

## Iron status and intake of older infants fed formula vs cow milk with cereal<sup>1-3</sup>

George J Fuchs, Rosanne P Farris, Marianne DeWier, Sharon W Hutchinson, Raj Warriar, Hosea Doucet, and Robert M Suskind

**ABSTRACT** One hundred four infants were randomly assigned to receive whole cow milk plus iron-fortified cereal (WCM + C) in accord with the previous recommendations of the Committee of Nutrition/American Academy of Pediatrics (CON/AAP); one of two iron-fortified, follow-up formulas; or an iron-fortified infant formula. Mean iron intakes and vitamin C exceeded the recommended dietary allowance in all groups. By 12 mo of age, mean ferritin and mean corpuscular volume were lower in the WCM + C group and significantly more infants had serum ferritin concentrations  $< 12 \mu\text{g/L}$ . We conclude that infants 6–12 mo of age fed whole cow milk and iron-containing table food are at risk of developing depleted iron stores but not anemia. The iron insufficiency in these infants is not due to inadequate intake of iron or vitamin C, but probably to relatively poor bioavailability of iron in infant cereal. *Am J Clin Nutr* 1993;58:343–8.

**KEY WORDS** Cow milk, iron deficiency, iron intake, iron supplementation, vitamin C intake

### Introduction

Adverse effects on iron nutriture have been demonstrated in infants fed whole cow milk (WCM) in the first year of life (1–4). WCM feeding in this age group is associated with iron deficiency because WCM is a poor iron source with low bioavailability; contains relatively little vitamin C, which enhances iron absorption; and increases the iron requirement by producing occult gastrointestinal blood loss (2, 3, 5). However, there is a relative lack of information on whether WCM feeding is detrimental in infants older than age 6 mo if supplemental iron and ascorbic acid are also provided. As a result, the Committee of Nutrition/American Academy of Pediatrics (CON/AAP) concluded in 1983 that WCM could be introduced at 6 mo of age if specific prerequisites are met (6). (Note: This study was conducted before the latest AAP recommendations, which are to withhold WCM before 12 mo of age.) These conditions were that the infant is provided with a balanced mixture of cereals, vegetables, fruits, and other foods containing adequate sources of iron and vitamin C, and that the amount of WCM is limited to  $< 1 \text{ L/d}$ . Further, the CON/AAP stated that the best source of supplemental iron is iron-fortified cereal. Recommendations regarding WCM intake in older infants are of particular concern because several million infants are fed WCM, primarily because WCM is a much less expensive alternative to infant formula.

Concerns that WCM may be detrimental to infants 6–12 mo of age have persisted and have been reinforced by the results of studies directed at this age group. Tunnessen and Oski (4) concluded that infants who ingested WCM after age 6 mo were more likely to develop iron deficiency, including anemia, by age 1 y (4). However, the conclusions of this study have been questioned on methodological and statistical grounds (7). Penrod et al (8) performed a cross-sectional, nonrandomized study using a single 3-d food diary or a 24-h diet recall and concluded that the recommendation of the CON/AAP failed to ensure adequate total iron intake from supplemental foods in infants fed WCM.

The appropriateness of WCM feeding to infants 6–12 mo of age, therefore, continues to generate controversy over questions of methodology and conflicting findings (4, 7, 9, 10). Furthermore, the applicability of the CON/AAP recommendations for the general population of infants who are eating self-selected diets with or without vitamin and mineral supplements remains in question.

The purpose of this study was to prospectively assess the intake of iron and nutrients important in iron absorption in the diets of 6 to 12-mo-old infants ingesting WCM plus iron-fortified cereal as compared with iron-fortified formula when mothers were counseled regarding the CON/AAP dietary recommendations. In addition, the impact of WCM feeding on indicators of iron status was examined.

### Subjects and methods

#### Population and feedings

Infants were recruited from three urban settings and one suburban setting. The urban settings included two private pediatricians' offices and a tax-supported health-care center; the suburban setting comprised a large private pediatric practice. Participants had to be fullterm at birth, be currently healthy, be exclusively bottle fed, and have a primary caregiver willing to comply with the responsibilities of the protocol. The study pro-

<sup>1</sup> From the Department of Pediatrics, Louisiana State University Medical School, and Tulane Medical School, New Orleans.

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<sup>3</sup> Address reprint requests to GJ Fuchs, Department of Pediatrics, Louisiana State University Medical School, 1542 Tulane Avenue, New Orleans, LA 70112.

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tolocol included parental consent, which was reviewed and approved by the Louisiana State University Medical School Institutional Review Board.

Infants at all study sites were randomly assigned at 4–6 mo of age into one of four feeding groups by using a predetermined schedule: WCM plus cereal (WCM + C;  $n = 26$ ); a ready-to-feed infant formula, (IF;  $n = 27$ ) (Similac With Iron, Ross Laboratories, Columbus, OH); or one of two ready-to-feed follow-up formulas (FUF1;  $n = 26$ ), or (FUF2;  $n = 25$ ) (the former an investigational formula and the latter Carnation Follow-up Formula, both produced by Carnation Nutritional Products, Glendale, CA). The term WCM signifies pasteurized homogenized cow milk obtained from a local dairy. The nutrient compositions of the four beverages are shown in Table 1. Infants in the formula groups entered the study beginning at 4–6 mo of age as part of a study to evaluate growth while consuming FUF compared with IF. The infants in the WCM + C group were enrolled between 4 and 6 mo of age as part of the randomization, but entered the study at 6 mo of age so as not to conflict with the CON/AAP guidelines at the time of the study. Before entry into the study, all infants were ingesting either traditional infant cow milk-based or soy-based formula.

The formulas were dispensed to the caregivers at monthly follow-up visits. Mothers of infants in the WCM + C group were given funds to purchase WCM from local markets or it was home-delivered biweekly if they resided in an area where commercial home delivery was available. The mothers in the WCM + C group were additionally provided with iron-fortified rice, oat, or mixed rice-oat cereal and counseled to feed their infants 135 mL (9 tbsp) cereal/d mixed in formula, milk, or water (but not in juice) to achieve the recommended dietary allowance (RDA) of iron of 10 mg (11). The mothers of infants in the formula groups were not given specific instructions about the use of infant cereal or other supplemental foods. Mothers in all the feeding groups were instructed not to give > 960 mL (32 oz) formula or milk per day or to administer supplemental vitamins and minerals to their infants.

#### Data collection

Contact with all mothers by a pediatric research nurse was made by telephone 24 h and again at 72 h after beginning the feedings to identify any potential problems, reinforce the study protocol, and answer questions. Infants were seen monthly by a pediatric research nurse from enrollment to completion of the study at 12 mo of age. Five-day diet histories were collected and discussed, a physical assessment was completed, and compliance with the study protocol was reinforced at each monthly visit.

#### Dietary data

Eating behavior and nutritional intake were qualitatively and quantitatively determined. Diet-history records were completed by the parent and/or primary caregiver monthly for 5 consecutive days, including a weekend day. Each parent was instructed in the proper method of completing the diet-history record, and uniform instructions were reinforced at each monthly visit. Food consumption according to time of day, food group, brand name, descriptions, and amounts consumed in ounces or tablespoons was recorded.

Once collected, the data were transferred for entry into the Extended Table of Nutrient Values (ETNV) database for analysis of nutrient composition (12). In this database, nutrient values

TABLE 1  
Composition of whole cow milk and formulas\*

Nutrients	WCM + C	FUF2	FUF1	IF
Energy (MJ/L)	2.64	2.80	2.80	2.83
Protein (g/MJ)	12.4	7.17	7.41	5.31
(% energy)	21	12	12	9
Fat (g/MJ)	13.43	9.32	9.46	12.83
(% energy)	50	36	36	48
Carbohydrate (g/MJ)	17.57	31.55	30.45	25.57
(% energy)	29	52	52	43
Phosphorus (mg/MJ)	351.3	215.1	216.3	138.6
Calcium (mg/MJ)	449.3	322.7	322.7	179.3
Vitamin C (mg/MJ)	3.56	19.12	19.12	21.51
Iron (mg/MJ)	0.38	4.54	4.30	4.30

\* Cow milk composition based on the Extended Table of Nutrient Values (12); formulas as stated by manufacturer. WCM, whole cow milk plus iron-fortified cereal; FUF1, investigational follow-up formula (Carnation Nutritional Products, Glendale, CA); FUF2, Carnation Follow-up Formula (Carnation Nutritional Products, Glendale, CA); IF, Similac with Iron (Ross Laboratories, Columbus, OH).

for individual foods are primarily based on values provided by the US Department of Agriculture, although certain values are derived from food-composition tables and proprietary information. Each food has descriptive nomenclature identifying preparation procedures, seasonings, form (fresh, frozen, canned), portion size, shape, brand, etc. In addition, each food has a nutrient profile or amount of dietary component for a given weight or portion. Internal checks were performed by a registered dietitian.

#### Laboratory data

At 4–6 (enrollment), 9, and 12 mo of age serum blood specimens were obtained by venipuncture. Hemoglobin was analyzed by the cyanmethemoglobin method, mean corpuscular volume (MCV) was determined from direct measurement by laser sizing, ferritin was determined by the two-site immunoradiometric assay, and free erythrocyte protoporphyrin (FEP) was determined by extraction with ethyl acetate and acetic acid followed by reextraction with 3 mol/HCl/L and subsequent fluorometric measurement (ICSH Standard EP 6/2, 1977; 13–18). Red blood cell indexes from the study infants were compared with reference values for age (19). Infants with hemoglobin <  $10^5$  g/L, ferritin > 12  $\mu$ g/L, FEP < 0.35  $\mu$ mol/L, and MCV < 70 fL at baseline were further evaluated by hemoglobin electrophoresis for hemoglobinopathy. Infants identified with a hemoglobinopathy precluding evaluation of iron status with the selected indexes used in this study were excluded.

#### Statistical methods

Analysis of variance (ANOVA) was used to determine differences among the four feeding groups in mean formula intake, total iron intake, vitamin C consumption, and selected red blood cell indexes. Analyses of MCV excluded three infants in the IF group and two infants in the WCM + C group with hemoglobin C trait, hemoglobin S trait, or probable  $\alpha$ -thalassemia trait,

identified on entry into the study. Comparative differences between feeding groups were examined by Duncan's multiple-range test. Because red blood cell indexes were not normally distributed, both logarithmically transformed and rank-ordered data (Kruskal-Wallis) were analyzed. Significance levels apply to unaltered data because adjustments did not substantially alter the statistical results. The *Statistical Analysis System*, release 5.18 (SAS Institute, Cary, NC), was used.

**Results**

A total of 104 infants completed the study and are the subject of this report. Fifty-six percent of infants were black, 41% white, and 2% Latino. Sixty-one percent of the infants were male and 39% female.

*Dietary intakes*

Mean milk or formula intakes for all groups were  $\approx 810$  and  $720$  mL/d at 7 and 12 mo, respectively, and were not different from each other at any month (data not shown). The intake of WCM was within the range recommended by CON/AAP.

Mean total daily iron intake was significantly lower in the WCM + C group than in one or more of the formula groups at 7, 8, and 10 mo ( $P < 0.05$ ). Iron intake for months 7, 9, and 12 are depicted in **Figure 1**. The trend for lower total iron intake in the WCM + C infants was evident at 11 and 12 mo but was not significant. Intake at 8 mo was lower in the WCM + C and FUF1 groups, followed by the IF then FUF2 groups. The mean total iron intake exceeded the RDA (10 mg) in all groups for each month. However, at age 7 mo one infant in the WCM + C group achieved only one- to two-thirds of the RDA for iron (**Table 2**). The remainder of the infants in all groups achieved

adequate iron intakes, that is, at least two-thirds of the RDA (data shown for only 7 and 12 mo). At 12 mo all infants with the exception of one child in the FUF2 group achieved greater than two-thirds of the iron requirement. More of the formula-fed than WCM + C-fed infants were dependent on their primary beverage to meet iron requirements.

As expected, the iron intake from milk or formula was significantly lower in the WCM + C group at each age ( $P < 0.0001$ ) (**Fig 1**, data shown only for 7, 9, and 12 mo of age). However, the iron contributed by cereal was not different among the groups except at 9 mo, when the WCM + C group had a greater iron intake from cereals ( $P < 0.001$ ).

Total vitamin C intake was much lower in infants fed WCM + C than in infants fed any of the formulas at each age (data for months 7, 9, and 12 mo depicted in **Fig 2**). The number of children with inadequate vitamin C intakes was greater in the WCM + C group, with three children at 7 mo and two children at 12 mo ingesting less than two-thirds of the RDA of 35 mg (**Table 2**). The remaining children in all of the formula groups achieved adequate vitamin C intakes. Regarding the various sources of vitamin C (formula fruits, and fruit juices) for each group and age, the WCM + C group had lower vitamin C intakes from milk at each age than the formula groups had from formula ( $P < 0.0001$ ). However, the contribution of vitamin C intake from fruits and juices was not statistically different among the groups.

*Laboratory data*

No significant differences were demonstrated in the mean hemoglobin values at baseline, 9, or 12 mo of age among the four groups (**Table 3**). Although there were no differences between groups at baseline and 9 mo, the mean FEP was greater in FUF2 infants at 12 mo than in the FUF1 and IF groups ( $P < 0.01$ ).

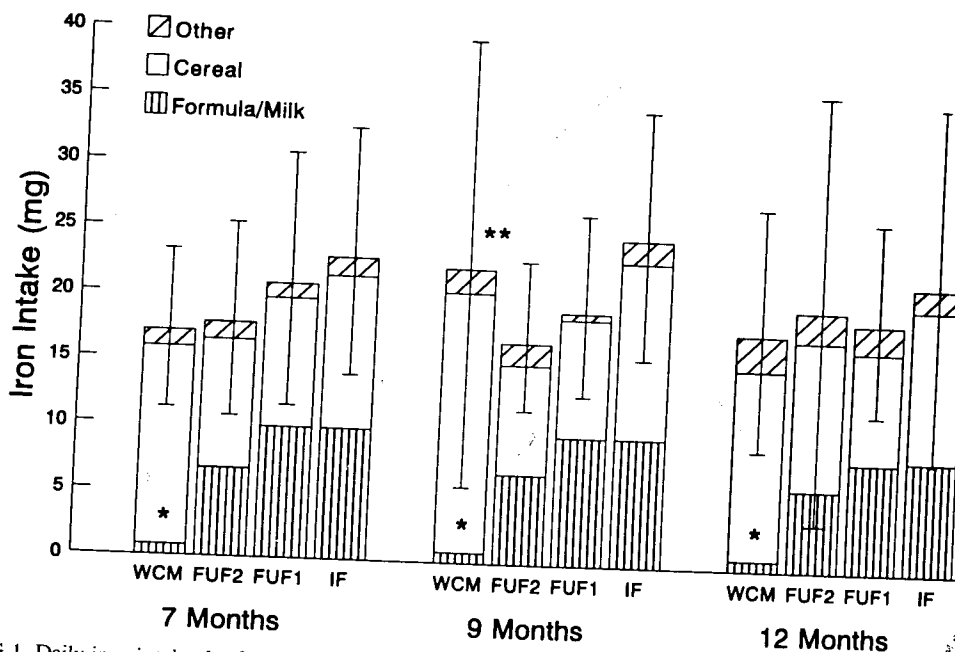


FIG 1. Daily iron intake, by feeding group and source.  $\bar{x} \pm SD$ . \*WCM + C significantly different from all other groups (formula/milk),  $P < 0.05$ . \*\*WCM significantly different from all other groups (cereal),  $P < 0.05$ . The numbers of infants in each group for each food source and total intake at each time point is available upon request from the corresponding author.

TABLE 2  
Number and percent of infants achieving the recommended dietary allowance (RDA), by age\*

	Vitamin C				Iron			
	WCM + C	FUF2	FUF1	IF	WCM + C	FUF2	FUF1	IF
n								
7 mo								
50-67% of RDA	3 [13]	0 [0]	0 [0]	0 [0]	1 [4]	0 [0]	0 [0]	0 [0]
67-100% of RDA	0 [0]	1 [4]	0 [0]	0 [0]	1 [4]	2 [8]	0 [0]	0 [0]
> 100% of RDA	21 [87]	24 [100]	22 [100]	24 [100]	22 [92]	24 [100]	22 [100]	24 [100]
12 mo								
50-67% of RDA	2 [8]	0 [0]	0 [0]	0 [0]	0 [0]	1 [4]	0 [0]	0 [0]
67-100% of RDA	1 [4]	1 [4]	0 [0]	0 [0]	3 [13]	1 [4]	2 [10]	2 [11]
> 100% of RDA	20 [83]	22 [96]	22 [100]	18 [100]	21 [87]	21 [92]	19 [90]	16 [89]

\* WCM, whole cow milk plus iron-fortified cereal; FUF1, investigational follow-up formula (Carnation Nutritional Products, Glendale, CA); FUF2, Carnation Follow-up Formula (Carnation Nutritional Products, Glendale, CA); IF, Similac with Iron (Ross Laboratories, Columbus, OH). Percent of infants in brackets.

There were no significant differences in ferritin and MCV among the four groups at baseline or at 9 mo of age. However, by 12 mo both the mean MCV ( $P < 0.005$ ) and ferritin ( $P < 0.0005$ ) were significantly lower in the infants in the WCM + C group.

All infants had a normal hemoglobin value at baseline (Table 4). At 9 mo one infant in both the FUF1 and the FUF2 groups had low hemoglobin values. By 12 mo one infant in the WCM + C group had low hemoglobin in addition to abnormal ferritin and MCV values. Differences between groups at 9 and 12 mo were not significant.

At baseline, there were five (19%) infants in the WCM + C, five (19%) in the FUF1, none in the FUF2, and seven (26%) in the IF groups with an MCV  $< 74$  fL. Three (12%) WCM + C

infants, one (4%) FUF1 infant, and two (8%) IF infants had low MCV values at 9 mo. By 12 mo six (24%) WCM + C infants, one (4%) FUF1 infant, and two (7%) IF infants had low values for MCV. FEP values  $> 0.35$   $\mu\text{mol/L}$  were evident in several infants at baseline in all four groups, a trend that persisted at 9 mo. By 12 mo, considerably fewer infants had high values.

A ferritin value  $< 12$   $\mu\text{g/L}$  was seen in one (4%) WCM + C infant at baseline. At 9 mo of age four (17%) infants in the WCM + C, three (13%) in the FUF1, one (4%) in the FUF2, and one (4%) in the IF groups had low ferritin, but the differences between groups were not significant. However, by 12 mo of age 7 of 24 (29%) infants in the WCM + C group had a serum ferritin  $< 12$   $\mu\text{g/L}$  compared with only 1 of 77 (1%) of the formula-fed infants

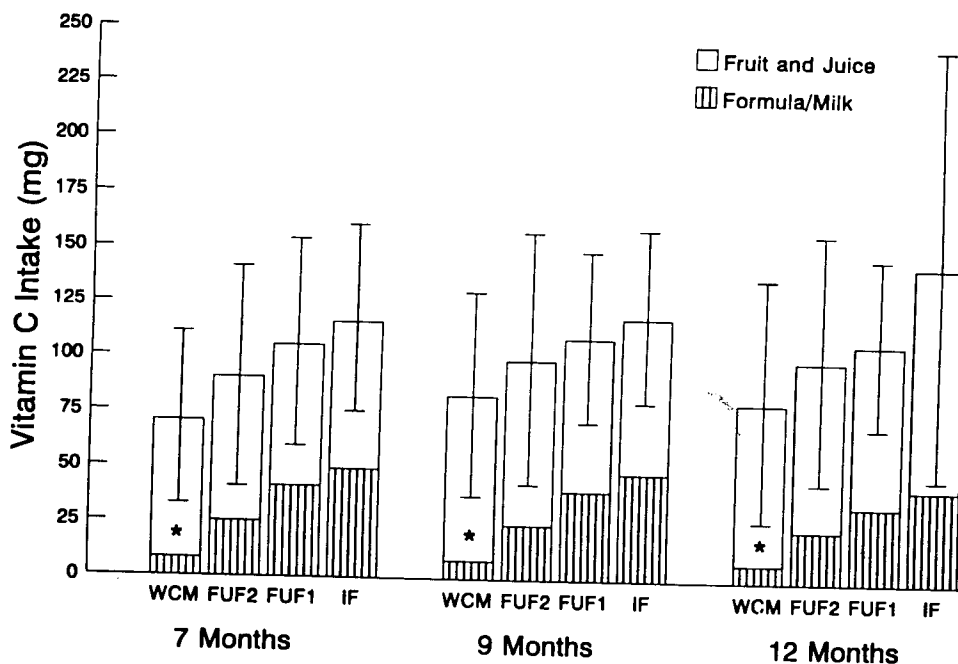


FIG 2. Vitamin C intake per day, by feeding group and source.  $\bar{x} \pm \text{SD}$ . \*WCM + C significantly different from all other groups (formula/milk)  $P < 0.05$ . The numbers of infants in each group for each food source and total intake at each time point is available upon request from the corresponding author.

TABLE 3  
Mean red bl

Baseline
Hb (g/L)
MCV (fL)
FEP ( $\mu\text{mol/L}$ )
Ferritin ( $\mu\text{g}$ )
9 mo
Hb (g/L)
MCV (fL)
FEP ( $\mu\text{mol/L}$ )
Ferritin ( $\mu\text{g}$ )
12 mo
Hb (g/L)
MCV (fL)
FEP ( $\mu\text{mol/L}$ )
Ferritin ( $\mu\text{g}$ )

\*  $\bar{x} \pm \text{SD}$ ;  
FEP, free erythrocyte protoporphyrin; WCM, whole cow milk plus iron-fortified cereal; FUF1, Carnation Follow-up Formula (Carnation Nutritional Products, Glendale, CA); FUF2, Carnation Follow-up Formula (Carnation Nutritional Products, Glendale, CA); IF, Similac with Iron (Ross Laboratories, Columbus, OH).  
†‡ Significant differences between groups at the same time point.  
§ Significant differences between groups at different time points.

( $P < 0.005$ )  
with a serum ferritin  $< 12$   $\mu\text{g/L}$ . The mean MCV. The mean ferritin by age 12 mo was significantly lower in the WCM + C group.

## Discussion

Infants of low socioeconomic status who do not receive adequate iron during the first year of life are at risk for developing iron deficiency anemia. It has been consistently shown that such infants do not consume sufficient iron because of inadequate intake of iron-rich foods. In addition, older infants who do not receive adequate iron during the first year of life are at risk for developing iron deficiency anemia.

Our data show that infants who receive sufficient iron during the first year of life, assuming WCM + C or formula plus iron, provided with iron-fortified cereal, have adequate iron

TABLE 3  
Mean red blood cell indexes, by formula group and age\*

	WCM + C	FUF2	FUF1	IF
Baseline				
Hb (g/L)	116 ± 8 [26]	115 ± 10 [25]	119 ± 9 [26]	115 ± 8 [27]
MCV (fL)	78.8 ± 4.8 [24]	81.8 ± 4.1 [24]	80.8 ± 5.2 [26]	78.9 ± 4.5 [27]
FEP (μmol/L)	0.42 ± 0.13 [26]	0.52 ± 0.17 [25]	0.46 ± 0.16 [26]	0.50 ± 0.22 [27]
Ferritin (μg/L)	55.8 ± 33.7 [26]	40.6 ± 22.9 [25]	54.1 ± 30.4 [26]	53.4 ± 30.5 [27]
9 mo				
Hb (g/L)	119 ± 8 [26]	120 ± 9 [25]	120 ± 9 [26]	119 ± 9 [25]
MCV (fL)	77.3 ± 5.8 [26]	79.8 ± 3.9 [25]	79.3 ± 5.2 [26]	78.1 ± 16.3 [25]
FEP (μmol/L)	0.26 ± 0.09 [26]	0.32 ± 0.12 [25]	0.25 ± 0.07 [26]	0.26 ± 0.11 [25]
Ferritin (μg/L)	30.1 ± 21.1 [24]	33.5 ± 26.1 [24]	32.8 ± 30.4 [23]	40.2 ± 18.2 [26]
12 mo				
Hb (g/L)	118 ± 8 [26]	122 ± 8 [23]	121 ± 9 [24]	121 ± 9 [27]
MCV (fL)	76.1 ± 5.1† [24]	79.3 ± 3.5 [21]	80.1 ± 4.0 [24]	80.0 ± 3.6 [24]
FEP (μmol/L)	0.43 ± 0.11 [26]	0.53 ± 0.16‡ [22]	0.42 ± 0.13 [26]	0.41 ± 0.14 [27]
Ferritin (μg/L)	19.5 ± 11.4§ [25]	32.7 ± 19.7 [24]	35.4 ± 15.4 [26]	37.6 ± 16.3 [27]

\*  $\bar{x} \pm SD$ ; *n* in brackets. Hb, hemoglobin; MCV, mean corpuscular volume; FEP, free erythrocyte protoporphyrin; WCM, whole cow milk plus iron-fortified cereal; FUF1, investigational follow-up formula (Carnation Nutritional Products, Glendale, CA); FUF2, Carnation Follow-up Formula (Carnation Nutritional Products, Glendale, CA); IF, Similac with Iron (Ross Laboratories, Columbus, OH).  
†‡§ Significantly different from that of the other feeding groups at 12 mo: (ANOVA, Duncan's multiple-range test); †*P* < 0.005, ‡*P* < 0.01, §*P* < 0.0005.

(*P* < 0.001). Of the eight infants (seven WCM + C, one FUF1) with a serum ferritin < 12 μg/L, only one infant also had a low MCV. There was no correlation between average daily iron intake per month throughout the duration of the study and serum ferritin by age 12 mo (*r* = 0.10, *P* values indicate no statistically significant correlation).

## Discussion

Infants older than 6 mo of age who consume WCM without deliberate supplementation with iron-rich foods are at risk of developing iron-insufficiency and iron-deficiency anemia. It had been considered by many, most notably the CON/AAP, that such infants are likely to maintain normal iron nutriture if they do not consume excessive quantities of WCM and if they receive additional iron and vitamin C from other sources (6). Primarily because of the lack of convincing data to the contrary, the recommendations by the CON/AAP condoned WCM feeding for older infants. In this study we tested the appropriateness of these recommendations.

Our data indicate that infants in the second half of the first year of life consume quantities of iron from supplemental foods sufficient to meet the RDA. This was true for the infants consuming WCM as their primary beverage, whose mothers were provided with iron-fortified cereal and were counseled to provide their infants with a volume of infant cereal necessary to ensure adequate iron intake.

Results of our study differ from those of previous studies perhaps because of the adherence to the CON/AAP guidelines. Penrod et al (8) calculated that significantly more WCM-fed infants than formula-fed infants had iron intakes insufficient to meet the RDA (8). Martinez et al (20) determined that infants who consumed WCM or non-iron-fortified formula had median intakes below the RDA. Unlike our study, which was prospective, randomized, and longitudinal, these two studies were cross-sectional observations. On the basis of our data we conclude that infants in this age group receive sufficient quantities of iron from table food within the context of our study protocol. The intake of vitamin C was greater in the formula-fed infants; however, nearly all infants in all feeding groups exceeded the RDA, often manyfold. The mean intake of vitamin C in the survey of Martinez et al also exceeded the RDA even though it was less than the intake noted in our study (20). It seems unlikely, therefore, that the lack of vitamin C intake is limiting iron absorption in infants consuming WCM.

Despite the adequate consumption of nutrients essential to maintain normal iron status, the infants in our study consuming WCM + C had a higher incidence of depleted iron stores, as evidenced by the lower mean ferritin and the greater number of infants with serum ferritin < 12 μg/L by 12 mo of age. The negative impact of WCM consumption on iron status was apparently less profound than in previous studies, however, in that there was no increase in iron-deficiency anemia (1, 4). It is worth noting that infants with anemia due to hemoglobinopathies were identified and excluded from participation in our study. When iron deficiency during the first year of life progresses to anemia, probable irreversible long-term deficits in mental and motor development are detected (21–23). The detrimental effects of iron depletion without anemia, including an increased risk to develop anemia at an older age, are incompletely defined. Infants in our


TABLE 4  
Iron-status indicators, by formula group and age\*

	WCM + C	FUF2	FUF1	IF
<i>n</i>				
Baseline				
Hb (< 95 g/L)	0 [0]	0 [0]	0 [0]	0 [0]
MCV (< 74 fL)	5 [19]	0 [0]	5 [19]	7 [26]
FEP (> 0.62 μmol/L)	3 [12]	8 [32]	5 [19]	7 [26]
Ferritin (< 12 μg/L)	1 [4]	0 [0]	0 [0]	0 [0]
9 mo				
Hb (< 105 g/L)	0 [0]	1 [4]	1 [4]	0 [0]
MCV (< 70 fL)	3 [12]	0 [0]	1 [4]	2 [8]
FEP (> 0.62 μmol/L)	3 [12]	8 [32]	5 [19]	5 [20]
Ferritin (< 12 μg/L)	4 [17]	1 [4]	3 [13]	1 [4]
12 mo				
Hb (< 105 g/L)	1 [4]	0 [0]	0 [0]	0 [0]
MCV (< 7.0 fL)	6 [24]	0 [0]	1 [4]	2 [7]
FEP (> 0.62 μmol/L)	0 [0]	5 [23]	2 [7]	3 [11]
Ferritin (< 12 μg/L)	7 [29]	0 [0]	1 [4]	0 [0]

\* Percent of infants in brackets. Hb, hemoglobin; MCV, mean corpuscular volume; FEP, free erythrocyte protoporphyrin; WCM, whole cow milk plus iron-fortified cereal; FUF1, investigational follow-up formula (Carnation Nutritional Products, Glendale, CA); FUF2, Carnation Follow-up Formula (Carnation Nutritional Products, Glendale, CA); IF, Similac with Iron (Ross Laboratories, Columbus, OH).

study with a low serum ferritin concentration at 12 mo received supplemental medicinal iron as mandated by the study protocol and were unavailable for further investigations in this regard.

Of particular interest in our study is that the consumption of WCM + C had a definite impact on iron status despite the apparent adequate intake of iron and vitamin C. There are several possible explanations for this observation. Although iron and vitamin C intakes were adequate as defined by the RDA, the WCM + C infants consumed less of these nutrients, and this difference may be physiologically significant. Occult gastrointestinal bleeding in older infants consuming WCM has been proposed as contributing to iron losses by some investigators. This phenomenon was not observed in the WCM + C infants in our study, who were no more likely to have increased fecal blood loss than were control infants (24). The relative insufficiency of body iron stores in the WCM + C infants is perhaps more likely related to the poor bioavailability of electrolytic iron in the matrix of infant cereal, upon which all the infants were dependent for supplemental iron (25). The lack of a correlation between iron intake and serum ferritin provides further evidence that not only the amount of iron, but an additional factor, such as bioavailability, is important. It is possible that supplementation with a more bioavailable form of iron in cereal or even medicinal iron would ensure adequate iron status in infants consuming WCM (26). Certain characteristics of WCM itself may effect iron absorption regardless of the form of the iron in cereal, although a study in adults suggests that milk neither promotes nor inhibits iron absorption (27).

On the basis of our data, we conclude that infants consuming WCM as their primary source of nutrients and who receive iron-containing table food according to the 1983 guidelines of the CON/AAP are at increased risk of developing depleted iron stores, but not anemia. This is not the result of inadequate intake of iron or vitamin C. Although our study did not evaluate iron bioavailability, we suspect that the difference in iron status may be related to low bioavailability of the iron contained in iron-fortified infant cereal. The latest revision of the CON/AAP recommendations regarding the use of WCM in infants older than 6 mo of age is warranted. 

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## Effect of and fat

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### ABSTRACT

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