# The effect of iron status of Nigerien mothers on that of their infants at birth and 6 months, and on the concentration of Fe in breast milk

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1. Within the limits of this study, neither maternal iron deficiency nor Fe-overload as measured at term appeared to affect the complement of Fe received by the foetus.

2. Infants feeding entirely on breast milk appeared to have normal Fe status 6 months postpartum regardless of the Fe status of the mother.

3. No relationship could be demonstrated between the Fe content of breast milk and the Fe status of the mother.

It is commonly believed that the iron status of the mother significantly affects that of her newborn and nursing infant. The accuracy of this belief has never been stringently tested in humans but Loh & Sinnathury (1971) observed that while the Fe content of breast milk of Chinese, Indian and Malayan women varied with their ethnic origins, it appeared to be independent of maternal levels of haemoglobin, serum Fe and total Fe-binding capacity, within the limits of their study. In a study of Indian women, Khurana, Agarwal & Gupta (1970) could find no relationship between the Fe content of their breast milk and their diet or socio-economic status. However, they did not specifically examine the effects of maternal Fe deficiency on the Fe content of milk. In rats, variations of maternal Fe status within wide levels did not appear to influence the complement of Fe received by the litter (Murray & Stein, 1971) but were observed to influence the concentration of Fe in breast milk (Ezekiel & Morgan, 1963). The following two-part study was conducted in an attempt to decide if maternal Fe status influenced Fe status of the newborn infant, the Fe content of breast milk and the Fe status of the 6-month-old infant.

## METHODS

All women in this study were delivered at the Diffa Hospital. None of the women received dietary supplementations, medicinal vitamins or Fe during pregnancy or lactation as these were not available. Each group consumed their own produce, but since famine conditions prevailed in eastern Niger throughout the period of study, food supplies were limited in quantity and variety. The diet of the Kanouri women was restricted largely to millet (*Eleusine coracana*) occasionally supplemented by small amounts of cassava (*Manihot utilissima*) and rice (*Oryz sativa*). Vegetables, eggs and meat were not available. The Fulani women subsisted exclusively on the dairy produce of their herds neither drinking blood nor eating meat except on rare ceremonial occasions.

In the first part of the study, women admitted for delivery were subjected to a general physical examination with special attention to clinical signs of malaria and nutritional disorder. Weights to an accuracy of 100 g and heights to an accuracy of 0·05 m were measured with a balance scale with an attached measuring rod (Detecto Scales; Brooklyn, New York 11205, USA). Blood samples were taken with plastic disposable syringes (Sher-

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Table 1. *Levels of haemoglobin (Hb; g/l), serum iron (µmol/l) and percentage transferrin saturation of Nigerien mothers* and their infants at birth*

(Mean values with standard errors)

| | | Mothers | | | | | | Infants | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hb | | Serum Fe | | Transferrin saturation (%) | | Hb | | Serum Fe | | Transferrin saturation (%) | |
| Fe status† | *n* | Mean | SE | Mean | SE | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Normal | 29 | 126 | 11 | 20·5 | 3·8 | 25 | 3·2 | 187 | 13 | 34·5 | 3·0 | 69 | 3·7 |
| Deficient | 33 | 89 | 12 | 6·4 | 1·9 | 6 | 2·1 | 189 | 9 | 33·8 | 4·3 | 67 | 4·1 |
| Overload | 7 | 123 | 7 | 43·0 | 2·3 | 61 | 3·9 | 190 | 9 | 32·7 | 2·7 | 64 | 5·2 |

* For details, see p. 627.

† For details of groups classified by relative measures of Fe status, see below.

wood Medical Industries, Deland, Florida 32720, USA) for determination of haemoglobin concentration using an optical haemoglobinometer (Model 1010D; American Optical Company, Buffalo, New York 14215, USA), for the presence of sickle-cell haemoglobin by the sodium metabisulphite test of Daland & Castle (1948) and for determination of levels of serum Fe by the method of Nelson (1964) and percentage transferrin saturation by the method of Herbert, Gottlieb, Kam-Seng, Fisher, Gevirtz & Wasserman (1966). Thick and thin blood smears were examined for changes in cellular morphology and the presence of malarial pharasites (Shute & Maryon, 1966). A method for determining serum ferritin was not available. At delivery, blood was obtained from the umbilical cord for haemoglobin concentration and levels of serum Fe and percentage transferrin saturation. Where necessary serum was frozen and stored in a paraffin-operated deep-freeze and thawed later for analysis.

In the second part of the study, the mothers, their breast milk and their infants were examined 2 weeks and 6 months after delivery. Infants were weighed on a balance scale accurate to 10 g (Pennsylvania Scale Co., Barnesville, Pennsylvania 18214, USA). Blood samples were obtained from mothers 2 weeks postpartum and analysed as before. Breast milk (20 ml) was expressed into small plastic bags, frozen rapidly and stored in a paraffin-operated deep-freeze. Later samples were thawed and the Fe content determined by the technique described by Khurana *et al.* (1970) using bathophenanthroline.

## RESULTS

According to the haematological findings, the women were arbitrarily divided into three groups: Fe-deficient characterized by haemoglobin concentration < 100 g/l (this level was chosen because the haemoglobin level in pregnancy may fall normally to 110 g/l from hydremia; a level of 104 g/l, however, is believed to represent a true reduction in erythrocyte mass (de Leeuw, Lowenstein & Hsieh, 1966)), hypochromasia of red cells, percentage transferrin saturation < 10; normal Fe status when the corresponding values exceeded those for Fe deficiency but did not meet those for Fe-overload; Fe-overload, characterized by haemoglobin concentrations > 120 g/l, levels of serum Fe > 35·7 µmol/l and percentage transferrin saturation > 60. Curiously, there were seven women in this last group which is why it was included. They were all members of a small band of nomadic Fulani.

The results of studies on mothers at delivery and their newborn infants are recorded in Table 1. No significant differences could be found between levels of serum Fe, percentage

Table 2. *Levels of iron (µmol/l) and percentage transferrin saturation in serum and total iron content of breast milk (µmol/l) of Nigerien mothers* 2 weeks postpartum*

(Mean values with standard errors)

| | | Mothers | | | | | |
|---|---|---|---|---|---|---|---|
| | | Serum Fe | | Transferrin saturation (%) | | Breast milk Fe | |
| Fe status† | *n* | Mean | SE | Mean | SE | Mean | SE |
| Normal | 24 | 20·9 | 4·8 | 27 | 4·1 | 21·6 | 6·6 |
| Deficient | 31 | 6·1 | 2·5 | 6 | 1·9 | 20·2 | 7·5 |
| Overload | 7 | 42·1 | 5·2 | 64 | 3·7 | 20·9 | 5·9 |

* For details, see p. 627.
† For details of groups classified by relative measures of Fe status, see p. 628.

Table 3. *Levels of haemoglobin (Hb; g/l), serum iron (µmol/l) and percentage transferrin saturation of Nigerien mothers* and their infants and Fe content of breast milk (µmol/l) 6 months postpartum*

(Mean values with standard errors)

| | | Mothers | | | | | | Infants | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hb | | Serum Fe | | Transferrin saturation (%) | | Hb | | Serum Fe | | Transferrin Saturation (%) | |
| Fe status† | *n* | Mean | SE | Mean | SE | Mean | SE | Mean | SE | Mean | SE | Mean | SE |
| Normal | 24 | 142 | 8 | 21·3 | 2·7 | 31 | 3·7 | 121 | 7 | 15·5 | 1·1 | 24 | 3·7 |
| Deficient | 19 | 92 | 9 | 6·6 | 2·1 | 8 | 2·1 | 119 | 4 | 15·9 | 1·4 | 25 | 3·3 |
| Overload | 6 | 146 | 6 | 41·3 | 1·6 | 68 | 4·2 | 118 | 8 | 16·1 | 0·9 | 24 | 2·9 |

* For details, see p. 627.
† For details of groups classified by relative measures of Fe status, see p. 628.

saturation of transferrin and haemoglobin concentration of infants born to mothers in each group despite wide maternal variations of Fe status. The mean birth weight of all infants was 3123 g which compared favourably with birth weights for other African communities (Lewis, 1974) and was 99 % of the 50th percentile of the Stuart–Stevenson series (Nelson, 1966). There were no significant differences between mean weights of babies born to any group. The mean weight of mothers at term was 59·15 kg, 11 % lower than the mean weight published for women at term in 'non-famine' conditions of the Cameroon grasslands (Lewis, 1974).

In Table 2 are recorded values for mean serum and percentage transferrin saturation of each group of mothers and the mean Fe content of samples of their breast milk 2 weeks after delivery. There was no significant difference between the Fe content of breast milk of any group despite the wide variations of serum Fe levels and percentage transferrin saturation of the mothers.

In Table 3 are recorded the results of determinations 6 months after delivery, of maternal and infant haemoglobin concentrations, serum Fe levels, and percentage transferrin saturation and breast-milk concentration. The mean weight of infants at 6 months was 6926 g, 91 % of the 50th percentile of the Stuart–Stevenson series (Nelson, 1966), a mean increase of 121 % on the birth weight. No significant differences were noted between mean weights of babies born to any group. The mean weight of the mothers at the same time was 50·3 kg.

There were no significant differences between the levels of breast-milk Fe and measures of infant Fe status. No infants were anaemic or Fe-deficient by Western standards (Wintrobe, 1974). It should be noted that following birth there is normally a slow decline in levels of haemoglobin, serum Fe and percentage transferrin saturation so that by 6 months the haemoglobin may reach 105 g/l (Wintrobe, 1974), the serum Fe 10 $\mu$mol/l and the percentage transferrin saturation 20 (Bothwell & Finch, 1962).

## DISCUSSION

Within the limits of Fe deficiency and Fe-overload of this study, the complement of Fe received by the developing foetus appeared to be independent of the mother's Fe status. These observations suggested the foetus must parasitize the Fe from the mother during maternal Fe deficiency and reject it during maternal Fe-overload. Furthermore, the concentration of Fe in mature breast milk also seemed independent of the Fe status of the mother, a mechanism presumably designed to protect the suckling infant from Fe deficiency or Fe-overload.

At birth the Fe stores of the infant are more than enough for its immediate needs and McCance & Widdowson (1951) have estimated that the liver contains between 30 and 50 mg storage Fe and that by the age of 6 months the average infant will have used 126 mg Fe. This means that between 70 and 100 mg Fe must be supplied in the diet. In communities where breast feeding is common the Fe must come from breast milk with little if any supplementation. In our study we could find no evidence of Fe deficiency in infants fed entirely on breast milk for 6 months which suggested that breast milk was an important and adequate source of Fe in Niger for infants up to that age.

The mothers of infants were underweight, being 11% lighter at term than their counterparts living in non-famine conditions of the Cameroons (Lewis, 1974). Their lower weights presumably reflected the effects of drought and famine which had prevailed in the Diffa area for over a year. The weights of their newborn infants, however, were not proportionately reduced so that the normal Fe status of the infants could not be attibuted to reduced need for Fe by smaller babies. Although the leanness of mothers continued throughout lactation they were able to suckle their infants and provide them with adequate supplies of energy and Fe for normal growth rates, haemoglobin and serum Fe levels.

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