Although anemia has a variety of causes, the most significant contributor is ID, accounting for approximately 50% of all cases. Thus, the terms anemia and iron-deficiency anemia (IDA) are often used synonymously, and the prevalence of anemia has often been used as a proxy for IDA (2,3). IDA is associated with diminished cognitive function, changes in behavior, delayed infant growth and development, and impaired immune function in children (4–7). Even in the absence of anemia, ID by itself may adversely affect long-term neurodevelopment behavior, which occasionally can be irreversible (8,9). A recent study estimated that ''Full-scale IQ loss in US children from ID was 9,000,000 points, more than the loss from autistic spectrum disorders and traumatic brain injuries'' (10). A reduction in nerve conduction velocity with an abnormal auditory and visual system functioning was shown in children who had IDA in infancy that did not improve with iron therapy (11,12).

It is estimated that 47% of preschool children worldwide have anemia, the highest prevalence of any population group (2). The main risk factor for ID among young children is low iron intake at a stage at which iron requirement is high. Toddlers older than 1 year no longer receive the routine supplementary iron preparations recommended for 6- to 12-month-old infants who are exclusively breast-fed (13). In addition to low dietary iron intake, socioeconomic factors such as low parental education and income, child age, sex, and family size have a major effect on anemia (14).

The prevalence of anemia in infants in Israel was up to 40% before 1985. It declined following the Public Health Service directives recommending iron supplementation for 4- to 12-month-old infants, coupled with routine testing of hemoglobin (Hb) at 12 months and avoidance of cow's milk in the diet of infants. This occurred in parallel with the rapid national economic growth and increased availability of iron-fortified formulas (15).

Nevertheless, the problem of IDA still exists in certain groups. A cross-sectional study on 34,512 infants ages 9 to 18 months showed a 15.5% prevalence of anemia (Hb <10.5 g/dL). The prevalence was significantly higher in the non-Jewish (22.5%), compared with the Jewish population (10.5%). In ultraorthodox Jews, the frequency of anemia was closer to that of the non-Jewish population (18.9%) (16).

In Israel, despite the high frequency of IDA in infants, the available data on the prevalence of IDA in toddlers are insufficient to justify an extension of the present recommendation for iron supplementation beyond 1 year. The objectives of this study were to determine the prevalence and associated factors of anemia and ID among children, and to investigate the relative contribution of dietary sources of iron.

METHODS

Study Population

The present cross-sectional study was conducted from October 2009 to November 2010. The study population consisted of full-term healthy children, ages 1.5 to 6 years from the Jewish sector in the Jerusalem area of Israel. A convenience sample of 263 children recruited by 5 primary care pediatricians of the Meuhedet Health Services in Jerusalem and Beitar was studied. The study was approved by the Helsinki committee (institutional review board) of the Hadassah Medical Organization, Jerusalem. Written informed consent was obtained from the parents before entering the study.

General Questionnaire and Food Frequency Questionnaire

Parents were interviewed by using a questionnaire about personal and socioeconomic characteristics that requested age, sex, birth weight, maternal education, religion sector (ultraorthodox, orthodox, and secular Jewish sectors), and length of stay at day care centers.

To characterize the consumption habits of dietary sources of iron and iron inhibitors, a qualitative Food Frequency Questionnaire (FFQ) was administered (17,18). The questionnaire was based on the Iron FFQ for infants and toddlers of the Department of Nutrition of the Israeli Health Ministry, adjusted for the Israeli population. The FFQ includes 9 food items selected as sources of iron or iron inhibitors: red meat (beef), poultry, turkey, fish, infant formula, fortified cereals, soy, legumes, and tea (4,19,20). The frequency consumption was defined by 5 categories: seldom, once per week, 2 to 3 times per week, 4 to 5 times per week, every day, or more often.

Blood Sampling

Venous blood samples were obtained from each study participant for complete blood cells and serum ferritin (SF). Anemia was defined using the WHO criteria as Hb <11 g/dL for ages 0.5 to 4.99 years and Hb <11.5 g/dL for ages 5 to 11 years. The definition of ID was ferritin <12 μg/L. IDA was diagnosed if anemia was accompanied by ID (2,21).

Statistical Analysis

We used the PASW statistical package version 18.0 (SPSS Inc, Chicago, IL) for data analysis. The sociodemographic, health, and nutrition characteristics of the study population are reported as the mean (95% confidence interval [CI]) for continuous variables and as the frequency for categorical variables. The χ^2 test was used to compare categorical variables between groups. Pearson correlation was used to find the linear relation between 2 continuous variables.

Independent t test was used to determine statistically significant difference between the means in 2 unrelated groups. The 1-way analysis of variance was used to determine whether there are any significant differences between the means of ≥3 independent groups. Multiple logistic regressions were performed to assess the effect of factors, which were found significant in increasing the risk for anemia or ID. Odds ratios and 95% CIs were calculated. The significance level was set at $P < 0.05$.

RESULTS

Subjects' Characteristics

A total of 263 healthy children were studied (109 girls and 154 boys): 200 were from the ultra-orthodox Jewish sector and 63 were from the orthodox and secular sectors. The mean age was 42 months. Subjects' characteristics are listed in Table 1. Dietary questionnaires were completed by 230 participants. For the other 33 participants, basic demographic details were collected from the medical record.

TABLE 1. Demographic characteristics of the study sample, N = 263

Variable	n	%
Age, y		
1.5–3	98	37.3
3–6	165	62.7
Sex		
Male	154	59
Female	109	41
Religiosity		
Ultraorthodox Jewish	200	76
Orthodox and secular Jewish	63	24
Day care		
Short-day kindergarten, home	183	80.3
Long-day kindergarten	45	19.7
Maternal education, y		
8–12	58	26.1
13–14	95	42.8
>14	69	31.1

Hematological Parameters of the Study Sample

Hematological parameters of the study sample are listed in Table 2. Hb levels were positively associated with child's age ($r = 0.331$, $P < 0.001$). Mean Hb was significantly lower in toddlers ages 1.5 to 3 years than that of children ages 3 to 6 years (11.9 g/dL [95% CI 11.7–12.1] vs 12.5 g/dL [95% CI 12.4–12.6], respectively; $P < 0.001$). Mean Hb was lower in children attending long-day kindergarten than that of children staying at home or at short-day kindergarten (11.9 g/dL [95% CI 11.6–12.2] vs 12.4 g/dL [95% CI 12.2–12.5], respectively; $P = 0.002$), but the difference was no longer significant after controlling for age. Mean Hb was significantly lower in children from ultraorthodox families compared with others (12.2 g/dL [95% CI 12.1–12.3] vs 12.5 g/dL [95% CI 12.3–12.8], respectively; $P = 0.024$). There was no significant difference in Hb levels between boys and girls. Mean birth weight was 3.22 kg (95% CI 3.15–3.28). Hb level was not associated with birth weight.

Independent of child's age, Hb levels were positively associated with maternal education (number of school years) ($r = 0.244$, $P < 0.001$). Children of less educated mothers had lower Hb than those of highly educated mothers. There was no statistically significant difference in mean ferritin levels according to age, sex, religiosity, length of stay at day care centers, and maternal education.

Prevalence of Anemia, ID, and IDA

Anemia was found in 11.2% of the study population, ID in 22%, and IDA in 3.7%. Eighteen percent had ID without anemia. Table 3 shows the prevalence of anemia, ID, and IDA in relation to age, sex, religiosity, length of stay at day care centers, and maternal education. The prevalence of anemia was significantly higher in toddlers ages 1.5 to 3 years compared with 3- to 6-year-old children (17.7% vs 7.3%, respectively; $P = 0.01$). The prevalence of anemia was higher in children attending long-day kindergarten compared with those staying at home or at short-day kindergarten (22.2% vs 10.5%, respectively; $P = 0.035$). The prevalence of anemia and ID was similar in boys and girls. Children of more educated mothers were less likely to have anemia ($P = 0.001$) and ID ($P = 0.04$) than those of less educated mothers.

TABLE 2. Hematological parameters of the study sample, N = 263

	Hb, g/dL		SF, μg/L	
	Mean (95% CI)*	*P*	Mean (95% CI)*	*P*
Age, y				
1.5–3	11.9 (11.7–12.1)	<0.001	23.4 (19.9–26.8)	0.429
3–6	12.5 (12.4–12.6)		25.5 (22.0–29.0)	
Sex				
Boys	12.3 (12.2–12.5)	0.833	25.1 (21.8–28.5)	0.743
Girls	12.2 (12.1–12.4)		24.1 (20.3–28.2)	
Religiosity				
Ultraorthodox Jewish	12.2 (12.1–12.3)	0.024	24.6 (21.4–27.7)	0.508
Orthodox and secular Jewish	12.5 (12.3–12.8)		26.6 (21.9–31.4)	
Day care				
Short-day kindergarten, home	12.4 (12.2–12.5)	0.002	24.6 (21.5–27.8)	0.832
Long-day kindergarten	11.9 (11.6–12.2)		23.9 (18.3–29.5)	
Maternal education, y				
8–12	12.0 (11.7–12.2)	0.005	27.6 (20.8–34.4)	0.15
13–14	12.3 (12.1–12.4)		21.5 (18.1–24.9)	
>14	12.5 (12.3–12.8)		26.7 (21.2–32.1)	

CI = confidence interval; Hb = hemoglobin; SF = serum ferritin. The significance level was set at $P < 0.05$ for all tests.
* 95% CI was calculated for means.

Food Consumption and Iron Status

A total of 226 parents completed dietary questionnaires. The prevalence of poultry consumption in the study population was extremely high: 97% of children were reported to consume poultry at least once per week. The consumption frequency of poultry was 5%, 52%, 29%, and 11%, for 1, 2 to 3, 4 to 5, and ≥6 per week, respectively. By contrast, red meat and turkey consumption was much lower (49% and 54% once per week or less, respectively). The median consumption frequency of red meat was less than once per week compared with 2 to 3 times per week of poultry. A significant positive correlation was found between ferritin levels and red meat consumption ($r = 0.143$, $P = 0.04$). Figure 1 shows the prevalence of ID according to red meat and poultry consumption frequency. Children with extremely low red meat consumption (seldom) were 4 times more likely to have ID than those who consumed 2 to 3 times per week or more ($P = 0.007$). The consumption of poultry, turkey, and others iron sources was not associated with ferritin levels or ID. Soy consumption was inversely associated with ferritin levels (marginally significant, $r = -0.134$, $P = 0.057$).

Multiple logistic regressions were performed to assess the effect of variables on the risk for anemia or ID. The 2 models contained 6 independent variables (sex, age, religiosity, short- or long-day kindergarten, maternal education, and red meat consumption). The significant predictors of anemia were maternal education and child's age. There was a significant inverse relation between maternal education and the likelihood to have anemia (OR 0.61; 95% CI 0.45–0.82; $P = 0.001$). For every additional year of maternal schooling, children had a 0.61 times lower risk to have anemia. A significant inverse relation was also found between age

TABLE 3. Prevalence of anemia, ID, and IDA

Variable	Anemia, %	*P*	ID, %	*P*	IDA, %	*P*
Total	11.2		22.0		3.7	
1.5–3	17.7	0.01	25.0	0.424	2.4	0.423
3–6	7.3		20.5		4.4	
Sex						
Boys	11.2	0.985	20.7	0.545	3.5	0.846
Girls	11.1		24.0		4.0	
Religiosity						
Ultraorthodox Jewish	13.2	0.151	24.3	0.127	4.5	0.345
Orthodox and secular Jewish sectors	6.5		14.5		1.8	
Day care						
Short-day kindergarten, home	10.5	0.035	20.7	0.58	4.1	0.77
Long-day kindergarten	22.2		24.0		5.1	
Maternal education, y						
8–12	26.3	0.001	28.3	0.08	9.6	0.04
13–14	9.5		28.2		4.7	
>14	5.8		13.8		0	

ID = iron deficiency; IDA = iron-deficiency anemia.

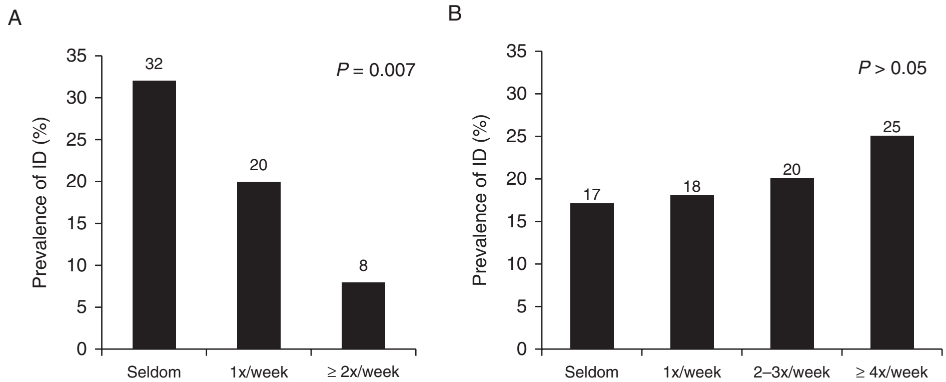

FIGURE 1. Prevalence of iron deficiency (ID) according to red meat (A) and poultry (B) consumption frequency.

and the risk for anemia (OR 0.96; 95% CI 0.926–0.996; $P = 0.03$), indicating that for every additional month of age, children were 4% less likely to have anemia.

A marginally significant association was found between the religiosity sector and anemia. The risk for anemia was decreased by 79% in the other sectors compared with the ultraorthodox sector (OR 0.213; 95% CI 0.038–1.174; $P = 0.076$).

The logistic regression analysis revealed a significant inverse relation between maternal education and the prevalence of ID (OR 0.861; 95% CI 0.778–0.952; $P = 0.004$). For every additional year of maternal schooling, children were 0.86 times less likely to have ID.

A significant inverse relation was found between red meat consumption and the likelihood to have ID (OR 3.98; 95% CI 1.21–13.03; $P = 0.023$). Children with very low red meat consumption (seldom) were 3.98 times more likely to have ID than those who consumed $\geq$2 times per week.

DISCUSSION

High prevalence of anemia (11.2%) and ID (22%) were found among 263 Israeli children ages 1.5 to 6 years. IDA was found only in 3.7%. Anemia and ID were more prevalent in toddlers ages 1.5 to 3 years (17.7% and 25%, respectively), much higher rates than those found in US toddlers in similar age group (5.1% and 9.2%, respectively) (13) and closer to those found in children from the UK in 1992–1993 (8% and 31%, respectively) (22).

The increased risk in younger toddlers has been attributed to a relatively large iron requirement, unmet by sufficient dietary iron intake. The choice of complementary foods at this age can markedly influence the risk of ID and anemia. In school-age children, iron status typically improves as growth slows and diets become more varied.

Although iron consumption from children's diets was not calculated, we assume that the high prevalence of anemia and ID found in Israeli children, in comparison with children in other developed countries, may reflect low iron intake because of vegetarian and low meat consumption diets served during lunch in many day care centers in Israel. This is explained by keeping up the Jewish Kosher restrictions, which require 4- to 6-hour intervals between eating meat (both poultry and beef) and dairy servings.

Children of educated mothers were less likely to develop anemia than those of less educated mothers ($P = 0.001$), in accordance with other studies (23–25).

Mean Hb levels in the ultraorthodox Jewish sector were significantly lower than in the other sectors, and there was a marginally significant association between religiosity sector and risk for anemia. Similar results were found in a study on 34,512 Israeli infants (16). The socioeconomic level of the ultraorthodox Jewish sector in Israel is considered lower than the national average. This population is characterized by a high birth rate, high housing density, and lower income per capita than the overall population (26).

A qualitative FFQ was used in this study to characterize the consumption habits of dietary iron sources in children's diets. Approximately 50% of the parents reported extremely low consumption of red meat (seldom). Low red meat consumption was found as a risk factor for ID. Children with extremely low red meat consumption were 4 times more likely to have ID than those who consumed $\geq$2 times per week ($P = 0.007$). A positive correlation was found between SF levels and the frequency of red meat consumption ($r = 0.143$, $P = 0.04$). By contrast, the frequency of poultry consumption was not associated with the risk for anemia and ID.

The effect of red meat consumption on body iron status was described in other studies. A study on 1674 subjects ages 16 to 24 years in the United Kingdom found that the total iron intake increased along with the increase in red meat consumption ($P < 0.0001$). The study found a direct link between red meat intake and body iron status assessed by levels of Hb and SF (27). The risk for ID was twice as high among 180 girls ages 12 to 17 years who consumed meat (beef, lamb, and pork) <4 servings per week compared with those who consumed $\geq$4 servings per week (18). Meat is a good source of bioavailable heme iron. Red meat contains 2 to 3 times more iron than poultry meat. The values of iron content in 100-g cooked beef and poultry, provided by the Israeli Ministry of Health, are 3.2 vs 1.17 mg, respectively (28).

The Israeli Cattle Council figures for 2006 indicate that beef consumption in Israel is extremely low in comparison with other developed countries and stands at 13.3 kg per capita per year compared with 42 kg per capita in the United States and 58 kg per capita in Argentina. In Germany, >50% of the meat consumption comes from pork, and in Argentina, the main type of meat consumed is beef because of the high availability and low cost. Israelis prefer poultry and beef, mainly because of not only low price but also health attitudes (29).

The consumption of poultry in Israel has been rising since 1998. According to Dun and Bradstreet, there has been an annual consumption increase of 6.5 kg per capita in the last several years, which brings the total consumption per person to >36 kg annually. In comparison to other countries, Italy and France consume one-third of the poultry compared with Israel, whereas in Canada, consumption is similar to that of Israel. Chicken meat constitutes approximately 78% of meat consumption in Israel, followed by beef (10%), turkey (8%), lamb (1%), and other meats (30).

Dietary iron bioavailability is low in populations consuming plant-based diets with little meat. In meat, 30% to 70% of iron is heme iron, of which 15% to 35% is absorbed, whereas in plant-based diets, most dietary iron is nonheme iron, and its absorption fraction is often <10%. The absorption of nonheme iron is increased by meat and ascorbic acid, but inhibited by phytates, polyphenols, and calcium (31,32).

A negative, marginally significant, relation was found between SF levels and soy consumption ($r = -0.134$, $P = 0.057$). Soy-based substitutes are commonly used in Israel as protein sources. Soy has low iron content and is rich in phytic acid, which binds iron and inhibits its absorption. Soy protein, regardless of phytic acid, was found to inhibit iron absorption (33).

The increased prevalence of ID in children in our study, attributed to reduced red meat consumption, was not compensated for by high poultry consumption, characteristic to the Israeli population. This observation may have wider implications. The trend of reducing red meat consumption in the United States and other Western societies, with increase in poultry consumption, owing to concerns of adverse health effects of red meat (34), may herald a high risk of ID in children if this trend persists.

In accordance with other studies, we found that the majority of children with ID were not anemic (35,36). This may indicate that Hb, used in Israel as a screening test for ID, is inefficient, giving us false assurance that nonanemic children are iron sufficient, although they may be at risk. Other markers such as ferritin should be considered in the evaluation of ID.

Our study has limitations. The study population (most children belong to ultraorthodox Jewish families) is not representative of the whole Israeli toddler and preschool-age child population. The disadvantage of convenience sampling is that the parents who agreed to enroll could have higher health awareness and thus their children could have better nutritional status.

The reliability of FFQ data is influenced by each subject's ability to accurately recall his or her food choices and consumption patterns during extended periods of time. Also, qualitative FFQ does not include portion size estimates, which does not allow the derivation and quantitative calculation of energy and selected nutrient intakes. Over- and underestimation of intakes are also a notable limitation of self-reported dietary assessment data. Data on parental education were obtained from parental self-reports, which may have resulted in an overestimation bias. Additionally, because we could not inquire about mothers' knowledge of nutrition, we could not analyze the direct association between maternal education and nutrition-related knowledge.

CONCLUSIONS

High prevalence of anemia and ID were found among Jewish children in the Jerusalem area of Israel. By contrast, the majority of children with ID were not anemic, indicating that Hb, used in Israel as a screening test for ID, should be combined with ferritin in the evaluation of ID. The study was targeted to children in this age group, which is no longer supplemented with iron.

The main explanation for the high rates of ID was low red meat consumption despite relatively frequent poultry consumption. Iron content in poultry is low compared with other meats such as beef or pork, generally consumed more in other developed countries. Other risk factors may be related to the Jewish custom regarding Kosher food, probably because of vegetarian diet and low meat consumption.

These findings underline the importance of supplementation interventions and adequate food practices such as food fortification and consumption of variable kinds of meat. The public health approach to achieving adequate iron status should emphasize the importance of a healthy balanced diet that includes a variety of foods and meats containing iron. Such an approach is more important than focusing on particular inhibitors or enhancers of the bioavailability of iron from diets.

In August 2012, the Israeli Ministry of Health updated its recommendations with expanding iron supplementation up to 18 months coupled with complete blood count testing, to reduce and prevent ID.

REFERENCES

1. World Health Organization. *The World Health Report 2002: Reducing Risks, Promoting Healthy Life*. Geneva, Switzerland: WHO; 2002.
2. World Health Organization. *Worldwide Prevalence of Anemia. 1993–2005*. Geneva, Switzerland: WHO; 2008.
3. McLean E, Cogswell M, Egli I, et al. Worldwide prevalence of anemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. *Public Health Nutr* 2009;12:444–54.
4. World Health Organization. *Iron Deficiency Anemia Assessment, Prevention, and Control: A Guide for Programme Managers*. Geneva, Switzerland: WHO; 2001.
5. Lozoff B, Jimenez E, Wolf AW. Long-term developmental outcome of infants with iron deficiency. *N Engl J Med* 1991;325:687–94.
6. Lozoff B, Klein NK, Nelson EC, et al. Behavior of infants with iron-deficiency anemia. *Child Dev* 1998;69:24–36.
7. Grantham-McGregor S, Ani C. A review of studies on the effect of iron deficiency on cognitive development in children. *J Nutr* 2001;131: 649–66.
8. Lozoff B, Jimenez E, Smith JB. Double burden of iron deficiency in infancy and low socioeconomic status: a longitudinal analysis of cognitive test scores to age 19 years. *Arch Pediatr Adolesc Med* 2006;160:1108–13.
9. Bruner AB, Joffe A, Duggan AK, et al. Randomized study of cognitive effects of iron supplementation in nonanemic iron-deficient adolescent girls. *Lancet* 1996;348:992–6.
10. Bellinger DC. Comparing the population neurodevelopmental burdens associated with children's exposures to environmental chemicals and other risk factors. *Neurotoxicology* 2012;33:641–3.
11. Algarin C, Peirano P, Garrido M, et al. Iron deficiency anemia in infancy: long-lasting effects on auditory and visual system functioning. *Pediatr Res* 2003;53:217–23.
12. Roncagliolo M, Garrido M, Walter T, et al. Evidence of altered central nervous system development in infants with iron deficiency anemia at 6 mo: delayed maturation of auditory brainstem responses. *Am J Clin Nutr* 1998;68:683–90.
13. Baker RD, Greer FR. Diagnosis and prevention of iron deficiency and iron-deficiency anemia in infants and young children (0–3 years of age). *Pediatrics* 2010;126:1040–50.
14. Osório MM. Determinant factors of anemia in children. *J Pediatr* 2002;78:269–78.
15. Kaluski DN, Levental A, Averbuch Y, et al. Five decades of trends in anemia in Israeli infants: implications for food fortification policy. *Eur J Clin Nutr* 2001;55:82–7.
16. Meyerovitch J, Sherf M, Antebi F, et al. The incidence of anemia in an Israeli population: a population analysis for anemia in 34,512 Israeli infants aged 9 to 18 months. *Pediatrics* 2006;118:1055–60.
17. Gibson RS. *Principles of Nutritional Assessment*. 2nd ed. New York: Oxford University Press; 2005.
18. Alaofè H, Zee J, Dossa R, et al. Iron status of adolescent girls from two boarding schools in southern Benin. *Public Health Nutr* 2008; 11:737–46.
19. Williams PL, Innis SM. Food frequency questionnaire for assessing infant iron nutrition. *Can J Diet Prac Res* 2005;66:176–82.

20. National Academy of Sciences, Institute of Medicine, Food and Nutrition Board. *Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc*. Washington, DC: National Academy Press; 2001.
21. Nathan D, Oski FA. *Hematology of Infancy and Childhood*. 7th ed. Philadelphia: WB Saunders; 2009.
22. Thane CW, Walmsley CM, Bates CJ, et al. Risk factors for poor iron status in British toddlers: further analysis of data from the National Diet and Nutrition Survey of children aged 1.5–4.5 years. *Public Health Nutr* 2000;3:433–40.
23. Choi HJ, Lee HJ, Jang HB, et al. Effects of maternal education on diet, anemia, and iron deficiency in Korean school-aged children. *BMC Public Health* 2011;11:870–7.
24. Bilenko N, Yehiel M, Inbar Y, et al. The association between anemia in infants, and maternal knowledge and adherence to iron supplementation in southern Israel. *Isr Med Assoc J* 2007;9:521–4.
25. Leal LP, Batista Filho M, de Lira PI, et al. Temporal trends and anemia-associated factors in 6- to 59-month-old children in Northeast Brazil. *Public Health Nutr* 2012;14:1–8.
26. Gurovich N, Cohen-Kastro E. *Ultra-Orthodox Jews: Geographic Distribution and Demographic, Social and Economic Characteristics of the Ultra-Orthodox Jewish Population in Israel 1996–2001*. Jerusalem: Central Bureau of Statistics; 2004.
27. Gibson S, Ashwell M. The association between red and processed meat consumption and iron intakes and status among British adults. *Publ Health Nutr* 2003;6:341–50.
28. Israeli Ministry of Health, Department of Nutrition. *Food Composition Tables*. Jerusalem: Geffen; 1997.
29. Israeli Cattle Board. An increase in beef consumption in Israel. *http://www.meat.org.il/info/meatclb/meatwnew/meatwnew-006.htm*. Accessed April 5, 2011.
30. Dun and Bradstreet. The Israeli consume more schnitzel and less steak. *http://dundb.co.il/dbnews/html/1206art1.html*. Accessed October 10, 2011.
31. Zimmermann MB, Chaouki N, Hurrell RF. Iron deficiency due to consumption of a habitual diet low in bioavailable iron: a longitudinal cohort study in Moroccan children. *Am J Clin Nutr* 2005;81:115–21.
32. Zimmerman M, Hurrell R. Nutritional iron deficiency. *Lancet* 2007;370:511–20.
33. Hunt JR. Bioavailability of iron, zinc, and other trace minerals from vegetarian diets. *Am J Clin Nutr* 2003;78:633S–9S.
34. Daniel CR, Cross AJ, Koebnick C, et al. Trends in meat consumption in the USA. *Public Health Nutr* 2011;14:575–83.
35. White KC. Anemia is a poor predictor of iron deficiency among toddlers in the United States: for heme the bell tolls. *Pediatrics* 2005;115: 315–20.
36. Male C, Persson LA, Freeman V, et al. Prevalence of iron deficiency in 12-mo-old infants from 11 European areas and influence of dietary factors on iron status (Euro-Growth study). *Acta Paediatr* 2001;90:492–8.