IRON INTAKE AND IRON DEFICIENCY IN YOUNG CHILDREN

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DEDICATION

This

Work

is Dedicated to

My Father, Brothers and Sisters,

Father-in-law, Dr. Abdulaziz Al-Fraih,

Mother-in-low,

Brother, Abdullah Al-Fadhel,

My Wife Hend and My Children

DECLARATION

In accordance with the requirements of the University of Edinburgh regulations, I hereby declare that this thesis has been entirely my own work and composition, except where assistance and advice has been duly acknowledged.
This thesis has not been submitted for any other degree or professional qualification

Abdulaziz M. Al-Othman
1998

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ACKNOWLEDGMENTS

ABSTRACT

INTRODUCTION

Iron deficiency anaemia is recognised as a common problem in young children in the UK (Department of Health, 1994), and even more in Saudi Arabia (Al-Fawaz, 1993 and Al-Hifzi, et al. 1996). However, there is a lack of studies showing how food intake affects iron status in young children in these countries. Such studies are urgently needed to develop informed prevention strategies.

These studies have sought to assess iron intake in young children (8-36 months), to identify nutritional and other factors that may affect iron intake and iron status and to ascertain whether a food frequency questionnaire can be designed to identify those at risk due to their diet.

METHODS:

A 4-day weighed food inventory, a semi-quantitative food frequency and social questionnaire and anthropometric measurements were used.

Haemoglobin (Hb), mean corpuscular volume (MCV), serum ferritin (SF), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and haematocrit (Hct) were estimated in blood, Compeat-5, food analysis software was used to calculate nutrient intakes and SPSS and Excel for data analysis.

STUDIES IN RIYADH, SAUDI ARABIA:

104 healthy children randomly chosen from eight different health centres have been studied either longitudinally (n=55) or cross-sectionally (n=49). The prevalence of iron deficiency anaemia was 36.3% in all children. Diet including iron intake has been compared to haematological data. Twenty four previously diagnosed iron deficient children from three hospitals were also studied.

STUDIES IN EDINBURGH:

62 healthy children aged 9 and 36 months old were studied. They were those whose parents agreed to participate from a larger number chosen randomly from children registered at three health centres in Edinburgh using the Lothian Health Board list. Diet including iron intake has been compared to haematological data.

ROYAL HOSPITAL FOR SICK CHILDREN (RHSC):

Over a 2 months period, the prevalence of anaemia period in children whose blood samples were analysed in the Haematology Department was 28.3% in children aged between 8 months to 3 years of age. In 59 children, 45 with Hb below 11 g/dl, and 14 with normal Hb whose parents completed a semi-quantitative food frequency and social questionnaire, the iron intake and iron status was studied in detail, and the results related to the haematological parameters previously measured.

CONCLUSIONS:

Iron intakes less than both the Recommended Nutrient Intake (RNI) and the Lower Recommended Nutrient Intake (LRNI) have been shown to be common in the children studied in both Saudi Arabia and Edinburgh. Comparison of the haematological parameters with the iron intake enables certain definite statements to be made. Fortified breakfast cereals with iron and meat in addition to infant formula are important dietary factors which positively influence iron intake and iron status in this age group who are vulnerable to iron deficiency anaemia. These foods should be strongly recommended to parents for inclusion in the post-weaning diet of children of this age. In contrast, extended exclusive breast feeding, milk and some milk products and eggs have a negative influence on iron intake, and should be avoided as far as possible for at least the first year of life. The importance of haem iron as a component of the diet of children of the ages studied is evident from these studies. It has been shown that a food frequency questionnaire can be used to identify children at risk.

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ABBREVIATIONS

AAP	American Academy of Paediatrics
ANOVA	Analysis of variance test
COMA	Committee on Medical Aspects of Food Policy
DH	Department of Health, UK
DHSS	Department of Health and Social Security
dl	decilitre
EAR	Estimated Average Requirement
EDTA	Ethylenediaminetetraacetic acid
FAO	Food and Agriculture Organisation
FFQ	Food Frequency Questionnaire
fl	femtolitre (10^{-15} litres)
g	gram (one-thousandth of 1 kg)
Hb	Haemoglobin
Hct	Haematocrit
HMSO	Her Majesty Stationery Office
KACST	King Abdulaziz for Science and Technology, Saudi Arabia
kcal	kilocalories (1000 calories). A unit used to measure the energy value of food
kg	kilogram (1000g)
LRNI	Lower Reference Nutrient Intake
MAFF	Ministry of Agriculture, Fisheries and Food, UK
MCH	Mean Corpuscular Haemoglobin
MCHC	Mean Corpuscular Haemoglobin Concentration
MCV	Mean Corpuscular Volume
mg	milligram (one-thousandth of 1 g)
μg	microgram (one-millionth of 1 g)
μmol	micromole (one-millionth of 1 mole)

mmol	millimole (one-thousandth of 1 mole)
MUFA	Monounsaturated fatty acids
NHANES	National Health and Nutrition Examination Survey, USA.
pg	picogram (10^{-12} g)
PUFA	Polyunsaturated fatty acids
RBCs	Red Blood Cells
RDA	Recommended Daily Allowances
RHSC	Royal Hospital for Sick Children
RNI	Reference Nutrient Intake
SF	Serum Ferritin
SFA	Saturated fatty acids
Sig	Significance
SPSS	Statistical Package for the Social Sciences
Std deviation	Standard deviation
TIBC	Total Iron Binding Capacity
UNICEF	United Nations Children's Fund
WHO	World Health Organisation

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CHAPTER

1

IRON AND IRON DEFICIENCY, ASSESSMENT AND DIETARY METHODS

IRON AND IRON DEFICIENCY

IRON

Iron is the fourth most abundant element and the second most abundant metal in the earth's crust (Bothwell et al. 1979). Iron has the ability to switch back and forth between two ionic status, two positive charge (ferrous iron) and three (ferric iron) (oxidized state). Thanks to this versatility, iron is the ideal mineral to work with proteins involved in oxidation-reduction reactions (Whitney et al. 1991b). In every cell, iron is found in several of the proteins at the end of the energy metabolic pathways. These proteins donate the hydrogen from energy nutrients to oxygen, completing the extraction of energy for the cells' use.

The body of a healthy adult contains between 3 and 4 g of iron (approximately 50 mg/kg). The major portion is found in the iron porphyrin complexes, haemoglobin, myoglobin, and a variety of enzymes that either contain iron or require it as a cofactor. The remaining body iron is present in the storage compounds ferritin and haemosiderin. The size of this reserve depends on previous iron nutrition. In iron-replete individuals living on a varied Western-type diet iron reserves are approximately 100 mg in males and 300 mg in females (Bothwell et al. 1979). Almost 80% of the body iron in the term newborn is in haemoglobin; 9% is in the lean tissues (Josephs, 1953).

Iron is required for the making of new cells, of amino acids, of hormones, and of neurotransmitters. It also forms part of haemoglobin (the oxygen- carrying protein of the red blood cells "RBCs") and myoglobin (the oxygen - holding protein in the muscle cells).

HAEMOGLOBIN

Haem

Haem consists of a protoporphyrin ring with a central ferrous iron capable of reversibly binding oxygen. The initial stages of porphyrin synthesis occur within the mitochondria of the erythroblasts. After further modifications by cytosolic enzymes, protoporphyrin re-enters the mitochondria for the incorporation of iron (Weatherall, 1996b). The major haemoglobin of adult red cells, haemoglobin A, is a tetrameter of two α and β chains consisting of 141 and 146 amino acids, respectively. Each globin chain is attached to a haem molecule.

Globin

In each haemoglobin molecule, two of the globin chains are derived from a cluster of related genes on chromosome 16 (α-globin gene cluster) and two from a cluster of related genes on chromosome 11 (β-globin gene cluster). During development from embryonic to fetal, and from fetal to extra-uterine life. There is an ordered switch in activation of genes from each cluster. In fetal life, haemoglobin F ($\alpha_2 \gamma_2$) dominates, its high oxygen affinity aiding oxygen uptake across the placenta at a relatively low oxygen tension. At around the time of birth there is a switch from γ to β globin chain production to form adult haemoglobin, HbA ($\alpha_2\beta_2$), which has a lower oxygen affinity and is more efficient in delivering oxygen to the tissues in extra-uterine life. A small amount of HbF (less than 1%) continues to be present in adult life, together with another minor adult component, HbA$_2$ ($\alpha_2\delta_2$) (Weatherall, 1996b).

Iron is supplied bound to plasma transferrin which captures the absorbed iron and carries it to the bone marrow and other blood-manufacturing sites where is taken up by the erythroblasts by a specific receptor-mediated endocytosis. The bone marrow takes large quantities of iron in order to make RBCs. RBC lives about four months, the spleen and the liver cells remove it from the blood, the liver can recycle the iron by

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attaching it to transferrin which transports it back to the bone marrow to be reused to make new blood cells. The chief storage site held in reserve is the liver.

The number of transferrin receptors is increased in iron deficiency, stability of the messenger RNA for the transferrin receptor protein being enhanced by a reduced intracellular iron content. The transferrin receptors have a much greater affinity for diferric (fully saturated) transferrin than for monoferric transferrin (Huebers et al. 1985). Since the loading of transferrin iron binding sites with iron appears to be a random process (Huebers et al. 1984), the amount of diferric transferrin is dependent upon the overall saturation with iron of the plasma total iron binding capacity (TIBC): measurement of the percentage saturation of the TIBC is thus a better overall guide to the iron supply to the erythroblasts than the serum iron concentration, a saturation of less than 16% being unable to support normal amounts of erythropoiesis.

BIOAVAILABILITY OF IRON

Bioavailability describes the proportion of the total iron in a food, meal or diet that is utilised for metabolism. Iron in breast milk is present in low concentrations (0.06 - 0.09 mg/100 ml) but is uniquely well absorbed and utilised, for reasons that are unclear (Booth and Aukett, 1997). A diet rich in iron does not necessarily ensure adequate iron status since the amounts of iron absorbed are affected by factors such as the sources of iron, the interaction of iron found in food between foods and the iron status of the individual. In addition there were genetic and environment determinants of iron utilization (Perry et al. 1992).

Haem iron

The dietary factors which affect the absorption of iron are different for the two forms of food iron. Haem iron is highly bioavailable since the iron bound to prophyrin in haemoglobin, and myoglobin, is absorbed intact and is therefore not exposed to the inhibitory ligands in the diet which affect the bioavailability of non-haem iron (Tunball et al. 1962). Haem iron is absorbed by a special receptor on the mucosal cell. Within

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the mucosal cell, the iron is released from the porphyrin molecule by a specific enzyme, haem-oxygenase (Weinraub et al. 1968; Raffin et al. 1974).

It is apparent that meat products are of critical importance for iron nutrition even when they from only a small part of the diet (Carpenter and Mohoney, 1992). Meat has another indirect effect, in that its presence in the diet enhances the absorption of non-haem iron. One heaped tablespoon of finely chopped grilled lean beef or lamb, about 3-7 heaped tablespoon of skinless chopped, baked chicken, or about eight heaped tablespoon of steamed, mashed fish fillet, can provide about 0.7 mg/day haem iron (English and Lewis, 1991). An increase in meat intake can prevent a decrease in Hb in late infancy, probably by enhancing iron absorption. However, there was no effect on iron stores or on cellular iron deficiency (Engelmann et al. 1998).

Non-haem iron

Substances such as calcium, phosphorus, phytate, tannins, protein as well as fibre all inhibit absorption (Hurrell, 1997). Bioavailability of iron from wheat-based products was more than that from oat-based products (Fly and CzarneckiMaulden, 1996). Phytates, which constitutes 1-2% of many cereals, nut, and legumes, tannin in tea and polyphenols in spinach, coffee and to some extent, cocoa and herbs, all bind to iron and hinder iron absorption which has a marked inhibitory effect of dietary iron bioavailability (Fairweather-Tait, 1989; Hallberg et al. 1989; Siegenberg et al. 1991). Non-haem iron in cereals, vegetables, fruits, roots, pulses and beans forms the main part of dietary iron (Belton, 1995). The absorption is very much influenced by the individual iron status (Martinez-Torres et al. 1986; Olivares et al. 1993; Hallberg et al. 1993), and gender at 12 months of age (Wharf et al. 1997). The bioavailability may vary more than 20-fold, depending on the composition of the meal (Davidson et al. 1983). The addition of 10 mg of phytate to phytate-free bread has been found to cause a drop in the iron absorption ratio to 0.41 (Hallberg and Rossander-Hulthen, 1982). Adding enhancing factors, removing inhibitors such as phytate by enzymatic and non-enzymatic hydrolysis, and using 'protected' fortification compounds can enhance the bioavailability of both fortificant and intrinsic foods (Gibson, 1997).

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Michaelesen et al. (1995) found that in children there was a positive significant association between serum ferritin levels and intake of infant formula and negatively association with intake of bread, also there was a trend for a positive association with intake of meat and a negative with intake of cow's milk.(Martinez and Ryan, 1985; Michaelsen et al. 1995). In industrialised countries only 10-15% of iron intake is as haem iron (Hallberg, 1981).

Table 1-1 summarises a number of dietary factors that have been shown to influence the bioavailability on iron absorption (Fairweather-Tait, 1989).

Table 1-1. Factors influencing dietary iron absorption

Haem iron absorption	Non-haem iron absorption
• Amount of haem iron, especially as meat.	• Iron status of subjects.
• Content of calcium in meal.	• Amount of potentially available non-haem iron.
• Food preparation (time, temperature).	• Balance between plus and minus factors.
Plus factors	**Minus factors**
• Ascorbic acid	• Phytate
• Fermented foods "Lactic acid"	• Iron-binding polyphenols
	• Calcium
	• Soy protein

Source: (Fairweather-Tait, 1989)

IRON INTAKE IN CHILDREN (GLOBAL VIEW)

The percentage of Spanish children with iron intake levels below the Catalonia Recommended Daily Amount varied from 24% to 77% (Arija et al. 1990). In Denmark, follow-up formula was the best source of iron in children aged from 3 to 9 months, bread became the highest when the children became in age between 10 to 12 months, followed by meat and fish (Michaelsen et al. 1995). A study of haem iron intake in 12-36 month old children in Australia showed that 0.42mg and 0.28mg daily

haem iron intake in iron replete and iron deplete children respectively. It was lower among children taking cows' milk before the end of the first year of life. There was no association between low intake of vitamin C and iron depletion (Mira et al. 1996). Wood et al. (1993) found that iron intakes were 13.2, 10.3 and 7.4 in children aged 6, 12 and 24 months respectively. There was no correlation between iron intake and ferritin, MCV, MCH or serum iron (Wood et al. 1993). The American National Food Consumption Survey found that total iron intake of 1-2 and 3-5 years-old children were 51% and 77% of their respective RDAs (Raper et al. 1984). Iron insufficiency was probably related to poor bioavailability of iron in infant cereals (Fuchs et al. 1993). Iron intake was much lower in Argentina, where 98% of children were below the RDA with mean intake of 5.6 mg/d (Calvo and Gnazzo, 1990).

IRON DEFICIENCY ANAEMIA IN CHILDREN

Iron deficiency anaemia is one of the most common nutritional disorders world-wide. In addition to affecting a large proportion of infants, children and women in the developing world, iron deficiency is the only nutrient deficiency of significant prevalence in virtually all developed nations as well (Yip, 1994). Iron deficiency may arise as a result of increased iron losses, increased tissue iron requirements, reduced dietary iron content or bioavailability, or, more rarely, malabsorption of iron due to intrinsic gastrointestinal disease (Sullivan, 1993). On a world scale, hookworm infestations are the commonest cause of gastrointestinal blood loss and iron deficiency anaemia. Iron deficiency anaemia is not only caused by direct dietary factors i.e. early introduction of unmodified cows' milk as the major milk source at around 6 months of age in Saudi Arabia or the UK, but it is the most common dietary characteristic of infant found to have iron deficiency anaemia at one year (Sadowitz and Oski, 1983). The prevalence of iron deficiency varies widely depending on the criteria used to establish the diagnosis (Oski, 1993). In Argentina, the iron deficiency anaemia prevalence in children was associated with low iron intake, early introduction of cows milk and low consumption of iron-fortified foods and iron supplements (Calvo and Gnazzo, 1990).

However prevalence of anaemia among infants and children in the USA has decreased sharply during the past two decades (Yip et al. 1987; Dallman and Yip, 1989; Dallman, 1990). Despite the current low prevalence, as shown in table 1-2, iron deficiency remains the leading cause of anaemia (Oski, 1993).

PATHOPHYSIOLOGY

Reduction in total body iron content can range in severity from diminished iron stores to severe anaemia and deficiency of tissue iron containing enzymes (Weatherall, 1996a). Only when iron stores have been utilised does a continuing negative iron

Table 1-2 Prevalence of iron deficiency anaemia in some countries in the world

Country	Age	No. of subjects	Rate	References
Africa				
Angola	1-5y	258	93.7%	FAO 1990 (*)
Benin	6-24m	100	89%	(Hercberg et al. 1988)
	6-24m	161	78.8%	
Burkina Faso	0-6y		70%	MOH 1987 (*)
Ethiopia	0.5-5y	88	50%	Gurney, J.M. 1989
Ghana	0-4y	184	25%	(Bruce-Tagoe et al. 1973)
Guinea	0.5-5y		9.1%	MOH 1985 (*)
Kenya	1-2y	90	60%	(Kigutha, 1997)
Mali	0-14y		28.4%	FAO 1989 (*)
Mauritania	0-3y	104	51%	WHO 1989 (*)
Mozambique	0-5y		94%	MOH 1992 (*)
Nigeria	0-5y	200	28%	(Fleming and Werblinska, 1982; Fleming et al. 1984)
Senegal	0-5y	172	63%	WHO 1992 (*)
Sierra Leone	6-23m	675	96.3%	MOH 1989 (*)
South Africa	1-4y	342	24%	(Hansen, 1990)
Tanzania	0-5y	979	25%	FAO 1988 (*)
Togo	6-12m		61.2%	(Stetler et al. 1980)
	12-23		49.3%	
	24-35m		70.7%	(Stetler and Huong, 1981)
Zaire	0-4y	95	79%	(Spencer, 1996)
Zambia	0-4y	7101	49%	FAO 1989 (*)
Eastern Europe				
Hungary	12m	108	54%	(*)
Romania	6-12m	757	51.8	(*)
	12-24m	1404	47%	(*)
Industrial Countries				
Australia	9-12m	69	20%	(Presgrave and Biggs, 1994)
	12-24m	122	35%	(Presgrave and Biggs, 1994)
	9-24m	100	20%	(Mira et al. 1996)
Canada	6-12m	166	11.4	(Chan-Yip and Gray-Donald, 1987)
	13-18m	79	16.5%	
Denmark	1-3y	270	9.3%	(Milman et al. 1984)
Greece	0.5-5y	289	33.6%	(Kattamis et al. 1974)
Spain	9-24m	523	23%	(Arija et al. 1990)
USA	12-23m	349	15%	(Yip et al. 1987)
	1-2	1339	3%	(Looker et al. 1997)
	9-23m	324	1%	(Vazquez-Seoane et al. 1985)

Latin America and Caribbean				
Argentina	9-24		55%	WHO 1990 (*)
	9-24	348	46%	(Calvo and Gnazzo, 1990)
Bolivia	0-5y	567	21.2%	FAO 1987 (*)
Brazil	0-5y	1593	17.5%	FAO 1991 (*)
Chile	3-6m	40	57.5%	(Olivares et al. 1989)
	6-18m	48	33.3%	
Cuba	12m		12.3%	WHO 1989 (*)
	4-6y		45%	WHO 1991 (*)
Dominican Rep.	1-14y		30.6%	UNICEF Review 1996 (*)
Nicaragua	12-59m		64.3%	National Micronutrient Survey 1993 (*)
Peru	0-2y	132	64%	WHO 1992, *
Middle East				
Algeria	3-36m	125	33.2%	(Hercberg and Galan, 1992)
Bahrain	2-4y		39%	(Musaiger, 1996)
Egypt	6-11m	169	57.3%	(*)
	12-23	383	59.4%	(*)
	24-35m	338	41%	(Jerome, 1997)
Iran Islamic Rep.	2-14y	8246	11.3%	Ministry of Health 1994 (*)
Jordan	6-36m	1204	75.3%	(Rawashdeh et al. 1996)
	3-60m	192	46%	
Kuwait	1-24m		41%	(Shaltout et al. 1985)
Lebanon	6-36m	1371	70.5%	UNRWA 1990 (*)
Morocco	0.6-5y	3238	35.4%	Ministry of Health 1995 (*)
Oman	2-4y		60%	(Amine, 1980)
Sudan	2-6y		67.2%	UNICEF 1996 (*)
Syria	1-2y		59%	FAO 1988 (*)
Tunisia	0-5y		43.8%	Institute of Nutrition and Food Technology 1975 (*)
Yemen	6-24m		66%	Ministry of Health 1992 (*)
South Asia				
Bangladesh	0-4y	421	73%	(Zeitlin and Ahmed, 1995)
China	0-13	1189	86.9%	Ministry of Health 1992 (*)
	0-7y	32940	55.5%	(Yeung, 1987)
India	2-4y	4338	66%	(Madan et al. 1996)
Malaysia	2y	96	52%	International Conference on Nutrition 1992 (*)
Pakistan	2-6y	300	55%	(Hamedani et al. 1987)
Philippines	1-6y	3200	30.7%	Dept. of Science 1989 (*)
Viet Nam	6-23m	3897	60.5%	UNICEF 1996 (*)

(*) (MN-NET.A Global Micronutrient Initiative Network, 1998)

balance lead to a reduction in iron supply to erythroid and non-erythroid tissues.

In the early stages of iron-deficient erythropoiesis (latent iron deficiency) the haemoglobin concentration and red cell indices (MCV, main corpuscular volume, and MCH, mean corpuscular haemoglobin) may still be in the normal range. However, transferrin saturation below 16 per cent is insufficient to maintain normal erythropoiesis.

Anaemia may result from defects at any stage of red cell and haemoglobin production or, less commonly, when an increased rate of red cell destruction (haemolysis) exceeds the capacity of the bone marrow to mount a compensatory increase in production. Changes in the relationships between red cell and plasma volumes may also result in a reduced haemoglobin concentration: such changes occur physiologically in pregnancy where red cell volume is increased less markedly than plasma volume, but also contribute to the 'sports anaemia' seen in endurance athletes.

Iron deficiency anaemia is the final and most obvious stage of a progressive 'negative iron balance', in which iron uptake from the gastrointestinal tract is insufficient to meet the need for an expanding volume of red blood cells (e.g. in growing infants or in pregnancy), or to keep pace with obligatory iron losses (predominantly through loss of gut enterocytes or desquamation of skin cells) or with pathological iron losses (e.g. haemorrhage into the gastrointestinal tract). Under such circumstances of negative iron balance, the serum ferritin concentration falls as any storage iron is mobilised to circulating plasma transferrin to be delivered to iron-requiring tissues, where it is incorporated into functional iron compounds including red cell haemoglobin and essential tissue enzymes. As storage iron is exhausted, the saturation of the plasma transferrin with iron falls below the level (16% saturation) which is necessary to support normal amounts of erythropoiesis. At this point iron deficient erythropoiesis begins to develop, even though the total amount of circulating haemoglobin may still be above the threshold used to define anaemia. Such iron deficient erythropoiesis is associated with an increased concentration of serum transferrin receptors, derived from the increased expression on the cell membranes of iron deficient developing erythroblasts (Skikne et al. 1990), as well as an accumulation of free erythrocyte protoporphyrin, and an increase in red cell

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heterogeneity as assessed by the red cell size distribution width (RDW) (Bessman et al. 1983). Finally, frank anaemia develops, associated with progressively more severe microcytosis (reduced mean cell volume, MCV) and hypochromia of the red cells on the blood film (Cook, 1982).

Babies born at term have accumulated iron in the liver and reticuloendothelial tissues. Babies born pre-term do not have these stores of iron and are particularly vulnerable to deficiency during the first year. In addition, as a normal physiological response to post-natal life, the high haemoglobin level of the newborn falls and the iron thus liberated provides a further store for later months. There is little increase in body iron during the first four months of life (about 250 mg total at birth and at 4 months) but thereafter the total body iron increases to about 420 mg at the age of one year (Dallman, 1986). Iron is needed to meet this increasing requirement as well as to replace normal daily losses. Breast milk has a low iron content; mean values are about 760µg/l, 0.5 mg iron/l during the first month post partum, falling to about 0.3 mg/l at 4-6 months. Iron in cow's milk is about 500µg/l and infant formula vary from about 700 µg/l up to 6000µg/l. Assuming a mean intake of 673 ml milk at 1 month post partum and 896 ml at 6 months (Lonnerdal, 1984), the calculated daily iron intake falls from 0.34 mg at 1 month to 0.27 mg at 6 months of age. However up to 70% of this iron absorbed by the infant (Saarinen and Siimes, 1979). Absorption of iron from breast milk, where it is bound to lactoferrin is substantially higher, averaging about 50% compared with only 5% to 10% from cows milk (Dallman, 1981). Bovine milk appears to decrease the absorption of iron from other foods (WHO), 1975). It is associated with other disorders such as the loss of blood from the gastrointestinal tract (Oski, 1985).

Diet and iron deficiency during weaning

The major cause of iron deficiency in this age group is dietary although there are other factors. The level of iron in human milk is low but since about 50 per cent or more is absorbed, which is a high rate of absorption for iron, this makes an important contribution for the breastfed infant during early weaning. Lactoferrin, which

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constitutes 10 to 20 per cent of human milk protein, binds with two molecules of ferric iron to facilitate absorption via specific intestinal receptors. Bovine lactoferrin is not effective in this way and the efficiency of absorption of iron from cows' milk or from infant formula is much lower than from breast milk (Iyer and Lonnerdal, 1993). After the age of 6 months, the amount of iron contributed from breast milk is insufficient to meet increasing needs, and adequate intakes of iron, as well as of zinc and copper, must be ensured from other dietary sources. The absorption of iron from breast milk is greater if breast feeds are given separate from solid food (Belton, 1991). Solids given close to a breast-feed, reduce the bioavailability of iron from the breast milk because inhibitors in the food bind the iron from breast milk in unabsorbable complexes (Oski and Landaw, 1980).

In infancy, occult gastrointestinal blood loss is commonly associated with feeding with unprocessed cows' milk (Fomon et al. 1981; Oski, 1985; Ziegler et al. 1990), adding to the effects of the low iron content and poor availability of the iron in cows' milk. A physiological increase in iron requirements is seen during periods of rapid growth in infants, children and adolescents, and iron deficiency is more common at these times. The majority of the worlds' population eats a predominantly vegetarian diet with a relatively low bioavailability of iron compared with meat-containing diets. The combination of physiological factors and poor dietary iron availability is probably the major contributor to the development of iron deficiency anaemia in the developing regions of the world. Nutritional iron deficiency appears after the age of 6 months and is undoubtedly linked to inappropriate feeding practice (Fairweather-Tait, 1992). Participation in programmes such as the WIC (Women, Infants and Children) programmes will help limit the development of iron depletion or iron deficiency anaemia in young children (Miller et al. 1985).

Iron deficiency persists despite increased understanding of methods for its prevention, improvements in the means for its detection, and a greater recognition of the fact that anaemia is only one manifestation of this systemic disease (Oski, 1993). Moffatt et al. (1994) studied the efficacy of iron-fortified infant formula in preventing development delays and abnormal behaviour of 283 healthy, bottle-fed infants from very low income families. This study conclude that iron fortified formula significantly

reduced iron deficiency and prevented a decline in psychomotor development quotients.

CLINICAL FEATURES

Features of iron deficiency anaemia are non-specific, and include pallor, breathlessness, and tachycardia. In severe cases angina or heart failure may develop. Up to 50 per cent of patients show glossitis, which may proceed to almost complete loss of lingual papillae. This is more common in older patients on a poor diet. Angular stomatitis is less specific for iron deficiency. Nails may be brittle and flattened though the almost diagnostic spoon-shaped deformity (koilonychia) is increasingly rare in United Kingdom practice (Weatherall, 1996a). Dysphagia may be due to anaemia oesophageal web (Patterson-Kelly syndrome). This is a pre-malignant condition which may occur in the absence of anaemia, usually in middle- aged women. Pica may occur in both children and adults with ingestion of ice, clay, soap or other unusual materials.

EFFECTS OF IRON DEFICIENCY

In addition to anaemia, iron deficiency has been reported to be associated with behavioural changes, increased susceptibility to infection, gastrointestinal abnormalities, and altered muscle function (Oski, 1979).

Hercberg and Galan (1989) reviewed the consequences of iron deprivation on iron-containing enzymes of different tissues in rats and human, these effects were described by Fairweather-Tait (1992) in Table 1-3 .

Iron status and growth

Birth weight and the rate of growth are major influences on iron status during the second half of the first year. At 4 months of age birth weight and body weight exert the greatest influence on iron stores (Wharf et al. 1997). Morton et al. (1988) found

Table 1-3. Biochemical and functional abnormalities associated with iron deficiency

Biochemical	Functional
• Decrease in haemoglobin, myoglobin, cytochromes and catalase	• Reduced tolerance to exercise
• Reduced activity of iron-containing enzymes, e.g. monoamine oxides	• Decreased work capacity
	• Growth retardation
• Reduced activity of enzymes in which iron serves as a cofactor, e.g. aconitase	• Impaired mental development
• Disturbed nucleic acid synthesis	• Compromised cellular immunity
	• Impaired thermoregulation

that iron deficiency at 1 year of age was significantly associated with greater weight gain, whilst no correlation was found between growth and iron intake or iron status up to 9 months of age in one study (Haschke et al. 1993). Iron depletion may impair growth (Owen, 1989). A study in the UK found an improvement in weight gain when anaemic infants were given iron (Aukett et al. 1986). In another study it has been found that there was a strong association between an increased risk of iron deficiency anaemia and a weight below the 10th centile (James et al. 1995). In animal studies, rats fed diet low in iron for 4 weeks, weighed less (P<0.001) compared with the baseline body weight (Droke and Lukaski, 1996).

Iron deficiency and psychomotor development

Iron deficiency in infancy and childhood is associated with a number of non-haematological manifestations, including the delay of mental and motor development, or behavioural effects (Haas and Wilson Fairchild, 1989; Seshadri et al.

1989; Lozoff et al. 1989; Wilson Fairchild et al. 1989; Walter, 1993). A number of studies of infants and young children have found lower mental scores in children with iron deficiency anaemia compared with non-anaemic children and the balance of investigations suggests a cause-and-effect relationship.

Walter et al. (1989) conducted a double-blind, prospective study of 196 infants from birth to 15 months old. At 12 months they were evaluated for the relationship between iron status and psychomotor development. Anaemic infants had significantly lower mental and psychomotor developmental index scores than the control or non-iron-deficient infants. No improvements were noted after 20 days or 3 months of iron therapy. Lozoff et al. (1987) studied mental and motor development in 191 iron-deficient Costa Rican children, ages 12 to 23 months, and a control group, after 3 months, lower mental and motor test scores were no longer observed. In another study, it has been found that children who have iron deficiency anaemia are at risk for long-lasting developmental disadvantage as compared with their peers with better iron status (Lozoff et al. 1991).

De Andraca et al. (1991) reported the cognitive development at pre-school age in the same infants who were anaemic at 12 months. The children were re-tested at $5_{1/2}$ years of age, using a larger battery of developmental and cognitive tests. The deficits found in the formerly anaemic infants persisted at school age in spite of the adequacy of iron therapy. Iron requirements and iron uptake into the brain are highest during periods of rapid growth (Beard et al. 1993) and prenatal iron deficiency alters myelination of nervous tissue (Morris et al. 1992).

The long term detrimental effect on mental development makes prevention of iron deficiency a high priority public health objective for the 1990s (Fairweather-Tait, 1992).

The mental performance of children can be improved to the level of performance of iron-sufficient infants by treatment with ferrous sulphate (Aukett et al. 1986; Aukett et al. 1987; Idjradinata and Pollitt, 1993), which is the most affective treatment for children (Oski and Honig, 1978; Lozoff et al. 1982; Walter et al. 1983; Oski et al. 1983). Lower mental test scores persisted in infants with iron deficiency anaemia

despite extended oral iron therapy and an excellent haematologic response (Lozoff et al. 1996)

ASSESSMENT OF IRON DEFICIENCY ANAEMIA

Diagnosis of iron deficiency anaemia is particularly difficult in the presence of other conditions i.e. chronic inflammation, which confound the interpretation of the laboratory results.

The first phase in iron deficiency anaemia is a decrease in iron stores, reflected by a decline in serum/plasma ferritin concentrations. The second phase, iron deficient erythropoiesis, is characterised by a decrease in serum/plasma iron (< 60 μg/dl) and an elevation in total iron binding capacity (TIBC), resulting in a fall in percentage transferrin saturation (< 15%). At the same time, erythrocyte protoporphyrin concentrations will be increased (> 100 μg/dl), because the supply of iron is no longer adequate for haem synthesis; the haemoglobin remains within the normal range. In the final stage of iron deficiency, frank microcytic, hypochromic anaemia occurs, when decreases in both the haemoglobin concentration and the haematocrit occur, resulting in a low MCHC. Plasma iron decreases (< 40 μg/dl) and ferritin (< 15 μg/l) will be apparent, and increases in erythrocyte protoporphyrin (> 200 μg/dl) and TIBC (> 410 μg/dl). Using a stained blood film can confirm the presence of hypochromic microcytic anaemia at this stage (Gibson, 1990).

Haemoglobin

Measurement of the concentration of haemoglobin in whole blood is probably the most widely used screening test for iron deficiency anaemia. A low haemoglobin concentration is associated with hypochromia, a characteristic feature of iron deficiency anaemia. Haemoglobin is relatively insensitive, concentrations falling only during the third stage of iron deficiency, also in infections, inflammations, haemorrhage, protein-energy malnutrition, thalassemia minor, vitamin B12 or folate deficiency, and in pregnancy. However in polycythemia and dehydration may haemoglobin may increase (Pilch and Senti, 1984; White et al. 1993). Considerable

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overlap exists in the haemoglobin values of normal nonanaemic and iron deficiency individuals (Garby et al. 1969).

Haematocrit

The haematocrit falls only after haemoglobin formation has become impaired. In the early cases of moderate iron deficiency, a marginally low haemoglobin value may be associated with a near-normal haematocrit (Graitcer et al. 1981). In addition to this limitation:

1- Haematocrit is relatively insensitive; haematocrit falls only in the third stage in the development of iron deficiency.

2- It is affected by all the factors influencing the haemoglobin concentration.

3- The values are dependent on age and sex.

4- The method is not very precise.

Cut-off values for children are 36% for children under 2 years of age, 37% for children between 2-6 years of age and 40% for 6-12 years of age (Dallman, 1977). Haematocrit was an inadequate indicator of iron deficiency anaemia in infants aged 9-18 months when compared with serum ferritin (Kazal, 1996).

Mean cell volume

Mean cell volume (MCV) is a measure of the average size of the red blood cell. It is best determined directly with electronic counters as results obtained are highly reproducible. Furthermore, it can be calculated from the haematocrit and red blood cell count:
$$MCV\ (fl) = \frac{\text{Haematocrit (volume fraction)}}{\text{Red blood cell count per liter}}$$

MCV is less affected than haemoglobin by sampling errors in capillary blood sample, because red cell size is unaffected if the sample is diluted by the tissue fluid .

Low values of MCV only occur when iron deficiency becomes severe, in that time MCV is a relatively specific index for iron deficiency anaemia, excluding the anaemias of infection, chronic inflammatory disease, thalassemia minor, and lead poisoning. Also it will be high in vitamin B-12 or folate deficiency, which differentiate iron

deficiency anaemia. The mean cell volume changes progressively during infancy, childhood and early adult life (Yip et al. 1984). Differences in MCV values according to sex are small and not for children.

MCV cut-off for the NHANES II survey (1976-1980) was 73, 75 and 76 for 1-2, 3-4 and 5-10 year old respectively (Pilch and Senti, 1984) These values were calculated from the haematocrit and red blood cell count.

Mean cell haemoglobin concentration

If the haemoglobin concentration and the haematocrit are known, the concentration of haemoglobin in the red blood cell can be determined, which can be known as mean cell haemoglobin concentration (MCHC). MCHC is less affected by age after the first few months of life. It is the last to fall during iron deficiency which make it the least useful of the red cell indices. MCHC can be calculated from haemoglobin and haematocrit:

$$MCHC \ (g/l) = \frac{Haemoglobin \ (g/l)}{Haematocrit \ (volume \ fraction)}$$

MCHC value is low in iron deficiency anaemia, but normal in the macrocytic anaemia of vitamin B-12 and folic acid deficiency.

Mean cell haemoglobin

Mean cell haemoglobin (MCH) refers to the haemoglobin content of the individual red blood cells. It expresses the ratio of haemoglobin to red blood cell count.

$$MCH \ (pg) = \frac{Haemoglobin \ (g/l)}{Red \ blood \ cell \ count \ (10^{12}/l)}$$

MCH value changes progressively throughout life and undergoes similar changes in iron deficiency anaemia to the MCV; it is low in iron deficiency anaemia but high in the macrocytic anaemias. In the severe iron deficiency anaemia the relative fall in MCH is greater that the corresponding fall in MCV (Dallman, 1977).

Serum iron, TIBC, and transferrin saturation

Serum iron, total iron-binding capacity (TIBC), and transferrin saturation are particularly useful for differentiating between nutritional deficiencies of iron and iron deficits arising form chronic infection, inflammation, or chronic neoplastic disease. The serum iron content is a measure of the number of atoms of iron bound to the iron transport protein transferrin. The International Committee for Standardisation in Haematology has recommended a reference method which is simple and reliable (Tietz and Rinker, 1994). Determination of serum iron and total iron-binding capacity is usually performed simultaneously, and transferrin saturation calculated:

$$\text{Transferrin saturation (\%)} = \frac{\text{Serum iron } (\mu mol/)}{\text{TIBC} (\mu mol/l)} \times 100\%$$

Sex doesn't affect serum iron, TIBC or transferrin saturation. When iron stores are depleted transferrin saturation is low as a consequence. Hence, transferrin saturation is a more sensitive index of iron status than red cell indices, and it is also more consistently useful for diagnosing iron deficiency than using serum iron or TIBC alone, also serum iron has considerable variation from hour to hour and day to day in normal individuals. Infection, inflammation, and malignancy typically reduce low serum iron and low TIBC levels, and hence a transferrin saturation which tends towards the low end of the normal range. Such trends arise from defects in the release of iron from the reticulo-endothelial cells and the subsequent transport of iron from these stores to transferrin. This called 'mucosal block' results in a shortage of iron in the bone marrow, despite adequate iron stores, so the body does not respond to the fall in serum iron by increasing the absorption of iron from the diet, so all of these indices will remain low. Hence, the determination of TIBC allows one to distinguish between the low transferrin saturation of chronic disease and that of true iron deficiency.

Serum ferritin

Changes in storage iron status, which reflect the previous iron nutrition of individual, can most conveniently be assessed by measuring the levels of serum ferritin. Serum

ferritin levels mirror the size of the iron stores, with each µg/L being equivalent to between 8 and 10 mg storage iron (Bothwell et al. 1979). The level is low (between 20 and 30 µg/L) during late infancy, childhood, and adolescence as most of the absorbed iron is needed for growth and an expanding red cell mass (Cook et al. 1976).

Variations in the iron status of different populations are reflected in their serum ferritin concentrations at different ages. In epidemiological studies, the serum ferritin concentration has proven particularly useful as a method for detecting the mildest stage of iron deficiency, which is storage iron depletion (serum ferritin < 12 µg/L) (Bothwell et al. 1979). It is also a useful tool for detecting the presence of iron overload.

Serum ferritin values fall during iron deficiency before the characteristic change in serum iron and TIBC. Measurement of the serum ferritin concentration is reproducible and well correlated with iron stores in normal people. The most realistic tool to date in a non-clinical setting for assessment of the size of the storage pool is the measurement of serum or plasma ferritin concentrations. The concentration of serum ferritin reflects the size of the storage iron compartment if the subject is not also in an inflammatory state. Serum ferritin values usually fall in the range of 20-300 µg/l, with each µg/l representing 10 mg of storage iron (Cook and Skikne, 1982). Concentrations below 20 µg/l are specific for storage iron depletion but values above 300 µg/l do not necessarily indicate iron overload. Plasma ferritin concentration can increase dramatically with both acute and chronic inflammations (Bothwell et al. 1995), vitamin B12 deficiency, folic acid deficiency, liver disease, leukaemia, Hodgkin's Disease, alcohol intake (Leggett et al. 1990), and hyperthyroidism. It is important to note that a low concentration of serum ferritin is characteristic only of iron deficiency (Dallman et al. 1980).

Erythrocyte protoporphyrin

Protoporphyrin, a precursor of haem, normally occurs in erythrocytes in very low concentrations. In the second stage of iron deficiency, when iron stores are

completely exhausted, protoporphyrin accumulates in the developing erythrocytes because the supply of iron is not adequate for the synthesis of haem. It is possible to make a diagnosis of iron deficiency anaemia some time after iron therapy has commenced, as it takes some weeks for a significant proportion of the circulating RBCs to be replaced with new cells. The small sample size (about 20 µl of venous or skin-puncture blood), simplicity, rapidity and reproducibility within a laboratory are advantages and make it useful for paediatric haematological tests. Mean concentrations vary relatively little with age but are slightly higher for children aged 1-3 years than the mean for adults (Deinard et al. 1983; Yip, 1994). In the general clinical laboratory, however, it provides less information about iron storage levels in anaemic patients than the serum ferritin assay (Worwood, 1995). Erythrocyte protoporphyrin can be used to distinguish iron deficiency from thalassemia minor, but not to differentiate between the anaemia of iron deficiency and that associated with chronic inflammatory disorders.

Serum transferrin receptor

Immunoassay can detect the soluble transferrin receptors in the circulation, and appear to reflect the number of transferrin receptors on immature red cells and thus the level of bone marrow erythropoiesis (Cazzola and Beguin, 1992). In normal subjects the serum transferrin receptor level also provides a sensitive indicator of functional iron deficiency in subjects with absent iron stores but who have not yet developed iron deficiency anaemia (Skikne et al. 1990), or overload iron in the individual (Khumalo et al. 1998). The serum transferrin receptor level is not elevated in patients with acute infection, including hepatitis, in chronic liver disease and other patients with the anaemia of chronic diseases. The ability to distinguish the anaemia of chronic disease from iron deficiency anaemia makes the transferrin receptor assay a potentially valuable addition to haemoglobin and ferritin in clinical practice and in epidemiological surveys of iron status (Ferguson et al. 1992). The receptor/ferritin ratio is of particular value in assessing temporal changes in the iron status of the population and in measuring the impact of intervention programs to combat iron deficiency anaemia (Cook, 1995).

The haematologic values indicative of iron deficiency and cut-off values used by the Second National Health and Nutrition Examination Survey and the values recognised by the American Academy of Paediatrics are shown in Table 1-4.

Summary

Selection of the most appropriate combination of tests depends on the health and age of the individual (Gibson, 1990). Table 1-4 lists tests used in the diagnosis of iron deficiency. The use of several indices of iron status simultaneously provides a more accurate measure of iron status than any single index (Cook et al. 1976). The presence of two or more abnormal values for iron status indices is considered indicative of impaired iron status. In the NHANES II, Haemoglobin, MCV and ferritin were used to assess iron status and iron deficiency anaemia (Pilch and Senti, 1984). The investigation of anaemia begins with the blood count in order to distinguish between anaemia due to inadequate supply of iron, or vitamin B-12 or folate deficiency (Worwood, 1995). Serum ferritin is the most sensitive index of the early depletion of body stores (Pilch and Senti, 1984). None of the other indices distinguish between changes resulting from iron deficiency but it can be confounded by infection and inflammation. However, it can provide a definitive diagnosis of iron deficiency. Multivariate analysis been used and found effective to diagnosis iron deficiency anaemia and related diseases (Shiga et al. 1997).

HEALTH EDUCATION

Health education concerning suitable weaning diet aims to encourage the consumption of foods from which iron is easily available. Any recommendation concerning the composition of suitable weaning foods must be made against this background (Wharton, 1989). Childs et al. (1997) assessed the dietary education programme to reduce iron deficiency anaemia for 100 children in Birmingham. The study concluded that there was no reduction in anaemia using a targeted nutritional programme and has highlighted the difficulties in conducting health education programmes with the scope of current health resources. Effective public nutritional

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education programmes have been reported from the USA (Miller et al. 1985; Yip et al. 1987; Yip et al. 1987; Yip, 1990). Table 1-5 lists a number of factors which can reduce iron deficiency in infancy and childhood.

FORTIFICATION OF WEANING FOODS WITH IRON

The Committee on Nutrition of the American Academy of Paediatrics (AAP-CON) recommends the use of iron-fortified formula in infants who are not breast-fed (American Academy of Pediatrics: Committee on Nutrition, 1976b).

Infant formulas are referred to as iron-fortified when they provide 12 mg of elemental iron per litre at the standard dilution and are referred to as non-iron-fortified when they provide 1.5 mg of elemental iron per litre (American Academy of Pediatrics: Committee on Nutrition, 1976a).

It is generally agreed that infant formulas should be fortified with iron (American Academy of Pediatrics: Committee on Nutrition, 1976b; ESPGAN Committee on Nutrition, 1977). Iron fortified weaning foods have been recommended as an effective way of ensuring an adequate iron intake in infancy (Siimes and Salmenpera, 1989), although this view has been challenged (Fomon, 1987), since the iron used in fortifying cereals is often only poorly available. Most commercially produced baby cereals marketed in the UK and Saudi Arabia are fortified with iron, whereas some commercially produced meals or meal constituents are not. There are currently no national or European recommendations for iron fortification of foods designed for the weaning period or for young children. Iron-fortified formulas prevent anaemia in infants and are not associated with untoward gastrointestinal side effects (Anonymous, 1989). To be effective, a combination of an iron fortificant and food vehicle must be selected which is safe, acceptable to and consumed by the target population, does not adversely effect the organoleptic qualities and shelf-life of the food vehicle, and provides iron in a stable, highly bioavailable form (Gibson, 1997).

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Table 1-4. Common laboratory tests and cut-off values for the diagnosis of iron deficiency in children

Test	Age (year)	Cut-off Value	
Biochemical			
Serum iron	1-2	< 30 μg/dl (5.4 μmol/l)	
	3-5	< 30 μg/dl	
Total iron-binding capacity	1-3	> 480 μg/dl (86.0μmol/l)	
	3-5	>470 μg/dl (84.2μmol/l)	
Transferrin saturation	1-2	< 8%	
	3-5	< 9%	
Erythrocyte protoporphyrin	1-5	≥ 35 μg/dl of whole blood (0.62 μmol/l), ≥ 90 μg/dl of red cells (1.6 μmlo/l), ≥ 3.0 μg/g of haemoglobin, or ≥ 90 μmol/mol of haem	
Serum ferritin	1-5	8 to 12 μg/l	
Haematologic		**NHANES II**	**AAP**
Haemoglobin	1-2	<10.7 g/dl	<11.0 g/dl
	3-5	<10.9 g/dl	<11.0 g/dl
Haematocrit	1-2	<32%	<33%
	3-5	<32%	<34%
Mean corpuscular volume	1-2	< 67 μm³	<70 μm³
	3-5	<73 μm³	<73 μm³
Mean corpuscular haemoglobin	1-2	<22 pg	
	3-5	<25 pg	
Mean corpuscular haemoglobin concentration	1-2	<32 g/dl	
	3-5	<32 g/dl	
Red/cell distribution width*	1-5	<32 g/dl > 14.5 %	

•NHANES II denotes the Second National Health and Nutrition Examination Survey, and AAP the Committee on Nutrition of the American Academy of Paediatrics.

*Not included in the NHANES II or MP guidelines.

Table 1-5. A number of factors help reduce the risk of iron deficiency in infants and young children

- Maximize neonatal iron stores

- Encourage breast feeding

- Do not feed solids near the time of breast feeding

- Use an iron fortified formula in place of cow's milk

- Avoid excessive weight gain in infancy

- Include promoters of iron absorption

- Reduce inhibitors of iron absorption

(Fairweather-Tait, 1992)

IRON SUPPLEMENTS FOR INFANTS AND CHILDREN

Indeed, a lowering in the incidence of iron deficiency anaemia during infancy through the use of iron fortified formula and cereal is well documented (Miller et al. 1985; Vazquez-Seoane et al. 1985; Dallman, 1990). The addition of a supplemental food to the diet of the breast-fed infant impairs the bioavailability of the iron from human milk. Despite increasing availability of iron-fortified food, iron deficiency remains a common cause of anaemia in infants and children.

European formula manufacturers have largely changed to lower levels of iron fortification. The effectiveness of these lower levels still requires through verification. Bioavailability of dietary iron can be improved by including enhancers of iron absorption, such as foods rich in ascorbic acid and meat, and minimizing inhibitors, such as high-fibre foods rich in phytate and tea (Fairweather-Tait, 1992). A survey amongst a nationally representative group of UK infants showed that 82% were fed some commercial infant food, and that most mothers introduced cereal, rusks and commercial infant foods rather than family foods such as pureed vegetables and fruit (Mills and Tyler, 1990). The question of bioavailability is extremely important, and the iron must not be high enough to cause undesirable interactions with other minerals, e.g. copper and zinc (Haschke et al. 1986; Fairweather-Tait and Southon, 1989).

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The extent of non-prescribed iron supplementation in children has not been well documented. In the national study of pre-school children (Gregory et al. 1995), iron supplements provided 2% of the average daily intake, although these tended to be taken by children whose daily intake was already high. Table 1-6 summarised the iron compounds used to supplement infant foods

It is common clinical practice to give iron supplements in the UK when haemoglobin values fall below 10.5 g/dl. However, one group of children aged 17-19 months with haemoglobin values of 10.6-11.0 g/dl were treated for 2 months and increased their haemoglobin levels, indicating a degree of iron deficiency (Parks et al. 1989). Iron supplements have not been used routinely for the prevention of iron deficiency in Britain, although low dose supplements are used extensively in the United States for this purpose. The use of an iron fortified infant formula for the first year of life has been shown to be as effective in preventing iron deficiency as medicinal iron (Irigoyen et al. 1991). Supplementation of children aged 12 to 18 months who were not iron deficient has been associated with slower growth rates compared with a non-supplemented group (Idjradinata et al. 1994). Some studies suggested that developing crops that are more iron bioavailable (Yip, 1997), or enhancement of natural seed ferritin content by biotechnology and breeding has the potential for a sustainable solution to the problem of global dietary iron deficiency (Theil et al. 1997). The ultimate success in control of iron deficiency will depend on how well the various intervention approaches can be integrated within the current framework of public health, food processing, and agriculture development (Yip, 1997).

Table 1-6. Iron compounds used to supplement infant foods

Good bioavailability	*Poor bioavailability*
Ferrous citrate	Ferric citrate
Ferrous gluconate	Ferric EDTA
Ferrous succinate	Ferric orthophosphate
Ferrous EDTA	Sodium iron pyrophosphate
Ferric ammonium citrate	Elemental iron (large particle size)
Ferrous fumarate	
Ferrous lactate	
Ferrous sulphate	
Elemental iron (small particle size)	

(Fairweather-Tait, 1992)

METHODS FOR DIETARY DATA COLLECTION

There are two main categories of methods used to assess food intake;

I- Category one, which collects data recorded at the time of eating.

    A- Weighed records: either normal weighed record or Precise weight method

    B- Estimated records

II- Category two, which collects data about diet eaten in the immediate, recent or distant past.

    A- Diet history

    B- 24- hour recall

    C- Food frequency questionnaire, this includes the semi-quantitative Food Frequency Questionnaires (Bingham et al. 1988).

CATEGORY ONE:

Weighed records

The weighed food record is considered to be the most accurate dietary assessment method to use for free living individuals (Marr, 1971), but it needs to be used with care. The subject is taught to weigh and record the food and its weight immediately before eating and to weigh any leftovers. Details of recipes are necessary and a data bank of average recipes used in a particular locality greatly simplifies the procedure (Wiles et al. 1980). The subject is given a set of equipment, accurate to at least ± 5 g and which can weigh up to 1.5 kg so that a normal plate can be used to contain the food to be eaten, also clear, simple instructions on how to use the scales and weighing the food and recording sheets (Marr, 1965). The subject records the weight of the plate, then plate weight plus the first food item, followed by the plate weight plus the first and second food item, and so on. On the final visit immediately after the subject has completed the survey, the record should be checked in detail and the subject thanked.

To improve accuracy of the weighed record, study design must randomise the study days, and include a mix of week and weekend days. The number of days of recording necessary depends upon the nutrients to be studied and the degree of precision required (Bingham, 1987; Bingham et al. 1988).

Regression analysis showed that records from the first two days of record keeping were more valid for assessing group comparisons than those from the last three days, because of deterioration in accuracy of recording (Gibson, 1994). Crawford et. al. 1994 found the 3-day food record has advantage over 24-hour recall and 5-day food frequency validated by observation of 9 and 10 year-old girls (Crawford et al. 1994). In another study, the investigators found even a 2-day record may equal or be better than estimated food diary (Karvetti and Knuts, 1992).

Precise weight method:

This method can be used when the food composition tables with values for cooked foods are not available. Raw ingredients, the cooked food, meal, or snacks, plus the individual portions must all be weighed (Pekkarinen, 1970), and leftovers are also recorded, and chemical analysis may also be necessary. This method is time consuming and requires a high degree of co-operation from the subject.

Estimated records

Estimated records are particularly well suited for collecting cross-sectional data and for large epidemiological studies as it doesn't require expensive equipment and a higher degree of co-operation from subjects may be achieved (Marr, 1971; Bingham, 1987). In the estimated food records, the subjects are taught to keep records, in portion sizes by using the household measures i.e. spoons, cups or bottles, of all the foods they eat on each day of the study. These measurement tools should be known by the investigator in order to converts their amount to volumes or weights (Bingham et al. 1988). In an open form subject are asked to describe all foods eaten each day by using either the measures provided by the investigator, which preferable in terms of accuracy, or their own household utensils. He/she should also indicate the number of

items of each food eaten each day, A pre-coded record form listing all of the commonly eaten foods in units of specified portion sizes is arranged in groups each of which has a similar nutrient composition (Kooistra et al. 1998).

CATEGORY TWO:

Diet History

A diet history provides a record of a person's food and beverage intake. The respondent orally reports all foods and beverages consumed on a usual day, then the interview progresses to questions about the frequency and amount of consumption of these foods; often, the respondent provides additional documentation of several days' intakes in the form of food diaries; food models, cross-checks on food consumption. The accurate recording of such data requires skill (Whitney et al. 1991a). The method of cooking and use of additives is important.

Trained dietitians often use food models or photos and measuring devices to help clients identify the types of foods and quantities consumed. This method is only infrequently used today because in takes so long, and the accurate recording of such data requires a trained, highly skilled dietitian (Jain, 1989). Other disadvantages are that it depends on the subjects' memory and is time consuming. The origins and form of the diet history have been described (Bingham, 1987). Burke et al. developed the dietary history technique called Burke-type which includes an interview, then a cross-check using a detailed list of foods to verify the eating pattern, and finally, the subject records his/her food intake at home (Lawson, 1995). This developed type produces a more complete and detailed description of both qualitative and quantitative aspects of food intake than do food records, 24-hour recall, or food frequency questionnaires (Heymsfield et al. 1994). Another advantage is that it eliminates individual day-to-day variations. This method been used to assess the food intake for of Indo-Asian children, in Sheffield, aged 4-40 months (Harbottle and Duggan, 1993).

24- Hour Recall:

The 24-hour recall provides data for one day only and is commonly used in nutrition surveys to obtain estimates of the typical food intakes of large numbers of people in given populations. The subject is asked to recount everything eaten or drunk in the past 24 hours or for the previous day. Food models, measuring cups and spoons, and other tools are used to help the client to get a rough estimate of portion sizes (Van Horn et al. 1993). It can be done face-face or by telephone. It does not provide enough accurate information to allow generalisations about an individual's usual intake and it cannot identify with precision those individuals whose intakes are likely to be high or low in the population. This includes the accurate recall of food eaten and also the translation of portion sizes into weight. This limitation can be partially overcome when recalls are collected on several non-consecutive days (Morgan et al. 1987). In comparison to longer observation periods, distributions of nutrient intake obtained from single 24-hour recalls are more spread out, with more very high and very low values (Anderson, 1986; Food and Nutrition Board, 1986).

An advantage of the 24-hour recall is that it is easy to obtain, quick, and inexpensive. The precision of reproducibility of group means may by improved by repeating the recalls and increased sample size. To make it more accurate in children's studies it can be assisted by food records (Lytle et al. 1993; Nicklas et al. 1997; Sabate, 1997).

Food Frequency Questionnaire: (FFQ)

Food Frequency Questionnaires (FFQs) are the most frequently used instruments for assessing dietary intake (Teufel, 1997; Thompson et al. 1997). This method is good for describing groups but has serious limitations for making statements about the absolute magnitude of the nutrient intakes of individuals (Bingham et al. 1988; Cameron and van Staveren, 1988).

The use of FFQ would greatly simplify epidemiological studies, including nutritional surveys of children by allowing parental compilation of questionnaires and optical scanning (Bellu et al. 1996). The respondent records or describes usual

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intakes from a list of different foods and the frequency of consumption per day, week, or month, over a period of several months or a year; the number and type of food items vary, depending on the purpose of the assessment (Block et al. 1985). It also may used for a specific food, for a specific disease as coronary heart disease for example (Hammond et al. 1993). FFQ may be either self- administered or interviewer- administered: response rates may be lower or incomplete when self-administered compared with the interviewer- administered (Hendricks and Senekal, 1996). This method is inexpensive, quick to administer, can be used for large population studies and can be analysed rapidly for nutrients or food groups using a computer.

Designing the food list should take into consideration the culture of the subject, and the different varieties of food for different ethnic groups (Teufel, 1997).

Semi-quantitative Food Frequency Questionnaires:

This is similar to a food frequency questionnaire; portion sizes are specified as standardised portion size or there is choice of a range of sizes; foods are chosen to encompass the most frequently consumed foods as well as the most common sources of nutrients; the major sources of nutrients for a given population should be included for questionnaire to be valid (Milner et al. 1979; Briefel, 1994; Briefel et al. 1997). This method has recently become a very popular dietary survey method in epidemiological studies (Liu, 1994), and it can be used to compare mean intakes among different populations (Block and Subar, 1992; Coates and Monteilh, 1997).

The population-based questionnaires are food tools for providing estimates of the nutrient intakes of groups. However, they also provide quantitative estimates of dietary intakes of individuals. The basic problem that makes this procedure invalid is that the nutrient values for each food category on the questionnaire are derived from weighted averages or medians (based on group estimates) for each food of frequency x portion size x number of servings per occasion for each food in the category among the population used for validating it. Thus nutrient intakes for each food category are derived from weighed group estimates and reflect population, not individual's values.

COMBINATIONS OF METHODS

Often dietary assessment studies for research purposes employ several methods simultaneously to increase accuracy. Single food frequency, semi-quantitative food frequency, and dietary history questionnaires are sometimes employed to minimise intra-individual variation because they purport to report typical or usual intakes (Hendricks and Senekal, 1996).

REPRESENTATIVENESS, VALIDITY, RELIABILITY

Dietary assessment methods differ in the ease with which representative samples can be obtained as well as in their validity and reliability and thus in the uses to which they should be put (Cameron and van Staveren, 1988; Kalver et al. 1988). Representativeness of the study population, the period under study, and the heterogeneity of food habits in the population are important considerations to take into account in drawing samples for study.

Validity describes the degree to which a dietary method measures what it purports to measure (Kalver et al. 1988). It is difficult to assess the absolute validity of dietary methods because diet is constantly changing and the very act of observing often alters intakes.

The most common validation technique used is concurrent validity; evaluation of the test dietary method against a "gold standard" reference method that is thought to be particularly accurate and precise (Block, 1982; Lee-Han et al. 1989). Some underestimation of concurrent validity with records and recalls often occurs because of the use of small and possibly unrepresentative number of days, whereas there may be an overestimation with dietary histories and other such instruments (Potosky et al. 1990).

The major sources of error that affect validity are random response errors and bias (systematic errors), which in turn is due to either systematic errors in response or otherwise imperfect information. Therefore it is important to get estimates of validity so that suitable corrections in analysis can be made to account for errors (Block et al. 1990).

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Weighed records:

Attempts to validate directly the seven-day weighed records have been made by comparing noon meals from each record with actual intakes, weighed surreptitiously during lunch at a congregate meal site (Gersovitz et al. 1978). The weighed record underestimated the actual food intake, but differences were only significant for energy and thiamin. The daily energy and nutrient intakes calculated from the one-year food records were significantly higher than those calculated from the records made during collection of the duplicate diets (Kim et al. 1984). As the energy intake may decrease as much as 20%, hence duplicate diets are not an ideal method for validating food record methods (Stockley, 1985). There is doubt that weighed intake is the most accurate method to assess food intake and so weighed intakes are one of the two methods used for assessment of intake in this study.

Dietary history:

This method produces higher estimates of groups mean intakes than the seven-days weighed record. In cases where a shorter time frame for the dietary history has been used, smaller differences in mean intakes have been reported (Trulson and McCann, 1959), but with longer term information, the validity is reduced (Byers et al. 1983). The validity of this method depends both on the subject's ability to give correct information on frequencies and an ability to estimate portion sizes correctly. Energy was underestimated in a study of fifteen obese patients studied (Bray, 1978). There were no significant differences between weighed inventory and diet history in assessing fat, iron and vitamin c intake in young children (Duggan et al. 1992), while energy and protein intake have some significant differences.

24 hour recall

The twenty-four-hour recall tends to underestimate mean intakes in children (Carter et al. 1981), but several studies reported acceptable group means. These contradictory results may be due to differences in the study design, the way that quantities been

estimated, how the results have been expressed, and differences in population groups within the same community. In some cases, the average results differed by as much as 30% (Gibson, 1990). Average recalls of vitamin A, thiamin, riboflavin, niacin, vitamin C, and iron were significantly less than actual intake, but no significant differences were found between actual intakes and the mean recalled intakes of energy, protein, calcium, and zinc for adolescent girls (Greger and Etnyre, 1978). Food intake of 17 children was measured for three days using 24 hour recall and Food Frequency Questionnaire. The investigators didn't find any significant differences between the two methods (Iannotti et al. 1994), but others found some differences in some nutrients by using the same methods (Treiber et al. 1990).

Food frequency questionnaires:

Despite the increasing use of food frequency questionnaire methods, there are limited studies on their validity. Comparison of this method with actual food consumption for twenty eight consecutive days indicated that a large proportion of individuals could accurately estimate their food intake using the food frequency questionnaire (Mullen et al. 1984). Using FFQ including quantities of the food to assess the prevalence of iron deficiency and its relation to food intake for children aged 12-24 years living in London showed that FFQ is good tool for children's food intake (Nelson et al. 1993). In another study by Hirving and Lawson (1994), a FFQ has been developed and used in conjunction with an on-going blood screening programme for children aged 12-14 months in London. The mean correlation between actual weight intake and FFQ was greater than that been found by Mullen et al. (1984) and Gelissen and Roberts (1992) and they concluded that the FFQ can be used to predict food consumption frequency in children aged 12-14 months, and for older children too (Frank et al. 1992; Rockett et al. 1995), or for children at risk (Hammond et al. 1993). Comparing intakes of eight nutrients computed from a food frequency questionnaire and from 3-day food diaries with known values, Kral and Dwyer (1987) found that all nutrients including iron were underestimated by FFQ, but the validity depends on the questionnaire format and mode of administration. While some research suggested that the FFQs provide enough accuracy (Rockett and Colditz, 1997), other studies found they do

not provide an accurate assessment of measured intake (Iannotti et al. 1994). No differences were found between FFQ and 24-hour recall for school children (Bellu et al. 1995; Bellu et al. 1996). In general FFQ is a very good tool to record food intake for all ages. When it combined with recording quantities of food (portion sizes) this increases the accuracy of this method. According to the above studies using FFQ, especially with children, the usefulness of recording the frequency of eating a food and then compare it with the actual food intake, make the semi-quantitative food frequency questionnaire a good option for use in this study. Dietary assessment in young children may affected by special problems such as vomiting and amount of wasted food during eating.

ERRORS IN DIETARY DATA

Dietary intake cannot be estimated without error (and never will be). Collection and analyses of dietary data is essential if we are to pursue questions about the relationships between food use and health. There are no perfect dietary methods but there are preferred ones (Beaton, 1994).

The reliability of calculation of specific nutrient intakes depends not only on the accuracy of food-consumption estimates but also on the food consumption data on which these estimates are based. Beaton et al. 1997 expressed that their researches are going ahead in understanding better insights into the nature of error in dietary data and gradually developing statistical methods to take this error into account.

Not all parents can be accurate enough (Eck et al. 1989), and methods that are brief enough to be acceptable to many subjects may not be comprehensive enough to yield reliable information. Some methods may be highly reactive, for example, subjects may change their habits when they are recording intake, or when they are aware of being observed (Baranowski and Domel, 1994).

FOOD DATA SYSTEMS

The first and the most important source for food data is McCance and Widdowson's "The Composition of Food" which was published for the first time in

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1940 (McCance and Widdowson. 1940). Now we have the fifth edition (Nelson et al. 1997). The first edition was mostly complied from a number of previous studies of the composition of foods in the 1933 by McCance and Shipp notably on meat and fish, then in 1936 by McCance, Widdowson and Shackleton for vegetables, fruits and nuts.

The Food and Agriculture Organisation (FAO) published the first table for food analysis in 1961. Subsequently, FAO published tables for Africa in 1968, and for the Middle East in 1970 then for Asia in 1972. Out of the conference organised in Italy in 1983 came the design and scope of the International Network of Food Data Systems (INFOODS) (Scrimshaw, 1997). The main recommendation of this conference is to established an international system of food composition.

In an attempt to improve dietary intake assessment and monitoring methodology, a state-of-the-art device to gather dietary intake information was designed and developed at the Western Human Nutrition Research Center (Kretsch, 1989). The Nutrition Evaluation Scale System (NESSy) device was developed to increase the accuracy of dietary processing time,. This device decreased the time required to weigh and record food intake by people with out high educational level (11-16 years of education) to 1.73 minutes compared with 8.4 minutes when this group used weighed food records (Fong and Kretsch, 1990). Many computerised nutrient databases exist, and in the light of the potential problems, the comparability of systems has been examined in several studies. Some showed good agreement (Hoover, 1983), others have reported significant differences between systems (Eck et al. 1988).

Now there are many software packages built on one or more food tables. Some of them have been used for assessment of iron intake (Daly et al. 1996). These packages have differences between them in many aspects depending on their targets, ease in handling and facilities available. Unfortunately no software has been built specifically for children's nutrition, which is important as they have special requirements for food.

COMP-EAT was selected for this study as it had been used before for research in children and many were using this software and had found it helpful. COMP-EAT version 5 (Nutrition Systems, 1997) food tables are compiled from food composition data prepared by the Royal Society of Chemistry / Crown copyright material from the

Nutrient Databank and The Composition of Food 4th Edition (1978), and 13 supplements. Five supplements to the fourth Edition (Nissenson, 1997; Chai et al. 1997; Bhandari et al. 1997; Nair et al. 1997; Pokorny, 1997), and six supplements to The Composition of Food 5th Edition (1991) (Morgan, 1980; Worwood, 1995; Fairweather-Tait, 1995a; Fairweather-Tait, 1995b; Baumeister et al. 1997; Cummins and Thompson, 1997) are been coded. Food Labelling Data from Manufacturers (Frongillo and Habicht, 1997) and Food Portion Sizes (Buss, 1995) have also been used. However this system is time consuming and takes more than one hour for inputting data. In addition to this it is not flexible in terms of saving and handling the data. The latest version COMP-EAT 5, contained many new aspects over version 4 but still has many disadvantages. Using statistical analysis software e.g. Excel or SPSS can overcome some of its disadvantages.

CHAPTER

NUTRITIONAL REQUIREMENTS FOR 1-3 YEAR OLD CHILDREN

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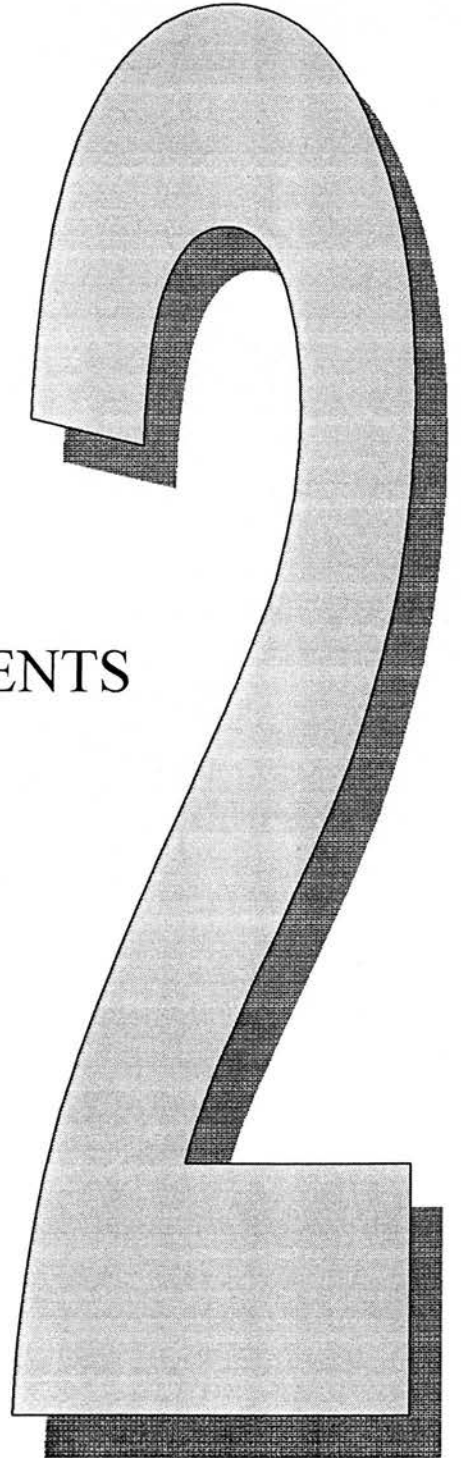
NUTRITIONAL REQUIREMENTS FOR 1-3 YEAR OLD CHILDREN

The nutritional requirements of infants and children reflect the unique needs of this population to support growth and developmental changes in organ function and body composition as well as for their maintenance needs. The infant grows faster during the first year than ever again, the metabolic rate is greater and the turnover of nutrients more rapid than in the adult. The growth of infants and children directly reflects their nutritional well-being and is an important parameter in assessing their nutrition status.

Weaning and the weaning diet report defined three types of requirements:

1- Estimated Average Requirement (EAR): The estimate of the average dietary requirement for food energy or a nutrient.

2- Reference Nutrient Intake (RNI): The amount of a nutrient that is enough for almost every individual, even someone who has high needs for the nutrient in the distribution of individual requirements.

3- Lower Reference Nutrient Intake (LRNI): The amount of a nutrient that is enough for only the small number of people who have the lowest needs.

ENERGY

Table 2-1 summarizes Estimated Average Requirements (EAR) for energy for normal infants and children until 3 years of age (Department of Health, 1991).

Table 2-1 Estimated Average Requirements (EARs) for Energy

Age in months	males		females	
	MJ/d	Kcal/d	MJ/d	Kcal/d
0-3	2.28	545	2.16	515
4-6	2.89	690	2.69	645
7-9	3.44	825	3.20	765
10-12	3.85	920	3.61	865
13-36	5.15	1,230	4.86	1,165

Although energy requirements of young children are vary from child to another, they are three or four times greater per unit body weight than the adult's requirements, These high needs of energy reflects both the infants' relatively high resting metabolic rate and the special needs for growth and development.

More recently it has been suggested that the requirements for both energy and protein are lower than the Department of Health recommendations (1994) (Clugston et al. 1996; Butte et al. 1996; Dewey et al. 1996; Torun et al. 1996).

PROTEIN

The protein requirement of the normal infant per unit of body weight also is greater than that of the adult and the young child requires a higher proportion of essential amino acids than the adult. This high requirement is because of the significant high growth, and is needed to achieved a positive nitrogen balance. The required intake of a specific protein is a function of its quality or how closely its amino acid pattern resembles that of human milk (Heird, 1994).

Whereas the amino acid composition of human milk is ideal, its overall protein content, approximately 1.0 g/dl, is such that ingestion of 189 to 200 ml/kg per day is required to ensure a protein intake equal to the recommended daily intake of 2.0 to 2.2 g/kg. A 1-3 year old requires 14.5 g of protein daily and this can be easily supplied by a child taking as little as 300 ml milk and eating 1 oz meat or fish or 1 egg daily.

FAT

Although fats should be consumed in moderation and aim to provide approximately 35% of the total energy intake of young children, fats are also an essential source of fat soluble vitamins and essential fatty acids.

CARBOHYDRATE

50-55% of total energy should be provided by carbohydrate. Useful sources include bread, potatoes, breakfast cereals. Sugar containing foods which predispose to caries should be limited (Department of Health 1994).

MINERALS AND VITAMINS

Requirements of minerals and vitamins are not as well defined as those for energy and protein. Nonetheless, Dietary Reference Values (DRVs) for most have been established. Tables 2-2 and 2-3 summarise requirements for minerals and vitamins (Department of Health, 1991). Breast milk is low in sodium, which goes with the concept that limitation of sodium intake may decrease the incidence of hypertension later in life. Iron in breast milk is highly absorbable and zinc is also. If protein intake is adequate, vitamin deficiencies are rare.

Table 2-4 shows the DRVs for iron at different ages, a topic that is covered elsewhere (Department of Health, 1991).

IRON STORES DURING THE FIRST 12 MONTHS

Dallman (1986) described three stages of postnatal iron metabolism; the immediate postnatal period which has high level of haemoglobin, the second stage of iron metabolism which takes place from 2 to 4 months of age, when erythropoiesis increases, and the third stage which takes place at 12 months of age. Haemoglobin concentrations change less than in the first 2 months, although there is an increase in total haemoglobin because of the increasing size of the infant (Aggett et al. 1989). Storage iron deposited in the liver during the earlier stage begins to decrease and by the age of 4 months the liver contains approximately 30 mg iron compared with 60 mg at birth; this is reflected in a decrease in serum ferritin levels. The total body iron shows little change from birth to 4 months of age and is about 250 mg.

After the 4th month of life, increasing body size begins to deplete body iron concentrations and the infant becomes increasingly dependent on exogenous sources

of iron. In a normal infant, total body iron increases from 250 mg at 4 months to about 420 mg at 12 months. Liver iron stores are depleted by the age of 6 months unless there is an adequate source of dietary iron.

WATER

The normal infant's absolute requirement from water is about 75 to 100 ml/kg per day. However, because of higher obligate renal, pulmonary, and dermal water losses as well as a higher overall metabolic rate, the infant is more susceptible to development of dehydration, particularly with vomiting and/or diarrhoea. 150 ml/kg per day is recommended and this amount can be provided by typical breast or formula infant feeding.

Table 2-2. References Nutrient Intakes for Minerals

Age in months	Ca (mg/d)	P (mg/d)	Mg (mg/d)	Na (mg/d)	K (mg/d)	Cl (mg/d)	Fe (mg/d)	Zn (mg/d)	Cu (mg/d)	Se (μg/d)	I (μgd)
0-3	525	400	55	210	800	320	1.7	4.0	0.2	10	50
4-6	525	400	60	280	850	400	4.3	4.0	0.3	13	60
7-9	525	400	75	320	700	500	7.8	5.0	0.3	10	60
10-12	525	400	80	350	700	500	7.8	5.0	0.3	10	60
13-36	350	270	85	500	800	800	6.9	5.0	0.4	15	70

Source: (Department of Health, 1991)

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Table 2-3. Reference Nutrient Intakes for Vitamins

Age in months	Thiamin	Riboflavin	Niacin (nicotinic acid eq)	Vitamin B6	Vitamin B 12	Folate	Vitamin C	Vitamin A	Vitamin D
	mg/d	mg/d	mg/d	mg/dl	µg/d	µg/d	mg/d	µg/d	µg/d
0~3	0.2	0.4	3	0.2	0.3	50	25	350	8.5
4-6	0.2	0.4	3	0.2	0.3	50	25	350	8.5
7-9	0.2	0.4	4	0.3	0.4	50	25	350	7
10-12	0.3	0.4	5	0.4	0.4	50	25	350	7
13-36	0.5	0.6	8	0.7	0.5	70	30	400	7

Source: (Department of Health, 1991)

Table 2-4 Dietary Reference Values for Iron

Age in months	Lower Reference Nutrient Intake		Estimated Average Requirement		Reference Nutrient Intake	
	mg/d	µmol/d	mg/d	µmol/d	mg/d	µmol/d
0-3	0.9	15	1.3	20	1.7	30
4-6	2.3	40	3.3	60	4.3	80
7-9	4.2	75	6.0	110	7.8	140
10-12	4.2	75	6.0	110	7.8	140
13-36	3.7	65	5.3	95	6.9	120

*1 µmol = 55.9 µg

Source: (Department of Health, 1991)

INFANTS 6-12 MONTHS OLD

By 6 months of age, the infants' previously compromised capacity to digest and absorb a variety of dietary components as well as to metabolise, utilise and excrete the absorbed products of digestion is near the capacity of the adult (Montgomery, 1991). Energy requirement will increase within the period between 6-12 months of age (Whitehead and Paul, 1991). Magnesium, sodium, chloride, copper and iron requirements will also increase during this period , while calcium, phosphorus and iodine will be that same and potassium and zinc requirements will decrease.

Weaning diet should usually be started by about 4 months of age (Department of Health, 1994), and such a pattern is common in the UK (Foster et al. 1997). Foods properly prepared in the home, are often encouraged as suitable weaning foods and it is only recently that the nutritional composition of home prepared weaning foods has been studied (Morgan, 1998).

During the 4-6 month period, the child should be given iron fortified rice cereal, followed by other cereals. When the child became 5-7 months of old, strained vegetables and fruits can be introduced. After that protein rich foods i.e. cheese, yoghurt, cooked beans, meat, fish, chicken and egg yolk can be taken by the child. Whole egg and chopped meat when the child can chew can be introduced after 9

months of age. Whole milk should not given before the first year of life (Department of Health, 1994). Thus at the end of this period a childs' organs have developed so the he/she can eat from the normal family food apart from cows' milk "as the main milk for drinking" (Whitney et al. 1991b). This change should not be made while the child is 12 months of age (Department of Health, 1994). Vitamin requirement also changed during this period, thiamin, niacin, vitamins B6 and B12 will increase while vitamin D requirement will decreases, and requirements for the rest of the vitamins will not change.

CHILDREN 1-3 YEARS OLD

The 1 year-old child has several teeth and the various digestive and metabolic system are functioning at adult or near-adult capacity (Heird, 1994). Most children tolerate table foods either as presented to other family members or cooked specially for them. Their activity also increases dramatically, so their energy needs increases, as well as that for some nutrients such as sodium, potassium, chloride, copper, selenium and iodine, the same requirements for calcium, phosphorus and iron decrease. All vitamin needs increase during this period. Four portions of milk and milk products (½-¾ c), 2 portions of meat and meat products (1-2 oz), 4 portions of fruits and vegetables and 4 portions of bread and cereals (½ slice) should given to the child after the first year of life until 3 years of age according to Whitny et al. (1991a).

CHAPTER

NUTRITIONAL STUDIES
IN SAUDI CHILDREN
WITH REFERENCE TO
IRON DEFICIENCY ANAEMIA

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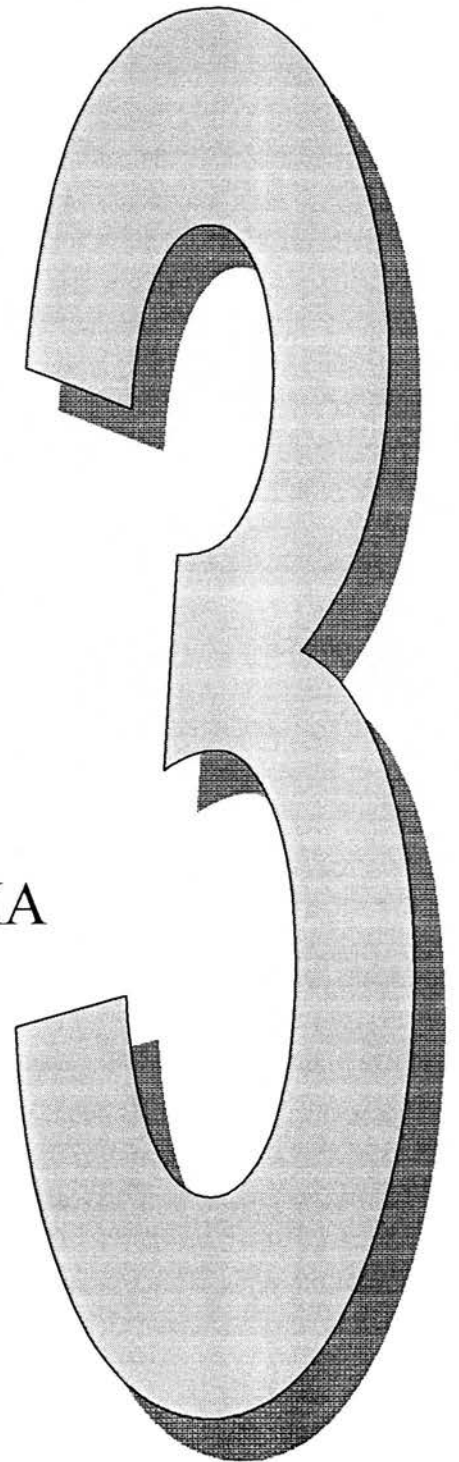
NUTRITIONAL STUDIES IN SAUDI CHILDREN WITH REFERENCE TO IRON DEFICIENCY ANAEMIA

SAUDI FOOD HABITS

There are only few studies available on the food habits of Saudies despite the vast area of the Kingdom. King Abdulaziz City of Science and Technology (KACST) report on evaluation of the nutritional status of the people of Saudi Arabia (Al-Nozha et al. 1997) is the first national survey in this field. The oldest survey was carried out in 1967 among three communities (settled, semisettled and nomadic) living in Turaba in the western province of Saudi Arabia, and it was reported that families in the settled area consumed more meat, vegetables, fruits and milk than families in the other two communities who lived mostly on bread, rice and dates with little variation (Sebai, 1985).

Sebai (1985) has conducted a follow-up to a study in 1981. He found that rice and bread were the staple diet in 1981, but the average family purchased lamb and beef more than previously. In this follow-up study, it has been observed that eggs and vegetables although available, were seldom consumed as their nutritional values were not recognised. In addition to rice and bread, milk came next in frequency in a survey carried out in 1977/78 in Barza (western zone). Chicken was frequently consumed, but other meats were not quite as common. Vegetables and fruits were consumed by less than half of the families. Dates were commonly consumed in season (Hammam et al. 1980).

NUTRIENT INTAKE

A dietary survey on infant and pre-school children in Saudi Arabia has reported that calcium and phosphorus were more than adequate for young babies, while protein and vitamin C were adequate compared with RDA. The most deficient nutrient was iron (Sawaya et al. 1985). A similar finding was found in another study (Sawaya et al. 1987a). In a study (based on 24-hour dietary recall) carried out on 767 infants and

children living in different regions in Saudi Arabia, the mean daily intakes of protein, calcium, vitamin A, thiamin, riboflavin and vitamin C were higher than the RDA, but the daily intake of calories and iron were found to be much lower than the recommended allowances. Available data indicates that the Saudi daily intake of vitamin D is much less than the RDA (Elidrissy, 1986).

In another study on 849 infants and pre-school children in different locations in Saudi Arabia, using 24-hour dietary recall, intake of protein, calcium, phosphorus, vitamin A, riboflavin and vitamin C were adequate, ranging between 80 and 190% of the US Recommended Dietary Allowances (RDA) for almost all age groups, but the energy, iron and niacin intake were grossly deficient in almost all of the children. Iron intake was lowest (14.3% of RDA) at age one year or less and 64.1% of RDA at 4 years old children (Al-Othaimeen et al. 1988a). In a pre-school children study, protein, carbohydrate, iron and vitamin C intakes were lower in anaemic children compared with non-anaemic (Al-Abdulkarim, 1996).

There are no significant differences between the lactating mother's diet and her diet previously (Al-Nozha et al. 1997). There was also no effect of mother's age or number of parity on milk content of Mg, Na, Fe, Cu, and Zn (El-Fawaz, 1995; Al-Othman et al. 1996a; Al-Othman et al. 1996b).

BREAST-FEEDING PATTERNS

Breast-feeding of infants in Arab countries has probably followed the tenets of the Qura'an with the directive to breast feed for 2 years (Patwardhan and Darby, 1972). This verse from Qura'an described that it is obligatory for a mother to suckle her child for a sufficient period *"The mothers shall give suck to their children for two whole years, (that is) for those (Parents) who desire to complete the term of suckling, but the father of the child shall bear the cost of the mother's food and clothing on reasonable basis"* (1: 233). *"And We have enjoined on man to be dutiful and kind to his parents. His mother bears him with hardship and she brings him forth with hardship, and the bearing of him, and the weaning of him is thirty months"* (46:15). Thus the six months the fetus is inside the uterus (minimum) and the 24 months during which the infant is breastfed (Kocturk, 1989).

In the 1967 study (Sebai, 1985), it was observed that breast-feeding was the predominant method of feeding infants and children up to 2 years of age in the three communities surveyed. Of children under 2 years of age in the settled community, 32% were given powdered milk, while among the semi-settled and nomadic communities the percentages were 9% and 4% respectively.

It was reported that breast-feeding for more than a year was the rule in most villages and rural areas in the Kingdom (Serenius and Fougerouse, 1981; El-Sayed, 1985; Sawaya et al. 1987b).

In a study carried out in Riyadh in 1978/79 it was reported that 72% of infants were initially exclusively breast-fed. The figure dropped to 42% at 3 months to 11% at 12 months (Lawson, 1981). Similar observations were found in later studies carried out in Riyadh, firstly on 6623 randomly selected Saudi families by Al-Frayh et al. (1988) who considered family income levels as a socio-demographic characteristic of the sample, and secondly in 1981 on 150 Saudi mothers who were in hospital (Haque, 1983). 40.5% of mothers continued breast-feeding for more than 12 months, 19.5% continued up to 18-24 months of age (Al-Nozha et al. 1997). In a further study the majority of mothers, 90%, breastfed their babies initially although a great number of them introduced bottle feeding early (Al-Skait, 1988).

A prospective study in rural areas of the Riyadh region indicate a smaller percentage of women breast feeding their infants (36.4%) out of the total (unsupplemented breast feeding) sample number of 4960 infants (Al-Nahedh and Morley, 1994), than that found by the National Child Health Survey (90%) (includes those who have ever breast fed) by Al-Mazrou and Farid (1991).

Al-Shehri et al. (1995) found the mean duration of breast-feeding among children in urban and rural communities were 11 and 13 months, respectively. This study also showed that the percentage of breast-feeding at the end of the first month was 93 per cent, but it declined to 78 and 45 per cent at the end of the sixth months and the first year respectively.

Powdered milk was introduced to 71% of the infants below 3 months of age in the urban areas, compared to 65% in rural areas of Saudi Arabia. Moreover, solid

foods were introduced to 78% of the infants at the age 3-6 months in urban areas, compared to 76% in rural areas (Al-Shehri et al. 1995).

KACST's report on evaluation of the nutritional status of the people of Saudi Arabia has reported that breast-feeding was practised by 63% lactating mothers, while 16.4% mix-feed their children. Only 7.2% of the children were exclusively artificially fed and 11% were breast feeding then used artificial feeding. 70% did not answer the question about the reason for starting infant formulas, but 14% indicated that it was the child's refusal and 12% because there was not enough milk to breast-fed the child (Al-Nozha et al. 1997). Despite the promotion of breast-feeding programmes, the availability of a wide variety of infant formulas (Al-Frayh, 1986) and other baby foods on the market with a reasonable prices is one of the factors which influences the mothers to stop breast-feeding, despite the fact that not all of these formulas have high quality (Al-Othman et al. 1997). The main reason for discontinuing breast-feeding in some Gulf countries was a new pregnancy; 40% in both Saudi Arabia and UAE and 22% in Bahrain (Amine, 1980a; Musaiger, 1987).

In PDR Yemen, 9% of the newborn infants were not given breast-milk until the second day of life. It was more common among the urban population than among the slum and rural people to postpone breast-feeding (Bagenholm et al. 1987a). The median duration of breast-feeding was 6.5, 10, and 14 months among urban, slum, and rural mothers, respectively. The prevalence of exclusive breast-feeding of infants below 3 months of age was significantly higher in the rural setting compared to both urban and slums areas (Bagenholm et al. 1987a).

There is no doubt that exclusive breast feeding beyond 6 months of age is associated with an increased risk of developing iron deficiency (Siimes et al. 1984; Michaelsen et al. 1995).

WEANING PRACTICES IN SAUDI ARABIA

The common definition of weaning among mothers and even many health professional is stopping breast or bottle feeding, not introducing solid foods. Saudi mothers were late in introducing solid food, 30.2% started giving solid food at one year and 36.6% were started after the first year of life (Al-Nozha et al. 1997), and 15 months in Qatif

(the eastern province) (Sawaya et al. 1985). The results of earlier studies on food habits and practices involving families of Armed Forces personnel, indicated that many infants and young children at Riyadh Military Hospital were suffering from malnutrition as a primary or secondary disorder (Lawson, 1981). Solids were gradually introduced as early as three months. By nine months of age, 97% of the children were receiving solid foods as supplement to milk formula (Haque, 1983).

Many infants were given supplementary foods at a late age and most of the mothers did not have any idea about the right age for weaning or the proper foods for weaning. It was observed that this late and inadequate supplementation is a common problem in developing countries and is a major cause of malnutrition (Chowdury, 1989).

One-third of the children (33.5%) were either weaned or supplementary foods were introduced before they were six months of age while nearly 51% were weaned between 6 and 18 months of age. Only 5% of the children were weaned after 18 months of age (Al-Othaimeen et al. 1988a; Al-Othaimeen and Villanueva, 1988b).

Available studies show that supplementary feeding often starts at the age of 4-6 months (Almokhalalati, 1989) and 3-5 months (Al-Frayh et al. 1988). There was no marked relationship between maternal age and pattern of feeding but the more educated the mother was, the shorter the breast feeding period became (Al-Frayh et al. 1988). At that age the child is given fruit juices, soft fruits, vegetables, corn-starch pudding (mahalabia) and biscuits, while meat and fish are given later (after the age of 1 year) because mothers believe that meat is too heavy for children (Sebai, 1981b; El-Sayed, 1985; Al-Othaimeen et al. 1987). Fruits were given as early as 4 months, followed by fruit juices at about 5 months. Cereals were introduced at age 5 months and vegetables at 6 months followed by eggs at 6.8 months (Al-Othaimeen et al. 1987). Among bedouin, solid foods were started at a median age of 20 weeks (4-36), twenty-eight out of 138 infants were fed with infant cereals, 37 with family foods which included rice, bread, vegetable soup, vegetables, eggs, and later meat, and 12 with a mixture of infant cereals and family foods. There was no significant difference between the median serum ferritin levels of infant fed with infant cereals and those fed family foods (Stevens et al. 1989).

Gradual weaning was practised by 49% of mothers while 28.5% of the children were abruptly weaned (Al-Nozha et al. 1997). Weaning foods that can be prepared at home from available ingredients and in a form of acceptable to Saudi taste should be encouraged (Al-Othman, 1994).

The first supplementary food introduced was biscuits, which were given from before 3 months of age in slum areas. Family food was introduced at a median age of 8.5, 7, and 11 months among urban, slum and rural children, respectively (Bagenholm et al. 1987b).

CHILDRENS' GROWTH PATTERNS

In a study it has been found that height and weight curves for Saudi children were below those of the Harvard standard (Sebai and Reinke, 1981).

Nutritional status of 337 pre-school children aged 0-5 years living in two rural villages situated in Central Saudi Arabia were evaluated. According to the Rutishauser and Waterlow classification it has been indicated that about 76% of the children were normal since their weight for height was above 90% of the Harvard standard, about 20% were mildly wasted (80-90%) and 3.3% moderately wasted (70-79%). Only 0.6% were below 70% of the standard and considered to be severely wasted. Regarding their height for age percentage distribution 39.1% were classified as normal (above 95% of Harvard Standard), 46.3% were mildly 11.9% moderately and 2.7% severely stunted (95-90%, 90-85% and < 85% of the standard respectively) (Abdullah et al. 1982). For older children it was found that the differences ranged between 5 and 28% (less than the WHO standard), up to 146 cm of height (Bhatty et al. 1981).

Other studies carried out on school children in different regions of Saudi Arabia, have also shown that Saudi children are smaller and leaner than boys from USA, Europe, other Arab countries and well-to-do Indian boys (Abahessen et al. 1981). Weight for height for the age-group 0-36 months falls between 25th and 50th NCHS percentiles (Wirth et al. 1977; Hammam et al. 1980; Serenius and Fougerouse, 1981; Al-Frayh et al. 1988)

IRON DEFICIENCY ANAEMIA

Anaemia seems to be a common health problem in Saudi Arabia and is caused by a variety of nutritional, environmental and genetic factors (Almokhalalati, 1989). Studies carried out in the Kingdom demonstrate that non-nutritional anaemia constitutes about one-third of the total number of anaemia cases (Sejeny et al. 1980; El-Hazmi and Sebai, 1981; Hafez and Marshal, 1982; El-Hazmi et al. 1982b; El-Hazmi et al. 1982c; Ranasinghe and Malik, 1987; Ranasinghe et al. 1988).

A study in Western Saudi Arabia (1969) reported a rate of iron deficiency anaemia in children less than 5 years of 45% (Hb< 10mg/dl) (MN-NET.A Global Micronutrient Initiative Network, 1998). Another study in 1968 in Eastern region reported anaemia rate of 39.6% in 500 infants and children. The highest rate (66%) was among the youngest children (0.5-6 years) and 32% among children with age between 6-14 years (McNeil, 1969).

In Turaba study it has been found that the level of haemoglobin ranged between 6 and 10 g/100 ml in 34 of 90 nomadic children under 5 years of age. The investigator considered these children anaemic as the level of Hb was less than 10 g/100 ml. Although the distribution of levels of Hb at different ages of the children were not indicated in the study, the findings apparently indicated that a significant number of nomadic children under 5 years of age suffered from iron-deficiency anaemia (Sebai, 1981a). Another Study in 1968 in Eastern region reported anaemia rate of 39.6% in 500 infants and children, among those who visited a health clinic, 168 (33.6) were found to be anaemic. But children with ages between 0.5- 5 years have rate of 66.0% (Hb <12 mg/dl).

In the Qassim region (1979/80) it was shown that 63 of 216 pre-school and school children were anaemic and were suffering mainly from nutritional anaemia (El-Hazmi, 1982a). The article did not show the level of haemoglobin below which children were classified as anaemic. In the Asir province, it was reported that out of 436 mothers who attended the antenatal clinic at the King Faisal Hospital during the years 1978-1979, 20 women were anaemic (Hartly, 1980) (Anaemia was defined as a haemoglobin of less than 10 g/ 100 ml).

In reviewing the cases of anaemia which were diagnosed between June 1981 to January 1982 in the primary care department of the Riyadh Armed Forces Hospital, 48 cases of anaemia were identified (30 females and 18 males); iron deficiency anaemia was encountered in 32 out of 48 cases (anaemia < 12 g/ 100 ml in males and < 11 g/ 100 ml in females) (Hafez and Marshal, 1982).

In 1981/82 a survey was carried out among 217 pregnant Saudi women at the Jeddah Armed Forces Hospital to investigate their haemoglobin levels, and 14 of 217 women were found to have haemoglobin below 10 g/100 ml at some stages of pregnancy (Smart et al. 1997).

In Tabuk (Northern Saudi Arabia), a high incidence of anaemia was observed in 1981. 71 out of 138 (52%) children were anaemic (Badawi and Huaman, 1982) (haemoglobin concentration of less than 12.0 g/100 ml).

Vitamin B12 and folate data show that this is the least common type of anaemia in Saudi Arabia (Sejeny et al. 1980; Hafez and Marshal, 1982; Mohamed and Madkour, 1984). The prevalence of iron deficiency anaemia was found to be 38% among children at age between 6 months to 6 years. It was highest (53%) at age between 1-2 years. It was also higher among non-Saudies (Babelli, 1988). No strong correlation was found in this study between number of children in the family, weight and the prevalence of iron deficiency anaemia. The author used fathers jobs according to UK classifications, as the index of the social class, and found a negative association with iron deficiency anaemia, as well as with educational level. In this study, Hb and MCV were used to diagnose iron deficiency anaemia. As this data was collected from 100 paediatric inpatient files, there were no data about the duration of breast-feeding for 18 patients For the remaining patients, breast-feeding for less than 6 months was found associated with anaemia, and starting weaning later than 6 months of age was associated with anaemia too.

A cross-sectional study was carried out for children from birth to 15 months of age. The cut off of transferrin saturation was < 10% and serum ferritin was < 12 μg/l. 3.3% of 304 months old infants had iron deficiency. In the older infants the prevalence of iron deficiency increased significantly with age from 9.3% at about 6 months to 12.7% at 8 months and reached 14.5% at 12-15 months of age (Babiker et

al. 1989). Stevens et al. (1989) found 7% had a low serum ferritin below 10μg/l, whereas low Hb (<11 g/dl) was 30% and MCV (<70fl) was 26% among 138 Saudi Bedouin infants aged 9 months in western and central areas.

Al-Fawaz (1993) studied 366 infants aged between 6 and 24 months who were attending a well baby clinic for immunisation in Riyadh. He found that 157 (42.9%) were suspected to be iron deficient (Hb<11 g/dl) and/or (MCV <70 fl), but 22.9% with transferrin saturation less than 10% and serum ferritin less than 12 μg/l (Table 3-1).

Table 3-1 Incidence of low haemoglobin

Group	Sample	Cut-off	Rate
6-8 months	39	Hb < 11 g/dl	38.5%
9-12 months	193	Hb < 11 g/dl	38.3%
13-15 months	66	Hb < 11 g/dl	36.4%
16-24 months	68	Hb < 11 g/dl	33.8%

The availability of food alone does not guarantee that the right choice of food would be selected for the children (Al-Frayh and Bamgboye, 1994). Authors of this study found that the need of health education programmes of proper infant feeding practices for Saudi mothers cannot be overemphasised.

Significant positive correlation between the haemoglobin levels and housing location and soci-economical status were found by Al-Bader and Al-Shagrawi (1995).

The newborn babys' haemoglobin and haematocrit values at birth were studied in Abha the south region of Saudi Arabia The values were higher than in Riyadh (Niazi, 1994), Jeddah (Ghafouri et al. 1987) and Dammam (Al-Awamy et al. 1991). The authors postulated that the high altitude of Abha has an impact on the red cell values (Bassuni, 1996).

Al-Abdulkarim (1996) found that 19.1% (22% males and 16.7% females) of children aged 36-71 months were anaemic by using haemoglobin, haematocrit and MCHC as indicators of iron deficiency anaemia. A stepwise regression indicated that the carbohydrate and vegetable intakes were significantly positively correlated with

low level of haemoglobin. Anaemia did not affect the growth parameters of these children. Iron intake was higher for younger girls. 21% of children who were breast-fed beyond 9 months showed presence of anaemia.

A screening programme of infants at nine months of age carried out in a well baby clinic in Tabuk (North west of Saudi Arabia), while 2668 (56.0%) of 4751 infants screened have Hb less than 11 g/dl and 51.7% were iron deficient, a haemoglobin value less than 11 g/dl, MCV less than 80fl, MCH less than 27pg and MCHC less that 33 g/dl were used as indication for iron deficiency anaemia (Al-Hifzi et al. 1996). Karrar and Al-Othaimeen (1995) found that consumption of foods high in phytate content and drinking tea are common among the population of the Kingdom, which may help to increase the incidence of iron deficiency anaemia. Tea was found associated with incidence of iron deficiency anaemia among pre-school children (Osman and Al-Othaimeen, 1995; Al-Abdulkarim, 1996).

The highest prevalence of anaemia in Gulf countries was found in Omani children (65.9%) (Amine, 1980b), followed by Kuwaiti (46.9%) (Amine et al. 1989) and Bahrain (34.3%)(Amine, 1980a). Factors responsible for the incidence of anaemia in the Gulf region were not investigated (Musaiger, 1987).

CHAPTER

NUTRITIONAL STUDIES IN CHILDREN IN THE UNITED KINGDOM WITH REFERENCE TO IRON DEFICIENCY ANAEMIA

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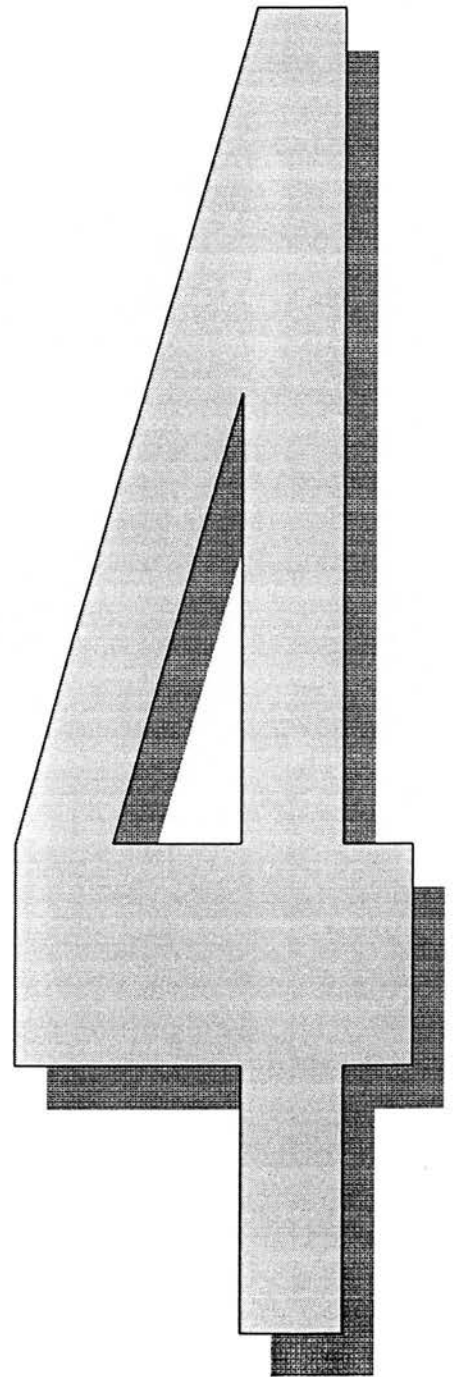
NUTRITIONAL STUDIES IN CHILDREN IN THE UNITED KINGDOM WITH REFERENCE TO IRON DEFICIENCY ANAEMIA

BREAST FEEDING

European figures for breast feeding are the lowest in the world. Finland with 97% of infants being breast fed from birth scores well, but Ireland, France and Scotland are lowest with 48% of mothers initially breast feeding (Salariya, 1993). The incidence of breast feeding rose substantially in England and Wales from 51% to 67% between 1975 and 1980 (White et al. 1992). In 1995 the proportion of women initiating breast-feeding and those continuing to breast-fed increased further (Foster et al. 1997). Only 36% of mothers in Scotland breast-fed for at least the first week (Ferguson et al. 1994).

In the 1990 survey 93% of women had decided on the method of feeding before the baby was born, and almost all (95%) carried out their intention (Wharton, 1997).

COWS MILK

In 1995 only 16% of mothers were giving cows milk at 8-9 months of age, compared with 67% in 1985 (Foster et al. 1997). Asian mothers were still using liquid cows milk as the main type of non-human milk at 9 months of age in 1995, this percentage being higher than white mothers living in the same area (Thomas and Avery, 1997). 31% out of 100 infants taking cows milk were anaemic at 12 months of age, and 24% were anaemic at 24 months. This compared with only 3% infants taking follow-up formula being anaemic at 12 months, and none of the follow-up formula group being anaemic at 24 months of age (Daly et al. 1996). Having safe breast-milk substitutes available and ensuring how to use them appropriately are recommended to solve this problem (Williams, 1998).

WEANING

Despite the recommendation in Weaning and the Weaning Diet (Department of Health, 1994), that the majority of infant should not be given solid foods before the age of four months, 91% of mothers did not did so in 1995 (Foster et al. 1997). In

Scotland, it has been found that introducing solid foods before 13 weeks of age was significantly associated with the incidence of eczema and wheezing (Forsyth et al. 1993). Reports from Australia, USA and UK confirm that formula fed infants are weaned earlier than breast fed infants (Morgan, 1998). Data from the Ministry of Agriculture, Fisher and Food (MAFF) study, "Food and nutrient intake of British infant aged 6-12 months" (Mills and Tyler, 1992), shows that both male and female formula fed infants received solid foods about 1 week earlier breast fed counterparts. James et al. (1995) have shown that up to 25% of pre-school children attending a deprived inner city general practice had iron deficiency anaemia at 24 months of age. Cultural and religious beliefs have a powerful influence on weaning and dietary practice; dietary restrictions can result in considerable difficulties (Senior and Bhopal, 1994; James and Underwood, 1997). Whereas meat or fish were not eaten at all by Asian infants less than 9 months, 47% of all infants between 9-12 months had been introduced to meat or fish (10g/day) (Duggan et al. 1992). These figures increased to 50, 73 and 88% for children aged 12-18, 19-24 and 25 months and older respectively.

Cereals, particularly baby rice and rusks are the most common foods first offered to infants starting from about 13 weeks, only 5% of mothers prepared fruits or vegetables purees as first foods (Mills and Tyler, 1992). This survey also showed that infants aged 6-9 months who received predominantly commercial foods had an average iron intake of 10mg per day compared with 5mg per day in those infants receiving mainly family foods. 95% of mothers considered a wide variety of foods to be important or very important, while 80% attached the same degree of importance to a high fibre, low fat diet 98% considered plenty of fluid to drink is important too in good feeding practice (Stordy et al. 1995). Foods properly prepared in the home, are often encouraged as suitable weaning foods and it is only recently that the nutritional composition of home prepared weaning foods has been studied. Stordy et al. (1995) revealed that some home-made meals contained surprisingly low amounts of energy, iron and zinc and high amount of non-starch polysaccharides (NSP), protein and sodium.

Older mothers were slightly more likely to make infant foods in the home, with no significant differences between mothers who were employed outside the home

and those were staying with their children (Seaman et al. 1996). The most common reason for using commercial infant food in this group was convenience (78.6%).

IRON INTAKE

Average iron intake in infants in the UK appears to meet the Reference Nutrient Intake (RNI) in two out of three recent studies (Table 4-1). In the survey by Mills and Tyler (1992) of infants aged 6-12 months, the mean intake of iron was 104% of the (RNI), but the distribution was skewed and the median value was 90% of the RNI. In the study, iron intake was significantly higher in infants who received mainly commercially produced foods compared with those on mainly family foods (10.1 and 10.5 mg/d for 6-9 and 9-12 month-old infants, respectively, compared with 4.6 and 4.9 mg/d in those who received family foods).

Intakes of dietary iron were generally low, with a mean of 5.3 mg/d, for 1-3 year-old Asian children in Sheffield (Harbottle and Duggan, 1992). In this study, there was no significant difference in the combined mean intakes of total and haem iron and of vitamin C between iron deficient and non-deficient children. The mean daily iron intakes for Scottish children were 5.1 mg for girls and 5.6mg for boys aged 2 years, and 6.1 mg for girls and 6.5 for boys aged 3 years (Payne and Belton, 1992) Older children (7-8 years old) had a sufficient iron intake compared with RNI (Ruxton et al. 1996). In adolescent, the mean iron intakes were 10.4 mg/d for girls and 12.9 mg/d (Belton et al. 1997).

Table 4-1. Daily dietary intake levels of iron in mg

	Age in months	
	6-9	9-12
Number of male children	130	96
male mean	9.6	7.2
median	9.2	6.0
Number of female children	128	134
female mean	9.0	6.4
median	8.2	5.7

Source: (Mills and Tyler, 1992)

Table 4-2 shows iron intakes recorded in a number of British studies on young children.

Table 4-2 Iron intakes in British infants and children

Author(s)	Age (years)	Intake (mg/day)	%RNI
Harris et al. (1983)	0.5-1.0	9.6	123
	1.0-2.0	9.4	136
	2.0-3.0	7.0	101
	3.0-5.0	6.0	98
Duggan et al. (1991)	0.5-1.0 iron depleted	3.17	41
	iron sufficient	4.15	53
	1.0-1.5 iron depleted	4.91	71
	iron sufficient	3.72	54
	1.5-2.0 iron depleted	2.56	37
	iron sufficient	4.81	70
	> 2.0 iron depleted	3 81	55
	iron sufficient	3.34	48
DH (1989)	Boys 10-11	10.0	100
	Girls 10-11	8.6	73
Nelson et al. (1990)	Boys 7-10	9.1	104
	Girls 7-10	9.2	104
	Boys 11-12	11.2	100
	Girls 11-12	10.0	97
Mills and Tyler (1992)	Boys 0.5-0.75	9.6	123
	Girls 0.5-0.75	9.0	115
	Boys 0.75-1.0	7.2	92
	Girls 0.75-1.0	6 4	82
Gregory et al. (1995)	Mixed 1.5-2.5	5.0	73
	Mixed 2.5-3.5	5.6	81
	Boys 3.5-4.5	6.2	95
	Girls 3.5-4.5	5.9	92

Source: (Lawson, 1995)

Sources of iron

Table 4-3 indicates the daily mean iron intakes from foods in the first 12 months of life.

Table 4-4 shows a comparison between sources of iron from commercial food group and family foods, such as foods in jars/cans, instant dried weaning foods, rusks and infant formula made major contributions to the intake; For the family foods group, breakfast cereals and meat were important sources of iron, although commercial weaning foods made a total mean contribution of 15% to intake in this group also (Lawson, 1995). For Asian children, cereals and baby foods were major sources of iron, savouries (28.3%), followed by baby cereals and rusks (22.3%) then cereals (16%) were the highest source of iron for normal children. Savouries (31%), followed by cereals (28.4%) then cow's milk were the highest source of iron for anaemic children (Harbottle and Duggan, 1992). Weaning diet has an effect on iron stores; commercial baby foods have a positive effect, where cows milk has a negative effect in 8 months old children. Non-haem iron intake has a negative effect too but in 18 months old children (Wharf et al. 1997).

In an Australian study, the median daily intake for 1-3 year old children of haem iron was 0.71 mg/d for iron replete children, while for iron depleted children it was only 0.28 mg/day (Mira et al. 1996).

Table 4-3. Daily mean intake of iron from specified foods (% total intake)

	Age in months	
	6-9	9-12
Commercial instant/dried foods	2.4 (26%)	0.8 (12%)
Infant formulae	2.0 (22%)	0.7 (10%)
Rusks	1.7 (18%)	1.0 (15%)
Commercial foods in jars/cans	1.3 (14%)	0.9 (13%)
Breakfast cereals	0.5 (5%)	0.9 (13%)
Meat and meat products	0.26 (3%)	0.46 (7%)

Source: (Mills and Tyler, 1992).

Table 4-4 Percentage daily iron intake from main food groups

Foods	Infants 6-9 months		Infants 9-12 months	
	Commercial	Family	Commercial	Family
Total cereal	2	39	9	41
Bread	0	8	1	10
Breakfast cereals	1	26	6	24
Milk and milk products	1	5	2	6
Cows' milk	1	4	2	5
Meat/meat products	0	13	0	13
Vegetables	0	8	0	12
Fruits and nuts	0	2	0	1
Commercial foods	70	15	66	5
Foods in jars/cans	19	3	31	1
Instant/dried	34	9	18	1
Rusks	16	3	17	4
Infant formula	26	7	21	8
Breast milk	1	2	0	0
Total Intake (mg/day)	10.1	4.6	10.5	4.9

Source: (Mills and Tyler, 1992)

Approximately 8% of infants fed by cows' milk were consuming less than the Lower Reference Nutrient Intake (LRNI) for iron. However, although a small positive association was found between iron intake and ferritin levels at eight months, there was no association with Hb levels, nor was there any between type of milk consumed and Hb. Vitamin C intake shows a small positive association, but only in boys ($p=0.008$) (Sadler, 1996).

Mean haem iron intake for the British population was 0.53 mg/d. Sources of that haem iron were as follows: from beef 0.11 mg/d, lamb 0.03mg/d, pork 0.02 mg/d, offal 0.04 mg/d, poultry 0.06 mg/d, meat products and dishes 0.22 and from fish 0.04 mg/d (Tull et al. 1997).

Table 4-5 shows the sources of iron in children aged 1½ -4½ in the recent UK study (Gregory et al. 1995).

Table 4-5 Percentage contribution of food groups to daily iron intake by age and sex

Foods	Mixed 1½-2½	Mixed 2½-3½	Boys 3½-4½	Girls 3½-4½
Cereals and cereal products	44	49	51	48
Bread	11	11	12	12
Breakfast cereal	20	22	22	20
Biscuits	5	5	6	5
Milk and milk products	9	6	5	5
Cows' milk	5	4	4	4
Meat and products	14	14	14	15
Commercial infant food	2	0	0	0
Vegetables/savoury snacks	14	15	14	15
Fruits and nuts	3	3	2	3
Average daily intake (mg)	4.9	5.4	6.1	5.6

Source: (Gregory et al. 1995)

IRON DEFICIENCY ANAEMIA IN THE UK

Iron deficiency remains a significant problem in UK (Wharton, 1998) It is seen most commonly in children aged 6-24 months from ethnic minority groups (particularly Asian) despite major advances in our knowledge of iron nutrition in infancy and childhood (Booth and Aukett, 1997). Its' prevalence depends upon the socio-economic, cultural group studied, age and the criteria used to establish the diagnosis (Lawson, 1995).

Table 4-6 lists recent surveys carried out in the UK, and shows incidences of iron deficiency in different age groups. Similar problems have been reported from other countries (McPhail and Bothwell, 1989).

The National Diet and Nutrition Survey commissioned by the Departments of Health and the Ministry of Agriculture, Fisheries and Food, examined a sample of children aged $1_{1/2}$ to $4_{1/2}$ years in 1992/3 who had been selected to be nationally representative of the population of Britain. This study's results show that 12 per cent of children were anaemic in the group aged $1_{1/2}$ to $2_{1/2}$ year and 6 per cent in both the

Table 4-6 Prevalence of anaemia and iron deficiency in infants and young children in Britain (based on a table by Stevens, 1991)

Year of survey fieldwork	Location of survey	No. subjects	Age (months)	Ethnic group	Criteria used	Proportion anaemic (%)	Proportion low serum ferritin (%)
1983/4 (Ehrhardt, 1986)	Bradford	598	6-48	European Asian	Hb<11g/dl MCV<70fl Ferritin < 10µg/l	12 28	23 45
1983 (Grindulis et al. 1986)	Birmingham	145	21-23	Asian	Hb<11g/dl MCV<70fl Ferritin < 10µg/l	Low Hb 31 Low MCV 51	58 ferritin<7=90
1984/5 (Aukett et al. 1986)	Birmingham	470	17-19	European Asian	Hb 8-11g/dl MCV<70fl Ferritin < 7µg/l	18 25	Ferritin<7= 47
1985 (Marder et al. 1990)	Nottingham	130	15-24	European Asian Caribbean	Hb < 11 g/dl	16 39 20	Not estimated
1987/8 (Mills, 1990)	London	148	8-24	European Asian Predominantly Caribbean	Hb < 11 g/dl	17 26 18	Not estimated

Table 4-6 (Continued) Prevalence of anaemia and iron deficiency in infants and young children in Britain (based on a table by (Stevens, 1991)

Year of survey fieldwork	Location of survey	No. subjects	Age (months)	Ethnic group	Criteria used	Proportion anaemic (%)	Proportion low serum ferritin (%)
1988 (Wright et al. 1989)	Newcastle	71 70	9-15	'Affluent' 'Deprived'		11 16	Not estimated
1988 (Morton et al. 1988)			6-12 6-12	Asian Non-Asian	Hb < 110 g/l Ferritin < 10 µg/l		40-26 36-21
1988/9 (James et al. 1989; Stevens, 1991)	Bristol	122	13-24	European Caribbean	Hb < 10.5 g/dl MCV <75fl	18 26	Not estimated
1989/90 (Duggan et al. 1991)	Sheffield	138	4-40	Asian	Hb<11g/dl MCV< 70fl Ferritin < 10µg/l	17	34
1992/3 (Gregory et al. 1995)	Britain Britain	300 353	18-29 30-41	Nationally representative Nationally representative	Hb<11g/dl MCV<70fl Ferritin < 10µg/l	12 6	28 18
(Emond et al. 1996)			8	Mixed	Hb<110 g/l Ferritin< 12 µg/l	27	1.2
1996 (Daly et al. 1996)	Birmingham	100	6-24	White, Afro-Caribbean and Asian	Hb<11g/dl MCV <70fl Ferritin <8µg/l	34 31	Not included

$2_{1/2}$ to $3_{1/2}$ year group and the $3_{1/2}$ to $4_{1/2}$ year group using the WHO classification (Gregory et al. 1995). The proportions of children in the same three age groups who had a serum ferritin below 10 µg/l were 28 per cent, 18 per cent and 15 per cent respectively and these values show that anaemia and iron deficiency are common in 2 year olds in this country and these conditions become less common as the children get older.

A longitudinal study of pregnancy and childhood (ALSPAC) studied haemoglobin and ferritin concentrations in 1175 infants at 8 months of age, and they found that 23% of infants were identified as anaemic (Emond et al. 1996). Using the recommended WHO definition of anaemia (Hb <11 g/dl), 23% of the 1175 children from Avon would be regarded as anaemic, 1.2% of this population below 12 µg/l of serum ferritin. No correlation was found between Hb and ferritin. Neither of Hb or ferritin were related to sex, ethnicity or social class as measured by maternal education level (Emond et al. 1996).

Prevention

The Committee on Medical Aspects of Food Policy (COMA) Working Group recommended that there should be an assessment of the need for, and feasibility of universal or subgroup screening for iron deficiency anaemia in infants and young children (Department of Health, 1994).

Walker (1998) reviewed what priority should the remedying of iron deficiency have. The need for a UK national screening programme for iron deficiency has been suggested (Anonymous, 1987; Hall, 1996) and screening at risk infants at 9-12 months and/or routine supplementation with medicinal iron has been proposed (Addy, 1986; Hall, 1996). Small-scale screening programmes have been shown to be acceptable in the GP surgery and in community child health clinics (James et al. 1988; Marder et al. 1990). A number of questions about the feasibility of national screening need to be considered: a practical and useful age for screening in the UK has not been determined (James et al. 1997), the most appropriate laboratory tests for diagnosis of iron deficiency remain unclear, and a strategy needs to be developed for children who have been screened.

Improvement of foods for children by the manufacturers can help in reducing the prevalence of iron deficiency anaemia. Hurrell et al., (1998) found that using the results of studies of iron absorptions on adults to assess the influence of enhancers and inhibitors of iron absorption in infant formulas can be used.

Education programmes coupled with screening are successful in reducing iron deficiency in the short term (James et al. 1988; James et al. 1989), although the long-term effects appear to be less effective (Walter et al. 1989; James et al. 1993). Similar findings have been reported in other countries (Pollitt et al. 1989; Soewondo et al. 1989). The benefits arising from a screening programme have not been evaluated and this has been identified as a priority area for research (Department of Health, 1994).

Cockburn (1998) concluded that within the UK there is no real lack of knowledge and understanding of mothers and infants basic nutrient requirement.

AIMS OF THE STUDY

1- Measure iron intake in young children between 9 months and 3 years of age.

2- To investigate what foods make a significant contributions to iron intake in young children.

3- To examine what factors may affect iron intake and iron status in this age group.

4- To correlate iron intake with iron status using recognised measures of iron status.

5- To examine the knowledge and attitudes of parents.

6- Using the results of these studies, to recommend health education measures which will prevent the occurrence of iron deficiency anaemia in young children.

CHAPTER

METHODOLOGY

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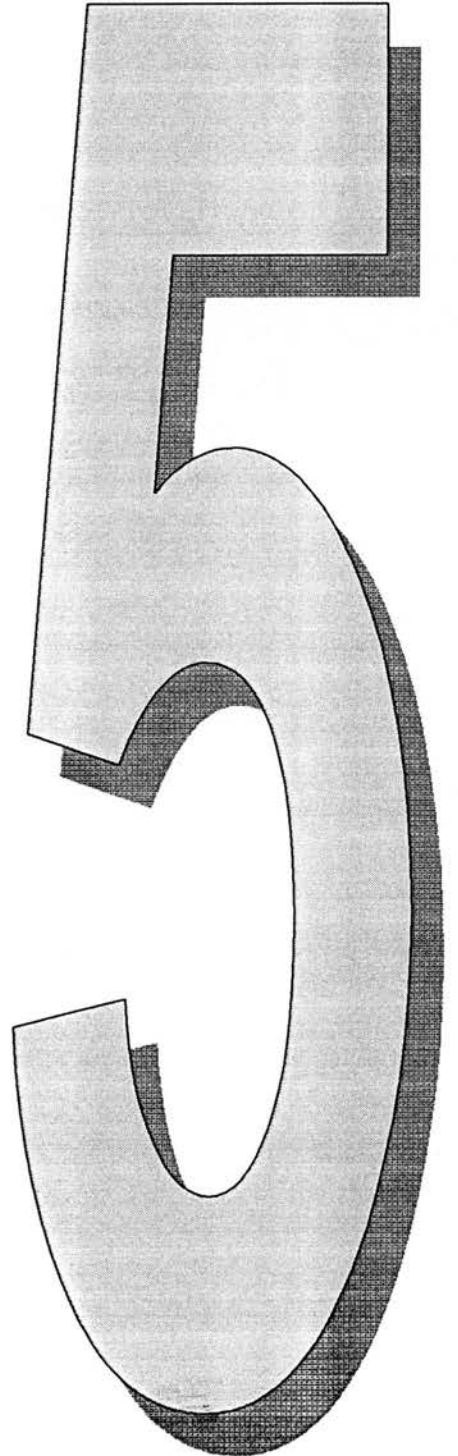
METHODOLOGY

DESIGN OF THE STUDY

The overall study has been divided in to four different studies:

1- Community study of the nutrient intake of Saudi children in Riyadh, Saudi Arabia, with particular reference to intake and iron deficiency.

2- Study of the food intake of anaemic children in Riyadh hospitals.

3- Study of the nutrient intake of children in Edinburgh with particular reference to iron intake and iron deficiency.

4- Study of the prevalence of iron deficiency anaemia and nutrient intake in children attending the Royal Hospital for Sick Children in Edinburgh.

The timing of starting studies was chosen carefully, especially for the Saudi Study, to avoid school exams, holidays and with reference to the period of study available.

These four studies were chosen to give an insight into the diet of young children in both Riyadh and Edinburgh with particular relevance to iron intake and iron deficiency.

Weighed dietary information

Instruments

Following a previous study by Payne (1991), UWE Model NKS-2000 electronic scales were chosen for their reliability, accuracy, portability, working by means of dry batteries and ease of use in surveys. These scales weighed to an accuracy of ±1g. 10 were purchased; 9 of them were used and one kept as a spare. Each set was tested for accuracy three times during the whole study, the first once at College of Applied Medical Sciences, King Saudi University, and twice at the Department of Child Life and Health, University of Edinburgh.

Lightweight disposable plastic bowls, dishes, spoons and measuring cups were provided for every family, to make weighing easier and more accurate. These were the same size and weight for all children in the visits of the survey.

Instructions

A pilot study was conducted with some families in Edinburgh and Riyadh. Four families were recruited from each place. Two were given the instructions with explanations and demonstration of weighing and recording and two were given the instructions without explanation or demonstration. Some changes were then made to the original instructions to make them clearer and more understandable.

The instructions were printed on two different coloured papers (pink and green) for clarity. One set was the general instructions, and the another was instructions for using the scales. A table was designed for recording the food intake and was printed on white sheets. Examples of food weight recording were included (Appendix 1). All instructions and questionnaires were printed in Arabic for the Saudi study.

In the Saudi study a free-phone number with answering machine facility was printed on the first page of instructions, and clear examples for weighing and recording different types of food were included.

Four days weighed intake, three weekdays and one weekend day were chosen after reviewing the possible methods (see chapter 5, page 69). A few mothers did not do the weighing on consecutive days. A follow up by telephone was made to ensure that everything was going well, especially with illiterate mothers for whom one of their children or housemaids/baby-sitters would weigh the foods. It was impossible to visit the mother at home in the Saudi society. Most of mothers found no difficulties in weighing and recording intake. However a few mothers were phoned after completing the weighing to clarify what had been written. Mostly this was about brand names. One mother had a faulty electric cable of the scale, which was exchanged. The weighing method was flexible. A few mothers preferred to write the net weight of a canned food whilst some others weighed everything, even water. This flexibility helped them to weigh all the food intake. It even made some difficulties when converting weight during entering of the data into the computer.

Analysis of food intake

Comp-eat was chosen for analysis of food intake for reasons that were given in chapter 1. As there were no traditional Saudi or Mediterranean foods available in data system, many new foods were added to the data-set. Additional data was added, from food analysis used by nutrition departments at the Military Hospital, King Faisal Specialist Hospital and Research Centre, some baby food analyses from different companies, dairy products from dairy manufacturers, food analysis from the national survey on evaluation of the nutritional status of the people of Saudi Arabia (Al-Nozha et al. 1997), and some published papers. These data were used, and averaged to get the composition of the new foods. Eighty-six new foods have been added to the system from the above information resources. No Saudi food recipes were added to the system as there was no special food were prepared for the children in Riyadh study.

Comp-eat 4 has been upgraded to Comp-eat 5 which is working under Microsoft Windows 95, so all data have been converted to Comp-eat 5. Comp-eat 5 has many limitations regarding data manipulation. However, analysed data have been exported to Excel and SPSS for analysis. Some data i.e. food sources of iron and haem iron, cannot be transported (to any system) and thus cannot be analysed to obtain the average for all subjects. To resolve this problem, these results have been analysed individually from food group data, then coded and analysed by Excel.

Anthropometric measurements

Height, weight, chest circumference, head circumference, in order to assess the childs' growth, and triceps and sub-scapular skinfold thicknesses to assess body composition were measured for each child. All these measures were done in the well baby clinics in each health centre in the Saudi study and at the home of the child in Edinburgh study.

Height

Weights of children were taken without shoes or socks, and length measured recumbent. In the Saudi study the child was placed, face upward, with the head towards the fixed ended the body parallel to the long axis of the board, the shoulder-blades rested against the surface of the board. A nurse applied the crown of the child's head into contact with the fixed headboard and another held the feet and took the reading. The reading was taken to the nearest millimetre according to Weiner and Lourie (1969). In the Edinburgh study, a portable stadiometer for measuring height was also provided. A pilot study for measuring weight and height was conducted with some volunteers.

Weight

The children's weights were taken while they were naked. A paediatric scale was used to measure weight for all children at well baby clinics in the Saudi study. The child was placed on the pan of the scale so the weight is distributed equally about the centre of the pan. Weight was recorded to the nearest 100 gram. A highly accurate electronic weighing scale for measuring the child's weight was provided, tested and used for Edinburgh study.

Head and chest circumference

This was measured following the methodology of Weiner and Lourie (1969). A narrow, flexible fibreglass tape for head circumference was used for measuring the head circumference. The subject was looking straight, the tape was passed above the external auditory meatus and below the top of the bone above the eye sockets. The tape was at the same level on each side of the head and was pulled tightly to compress the hair.

A flexible non-stretch tape was used to measure the chest circumference. Taking both measurements in duplicate are very important in paediatric studies.

Triceps and sub-scapular skinfold thicknesses

Skinfold thickness measurements are said to provide an estimate of the size of the subcutaneous fat depot, which in turn provides an estimate of the total body fat. A Holtain skinfold caliper was used to measure both triceps and sub-scapular skinfold thicknesses.

Triceps skinfold was measured at the midpoint of the back of the upper left arm. A fold of skin and subcutaneous tissue was grasped vertically between the thumb and forefinger to include the underlying fat but away from the underlying muscle, while the arm was hanging relaxed. The reading was taken after 2-3 seconds.

The sub-scapular skinfold was measured just below and laterally to the angle of the left shoulder blade, with the shoulder and left arm relaxed. Measuring and reading was the same as triceps thicknesses.

All anthropometric measurements were done twice for the same child and the mean of the readings recorded.

The questionnaire

A semi-quantitative questionnaire was administered by the author in the Saudi study and mostly by the parents in Edinburgh study. The questionnaire combined with two pages on social and behavioural questions covered all information expected to affect iron status. These questions included the number of children and position of the child, educational level and occupation of the parents, times of introducing and stopping the different type of the food, appetite of the child, family eating and shopping habits and the activity level of the child.

The food frequency questionnaire included all food which is likely to be eaten by the Saudi children in the Saudi study, or by children in the UK in Edinburgh study. These included baby foods; commercial and home-made and all types of food groups eaten by children and adults, leaving spaces to add food not included in the questionnaire. The order of the food names was organised to help parents to remember what their child eats, i.e. dairy products eaten in breakfast were put together, drinks such as milks and juices were put in two subsequent groups. If the

mother could estimate how much the child eats for a specific food, then the amount was recorded in grams, millilitres, portions or household measures.

THE STUDIES IN RIYADH, SAUDI ARABIA

Selection of subjects

A longitudinal study was designed for the Saudi study to be undertaken in three visits to Riyadh to follow up the same children as far as possible at average ages of approximately 9, 16 and 24 months.

Appropriate approvals were obtained from King Saud University and Ethical permission was obtained from the Ministry of Health. In the General Directory of Health Affairs in Riyadh, Riyadh city is divided into four geographic areas which include different social levels. Two primary health care centres (health centres) were chosen randomly from each of these four areas. These primary health care centres are in following areas:

East: Alrawdhah and Alrabwah .

South: Manfouhah and Almurgub .

West and South west: Alshefa and Shobra .

North: Alolaiya and Almursalat.

Further arrangements were made with these centres in order to find the most suitable time for them and avoiding immunisation days when the centre could be busy.

Three main hospitals belonging to the Ministry of Health in different places in the city were chosen to include anaemic children as comparison to the anaemic and normal children in the survey. These hospitals were:

1- Sulaimaneah Sick Childrens Hospital (in the north of the city).

2- Al-Yamamh Hospital (in the east of the city).

3- Maternity and Childrens Hospital, Riyadh Medical Complex (in the centre of the city).

These hospitals were visited twice a week to check if they had suitable patients. An answering machine and a pager number were given to the organiser in each

hospital in order to record a message when they have a suitable patient. The co-ordination from all hospitals was poor.

The first visit

From the well baby clinic in each centre names of children aged between 8-11 months were selected randomly. All necessary information about the child and the family was recorded and the well baby clinic specialist advised if any one of them were not suitable to be approached. If so they were withdrawn. The rest of the list were contacted by phone and the study was explained clearly and questions answered.

A detailed explanation of the survey and training were provided to the staff of the well baby clinics in each health centre and to some staff of the haematology lab at Sulaimaneah Sick Children Hospital.

Parents who accepted to participate in the study were invited to the well baby clinic at their primary health care centre and appointments were given to them. Mothers or parents were interviewed to describe the study in detail. This included demonstrating the weighing technique, filling the food frequency questionnaire, taking the anthropometric measurements and blood taking. All these were carried out in the well baby clinic within 1-1½ hour.

Table 5-1 shows the number of children who were recruited and who participated in the first visit.

There were many different reasons for non-participation by the parents. Reasons given for not participating were: mothers' work, the childs' health at that time, not being concerned too much about iron deficiency anaemia and feeling that the child is healthy, illiteracy and fear of blood samples being taken even after it has been explained that it was not obligatory to give a blood sample, were all reasons given for non-co-operation.

Table 5-1. Number of subjects in the first visit

Health Centre	Code	Number of subjects			
		Chosen	Contacted	Agreed	Participated
Alrabwah	A	20	16	6	4
Almurgub	B	20	17	7	6
Almursalat	C	20	18	6	4
Manfouhah	D	20	16	5	4
Alrawdhah	E	20	15	4	3
Alolaiya	F	20	16	8	7
Alshefa	G	20	19	12	10
Shobra	H	20	15	10	9
Total		160	132	58	47

Blood taking and analysis in the Riyadh study

The child was taken to the laboratory at the primary health care centre after completion of the interview and anthropometric assessments (to decrease the stress whilst information was taken). Two ml of blood was taken by myself with the help of the nurse in each health centre by venepuncture from all children whose parents agreed, 1ml was put in EDTA for total blood count tests and 1ml in a plain tube. After complete clot formation had taken place, the sample was centrifuged to get serum for the serum ferritin test. Some samples required centrifugation again to remove red cells. Both tubes were clearly labelled with the number of the child, name and the name of the health centre.

The total blood count included red blood cells, white blood cells, haemoglobin, haematocrit, mean cell volume (MCV), mean cell haemoglobin (MCH), and mean cell haemoglobin concentration (MCHC). All total blood samples were taken twice a day for total blood count analyses at the Sulaimaneah Sick Childrens Hospital just after finishing blood collection. The serum was kept in the freezer under -20° C, until subsequent analysis for serum ferritin by a Microparticle Enzyme Immunoassay method (MEIA, Abbott), using the AXSYM SYSTEM at the Immunoassay Section, Dept of Clinical Biochemistry, Royal Infirmary, Edinburgh.

The second visit

Seven months after the beginning of the first visit, the second visit was conducted. The aim was to obtain children aged approximately 16 months. All names, file numbers, dates of birth and telephones numbers from the first visit were sent to each health centre. This period was chosen to give appointments for those that had been seen at the last visit (starting with the first health centre which has been started at the last visit to keep the same difference between ages constant in the second and first visit).

Not all children from the first visit participated in the second visit. Change of address or phone number or no longer being attached to the original health centre, were the most common reasons for not participating in the second visit.

The same procedures for measuring food intake, carrying out the interview, questionnaires and blood test as used in the first visit were repeated in this visit. The second visit was much easier than the first one because the well baby clinic staff understood the survey and knew the children. New names were added to the list at each health centres' to compensate for children who had withdrawn. The numbers of children taking part in this visit is shown in Table 5-2.

Table 5-2 Number of subjects in the second visit

		Number of subjects			
		Continued	New names		All
	Code	From visit one	Contacted	Participated	Participated
Alrabwah	A	1	9	7	8
Almurgub	B	2	10	4	6
Almursalat	C	4	10	7	11
Manfouhah	D	3	10	4	7
Alrawdhah	E	2	10	7	9
Alolaiya	F	2	10	7	9
Alshefa	G	5	8	4	9
Shobra	H	5	8	3	8
Total		24	75	43	67

The third visit

Eight months after the beginning of the second visit, the third and last visit was carried out as the children were approximately 24 months of age. Names from both first and second visits were sent to the correspondent health centre with their details. A similar procedure used at the last visit was repeated.

Table 5-3 shows numbers of children in visit three. Table 5-4 shows the numbers of participants in each of the 3 visits, and Table 5-5 shows the number of times in children participated for all the three visits.

Table 5-3 Number of subjects in the third visit

		Number of subjects				
		Continued from visit:		New names		All
	Code	One	Two	Contacted	Participated	Participated
Alrabwah	A	2	3	4	2	7
Almurgub	B	2	3	4	3	8
Almursalat	C	4	5	4	4	13
Manfouhah	D	3	4	5	4	11
Alrawdhah	E	2	3	5	3	8
Alolaiya	F	3	5	2	0	8
Alshefa	G	4	3	4	2	9
Shobra	H	4	2	6	5	11
Total		24	28	34	23	75

Table 5-4 Participants from all health centres

	Code	Visit one	Visit two	Visit three	Total	% of total
		Number of participant subjects				
Alrabwah	A	4	8	7	19	10%
Almurgub	B	6	6	8	20	11%
Almursalat	C	4	11	13	28	15%
Manfouhah	D	4	7	11	22	12%
Alrawdhah	E	3	9	8	20	11%
Alolaiya	F	7	9	8	24	13%
Alshefa	G	10	9	9	28	15%
Shobra	H	9	8	11	28	15%
Total		47	67	75	189	
% from total		25%	35%	40%		

Table 5-5 Number of times participating children seen

	Once	Twice	3 times
Number of children	137	30	22
Percentage	72%	16%	12%

The anaemic patients

A total of 24 anaemic children with ages between 9 to 36 months were included (11 from Solaimaneah Sick Children Hospital, 12 from the Maternal and Children Hospital, and only 1 from Al-Yamamah). The latest total blood count results were recorded for each child, a 1ml blood sample was collected for the serum ferritin test for each child. The questionnaires were completed. As these children were in-patients, no weighed food intakes were taken.

THE STUDY IN EDINBURGH

Selection of subjects

Ethical approval was obtained from the Lothian Paediatric/Reproductive Medicine, Research Ethics Committee. The sample size and the way of surveying this sample was constrained by the period of time available for data collection. It was been agreed that studying children with ages between 9 to 36 months once would be enough to assess food intake and its' relationship with iron deficiency anaemia.

Children were selected from the Lothian Child Health Register, to provide a mix of socio-economic backgrounds from different areas in the city.

Children from 3 GP Health Centres, Bruntsfield, Gilmerton and Whinpark were chosen. Details of these children were provided from the Lothian Child Health Register, including date of birth and address for each child. Names were chosen randomly then sent to the co-operating GPs for approval and for checking if any were not suitable to be approached. Some Saudi children whose parents were studying in Edinburgh were chosen to compare their intake with those from the Saudi study. The numbers of children selected and those who participated are shown in Table 5-6.

Table 5-6 Details of number of children in the Edinburgh Study

Parents:		Bruntsfield	Gilmerton	Whinpark	Saudies	Total
Contacted	No.	131	99	95	8	333
Agreed	No.	26	19	18	6	69
	%	20	19	19	75	20
Participated	No.	24	14	18	6	62
	%	18	14	19	75	19

A personal letter printed on Departmental note-paper (appendix 2) was sent to the parent/guardian of all children (n=333) to invite them to participate in this study. The letter gave a clear description of the study, and makes it clearer that they may participate in the study without any obligation to have the blood sample taken.

A slip was attached at the bottom of the letter including the child's name, code, date of birth, address, and suggesting possible times for the parent to select the most convenient period to telephone to arrange the first visit. The opportunity to seek more explanation about the study was included and a space for the phone number. A stamped return envelope with printed address was attached with the letter for reply.

These letters were sent out in groups, so as not to allow too long time from the agreement to participate and the time of the first visit.

Instructions and questionnaires

The instructions were similar to those used in the Saudi study but with changes in the examples of foods given to include foods available in the UK. The author's name, telephone numbers at the department, and at home (with answering machine) and a mobile phone number were printed on the first page.

The questionnaire used was also similar to that used in the Saudi study with some changes to include all food expected to be eaten by children and adults in the UK populations. Spaces were included for food not covered in the questionnaire (see Appendix 2).

Procedure of the survey

The scales for weighing food were checked for accuracy. Plastic bowls, dishes and suitable measuring cups were provided to be ready for the survey. The parents who had agreed to participate were contacted to arrange the first visit. Appreciation for their participation was expressed, an additional full explanation of the study was offered, and a detailed demonstration of weighing and completing the questionnaire was provided.

Instructions were printed on different coloured sheets for clarity and the questionnaire were contained in a folder for convenience. Full flexibility was

allowed in choosing the time of starting the weighing and the method of weighing. Some mothers chose to use accumulation weighing i.e. to weigh the food and the plate together, whilst others preferred to take off the plate weight before weighing.

During the second visit, the anthropometric measurements of the child were taken, the food record and the questionnaire were reviewed. Some parents asked questions related to iron deficiency anaemia or paediatric nutrition. These questions were answered and some publications were distributed. Timing the second visit for taking the anthropometric measurements was chosen not to coincide with the weighing, in order to decrease stress for the child and parents.

At the end of the second visit, the optional blood test was offered to the parents for their children. Most of parents agreed to test their children (37 out of 61). A letter was given to them with details of how to get to the Haematology Dept. RHSC where the blood samples were all taken. Two mornings a week were offered for taking blood samples without any appointments.

Blood taking and analysis

At the Haematology laboratory, trained phlebotomists took 2ml blood from each child, 1ml for total blood count, and 1ml for the serum ferritin test, which was carried out at the Western General Hospital, Edinburgh. This hospital was used because they perform serum ferritin assay on EDTA blood. Anaesthetic cream (EMLA) was provided when required. The procedure of preparing samples and analysis were similar to the Saudi study.

THE ROYAL HOSPITAL FOR SICK CHILDREN, EDINBURGH (RHSC) STUDY

In order to find the prevalence of iron deficiency anaemia among children attending this hospital, and to study dietary iron intake and its' relationship to iron deficiency anaemia, a study was design to be carried out at RHSC. Ethical approval was obtained from the Lothian Paediatric/Reproductive Medicine, Research Ethics Committee. This study was carried out in conjunction with Dr. Angela Thomas,

Consultant Haematologist, RHSC and with the co-operation of the staff of Department of Haematology and consultants of the hospital.

Subjects

Results of all blood samples received and analysed in the Haematology Department in 2 separate months (14th Oct.-11th Nov. 1996 and 24th Feb.-27th March 1997 were studied. A copy of total blood count results were collected twice a day from the haematology lab. Patients whose presenting clinical diagnosis might lead to abnormal haematological results such as children with cardiac problems, oncology, inflammation, bleeding disorder, liver diseases, and nephrology patients were excluded.

Patients between the age of 8 months and 3 years with low Hb (<11 g/dl) and/or low MCV (<76 fl) were invited to complete a specially designed food frequency questionnaire (FFQ). A number of parents with children of the same age whose haematological parameters were normal were also sent a FFQ.

Out of 151 FFQs sent out, 59 (41 from children with abnormal haematological parameters and 18 from controls) were returned and analysed.

Blood samples

Samples with indication of iron deficiency anaemia i.e. those have Hb (less than 11g/dl), and MCV (less than 76 fl) were selected, labelled and sent to the Western General Hospital, Edinburgh for serum ferritin estimation.

Prevalence of iron deficiency anaemia

Prevalence rates for the total population having blood samples taken at RHSC and for the different age ranges were calculated.

It is accepted that a hospital population such as this will give a prevalence rate that is not equivalent to that pertaining in the community.

DATA ANALYSIS

The dietary data recorded in the food intake sheets were prepared for analysis by carrying out the following tasks:

1- Subtracting leftovers from original food offered to the child.

2- Calculation of the new recipes by generating a new recipe from amounts of food ingredients used. Each recipe was given a specific name which refers to that specific recipe, as the same recipe may be known by different names in different families.

3- Input of the data by food's name, to Comp-eat 4 in the beginning of the study and then Comp-eat5 when it was available later in the study, was made.

When all the food data had been completed, nutrient intakes were exported to the statistical programmes Excel (V5) and SPSS (starting with version 6 (1996) and ending with version 8.01 (1998) when all the analysis were completed.

Due to the lack of technical flexibility of the Comp-eat system, not all data were converted automatically. Thus some manual input was done from the printout of Comp-eat i.e. percentage of iron, vitamin C, haem and non-haem iron compared with RNI (Recommended Nutrient Intake) and LRNI (Lower Recommended Nutrient Intake).

All anthropometric data, blood test results and the whole data from the questionnaire were entered into SPSS. In addition, nutrient intakes generated from the Comp-eat system and those entered manually were also put into SPSS. Re-coding of some variables was undertaken as required. For the Saudi study, two SPSS files were generated from the total number of children to get a list of the children at the youngest age and another list for the children at the oldest age in order to test each childs' data once only.

In many of the figures, a regression line of the data is shown. Such lines, when produced using SPSS, are drown from the left-hand side to the right-hand side of the figure. It is acknowledged that regression lines should not extent beyond the data shown and thus the extrapolations produced by SPSS are not valid.

STATISTICAL ANALYSIS

The following data was analysed: blood parameters, anthropometric measurements, food intakes (from the FFQ and weighed intake), nutrient intakes (from weighed intake). The relationships between food and nutrient intake variables were also determined. Many statistical analyses were used to achieve this.

Minimum, maximum, frequency and percent were used to define the size of the sample were tested. Mean for normally distributed data, median for skewed distributed data and standard deviation to define how data is distributed and its' dispersion with relation to mean.

Bivariate Pearson correlation coefficients were used to define the association between data, and multiple regression to describe the strength of the associated variables and to predict what data may affect other data.

Kaplan-Meier survival test was used to define the periods of breast feeding.

Some other tests were used but not included here as there were no significant findings i.e. log survival for periods of breast feeding, Mann-Whitney U test to test the association between some small samples, ANOVA, Logistic Regression, Wilcoxon test for testing two related data sets and paired-Sample T test.

CHAPTER

RESULTS OF THE

RIYADH STUDIES

6
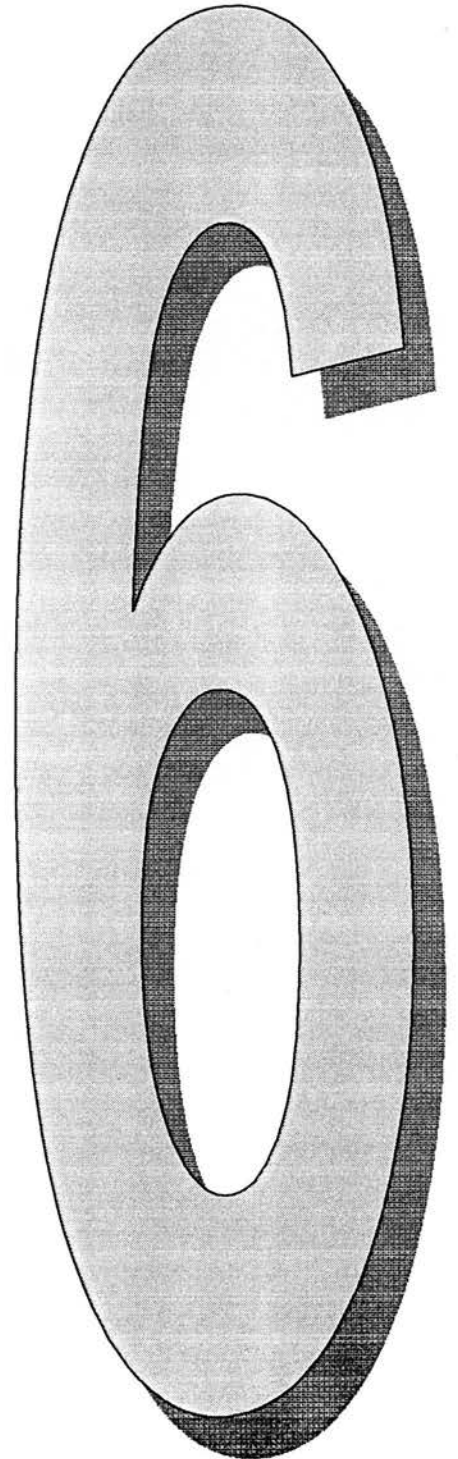
RESULTS OF THE SAUDI STUDIES

HAEMATOLOGICAL RESULTS

Descriptive information provided by figure 6-1 shows that out of 68 child in the first age group, up to 16 month, 13 children (19%) had low haemoglobin (Hb) concentrations (< 11 g/dl), whereas out of 71 children in the second age group (16-22 months), 17 children (23.9%) had low haemoglobin concentrations, and 8 children (20%) out of 40 children had low haemoglobin concentrations in the third age group (22 months or more). Regression lines in all figures reflect only the readings expressed as dots, the line out of that range should not be considered.

More children had low MCV concentrations (<76fl) than haemoglobin. In the first age group, 47 children (69%) out of 68 children had low MCV, with the same percentage in the second age group, 49 children (69%), and a lower number, 23 children (57.5%) had low MCV in the older age group (figure 6-2).

As shown in figure 6-3, the serum ferritin (SF) concentration was higher in younger children with only 18 children (28.6%) below the cut off for serum ferritin

Figure 6-1. Haemoglobin Concentrations For Different Age Groups
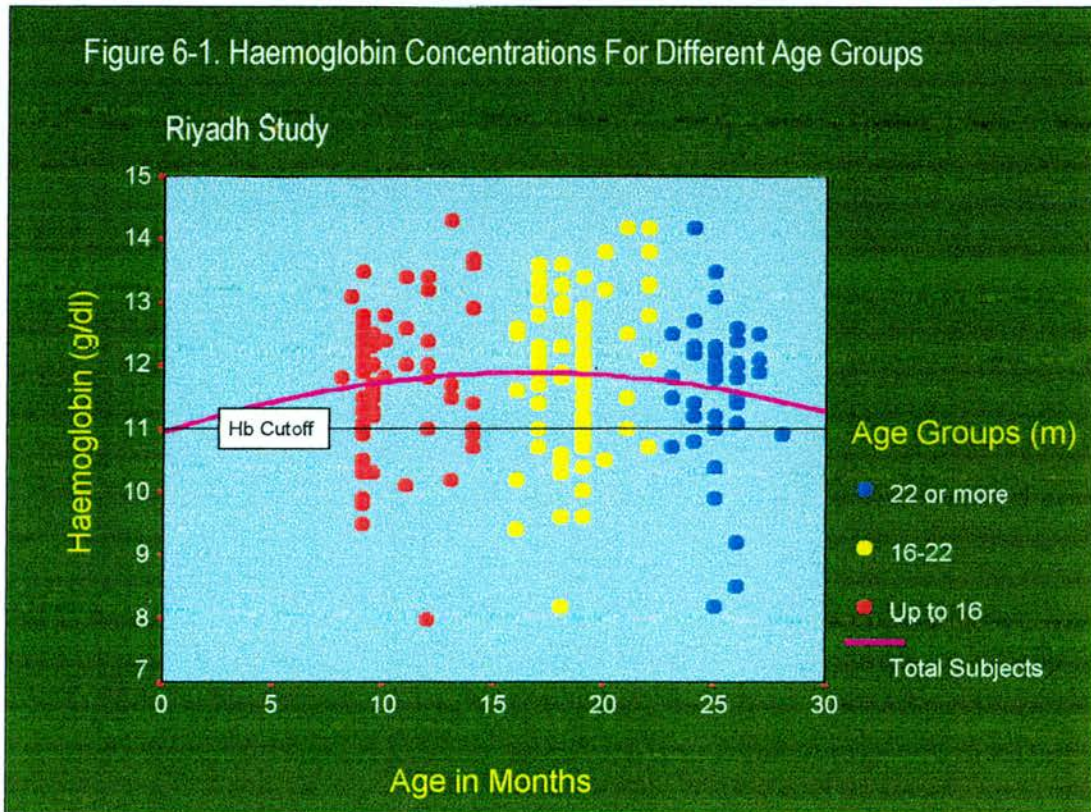
Figure 6-2. MCV Concentrations For Different Age Groups
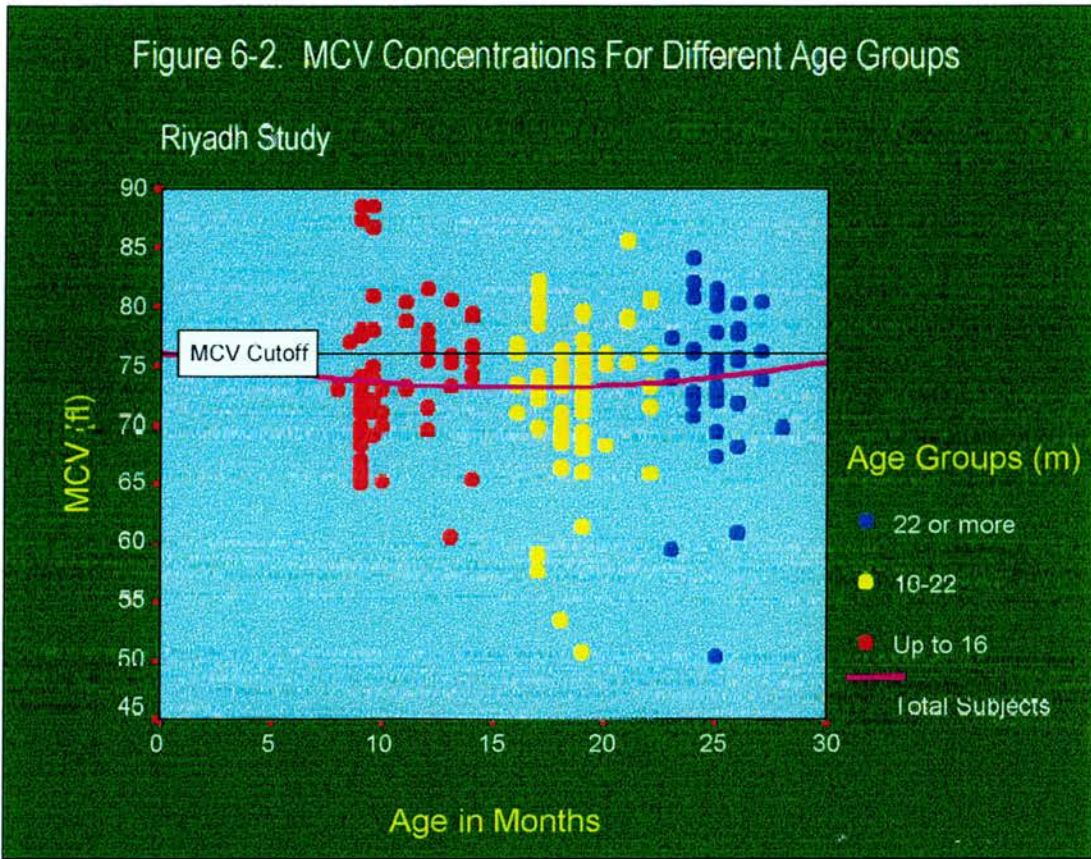
Figure 6-3. Serum Ferritin Concentrations For Different Age Groups
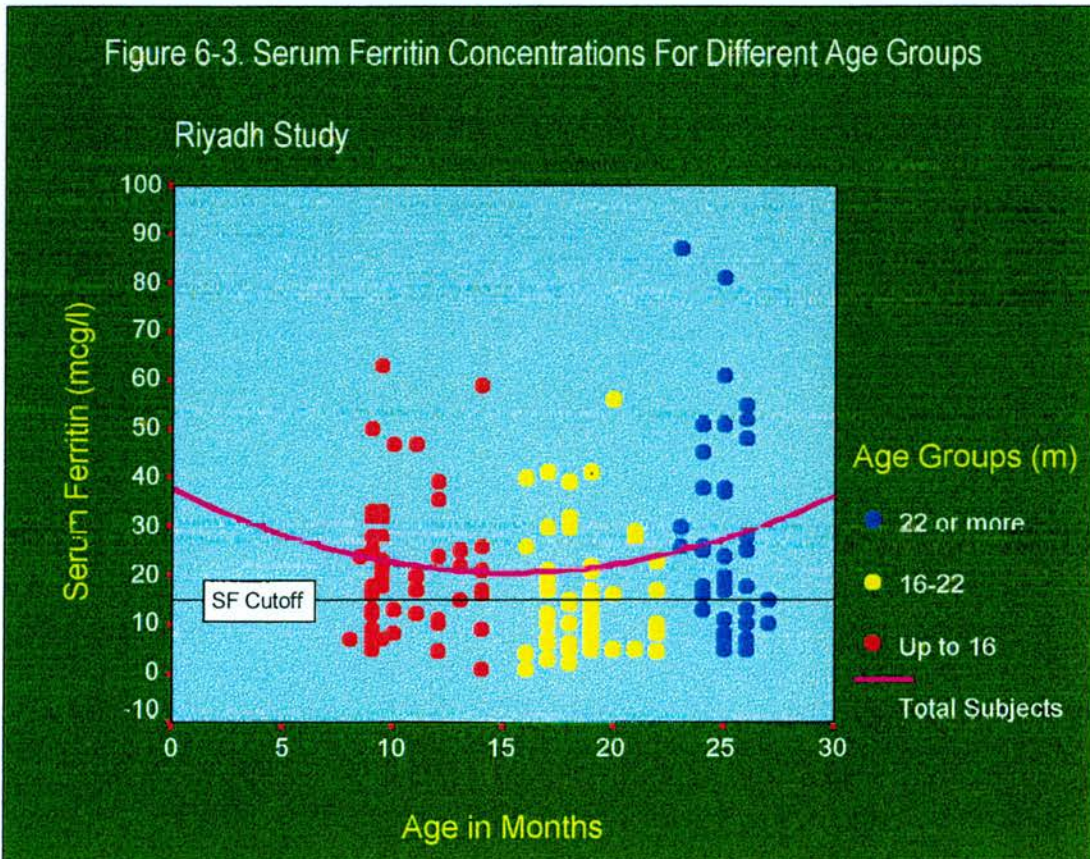
concentration (<15 µg/l), then values dropped down in the second age group, where 36 children (54.5%) had low serum ferritin, but as the regression line shows values increased after so that only 10 children (26.3%) in the highest age group had low serum ferritin.

Iron deficiency anaemia (IDA) was defined as any 2 or more of the parameters Hb, MCV or SF being low. 23 (35.4%) children were iron deficient in the first age group, 33 children (47.8%) in the second age group and only 9 (22.5%) in the third age group. Tables 6-1a and 6-1b summarise data for haemoglobin, MCV, serum ferritin and iron deficient children.

Table 6-1a Frequency of occurrence of iron deficiency in different age groups (The Riyadh study)

		< 16 Months	16-22 Months	22 or > Months
Low	Number of Subjects	68	71	40
Haemoglobin	Frequency	13	17	8
(<11mg/dl)	Percent	19	23.9	20
Low	Number of Subjects	68	71	40
MCV	Frequency	47	49	23
(<76fl)	Percent	69	69	57.5
Low	Number of Subjects	63	66	38
Serum Ferritin	Frequency	18	36	10
(<15µg/l)	Percent	28.6	54.5	26.3
Iron	Number of Subjects	65	69	40
Deficiency *	Frequency	23	33	9
	Percent	35.4	47.8	22.5

* Defined as 2 or more parameters (Hb, MCV and SF) below normal

Table 6-1b. Blood results of the Riyadh study by age groups and sex

		Children ages in months			Sex		
		< 16	16-22	22 or >	Boy	Girl	Total
Haemoglobin	Mean	11.7	11.90	11.58	11.73	11.8	11.78
(g/dl)	Median	11.8	11.85	11.80	11.80	11.9	11.80
n=176	Minimum	8.0	9.40	8.20	8.50	8.0	8.00
	Maximum	14.3	14.20	14.20	13.80	14.3	14.30
MCV	Mean	73.9	73.25	74.16	73.12	74.3	73.73
(fl)	Median	73.5	73.85	75.05	73.40	75.3	73.95
n =176	Minimum	60.5	50.70	50.40	50.70	50.4	50.40
	Maximum	88.6	85.60	84.10	88.60	87.4	88.60
Serum Ferritin	Mean	24.9	15.91	33.47	21.83	25.1	23.45
(µg/l)	Median	18.0	14.00	24.50	16.00	18.0	17.00
n=164	Minimum	0.9	0.80	5.00	0.80	3.0	0.80
	Maximum	148.0	56.00	217.00	148.00	217.0	217.00

* Defined as 2 or more blood parameters (Hb, MCV or SF) below the cut off

Table 6-2 shows correlations between blood parameters in different age groups. Hb and MCV in the second age group were correlated positively with Hb and MCV in the first age group, $r = 0.561$, $p<0.001$ for Hb and $r=0.320$, $p<0.05$ for MCV. Hb in the second age group is also correlated with SF in the first age group $r= 0.333$, $p<0.05$. Very highly significant positive correlations were seen between Hb and both MCV and SF within the second age group, $r=0441$ $p<0.0001$ and $r=0.540$ $p<0.0001$ respectively while MCV was positively correlated with SF in that age group, $r=0304$ $p<0.007$. There were strong positive correlations between Hb, MCV and SF in the second age group and Hb in the third age group, $r=0.622$ $p<0.0001$, $r=0.590$

p<0.0001 and r=0.430 p<0.005 respectively. MCV in the second age group was correlated positively with MCV in the third age group, r= 0.791 p<0.0001 but Hb had less strong correlation with MCV, r = 0.376 p<0.01.

Hb in the third age group correlated positively with Hb in the first age group, r = 0.411 p<0.05 and with MCV within the same age group, r = 0.660 p<0.0001. SF in this third age group was negatively correlated with MCV, r = -0.405 p< 0.05.

IRON INTAKE

The mean iron intake for all children was 5.38 mg/d with range of 0.95 to 13.28 mg/d. It was higher among boys than in girls, being 5.40 mg/d in boys and ranged between 0.95 to 11.57 mg/d versus 5.35 mg/d in girls and ranged between 1.29 mg/d to 13.28 mg/d. The mean iron intake per 1000 kcal dietary energy intake was 6.40, ranged between 2.44 and 18.95 mg/1000 kcal. Girls had the highest value 6.57 mg/1000 kcal ranged between 2.44 to 18.95 mg/1000 kcal. Boys mean was 6.24 mg/1000 kcal with minimum 2.52 and maximum 14.87 mg/1000 kcal.

0.53 mg/kg body weight was the mean for iron intake and this ranged between 0.11 to 1.98 mg/kg body weight. The mean for boys was 0.52 and for girls 0.54 mg/kg body weight. Table 6-3 summarises iron intake by sex for all Saudi children.

Table 6-4 shows iron intake expressed by mg/d, mg per 100 kcal and mg per kg body weight for the different age groups and for both sexes. The mean daily intakes for the first age group were 6.50 mg with a range between 1.95-13.28, 8.83 mg/1000 kcal with a range between 2.61-18.95 and 0.73mg/kg body weight with a range between 0.11-1.98 in mg, mg per 1000 kcal and mg per kg body weigh respectively.

The means for the second age group were lower then the first age group. There were 4.38 mg/d ranged between 1.29-9.51, 4-95 mg per 1000 kcal ranged between 2.44-9.72 and 0.40 mg per kg body weight ranged between 0.11-0.87. For the third age group the mean daily intake by mg was 5.14 with range between 2.71-8.56, 4.52 mg per 1000 kcal ranged between 2.97-8.51 and 0.42 mg per kg body weight with a range between 0.19-0.81. Figure 6-4 summarises the daily iron intake for the different age groups, but it shows only RNI and LRNI for infants.

Table 6-2. Correlations between blood parameters in different age groups

Age Groups		16-22 months									>22 months								
		Hb n=31			MCV n=31			SF n=30			Hb n=24			MCV n=24			SF n=24		
		r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
<16 months	Hb	0.561	0.001	**	0.320	0.039	*	0.287	0.062		0.411	0.023	*	0.333	0.056		-0.090	0.337	
	MCV	0.182	0.164		0.191	0.151		0.017	0.464		0.082	0.351		0.097	0.327		-0.405	0.025	*
	SF	0.333	0.039	*	-0.292	0.062		0.155	0.215		0.051	0.409		0.138	0.265		-0.138	0.265	
16-22 months	Hb				0.441	0.000	***	0.540	0.000	***	0.622	0.000	***	0.376	0.012	*	0.238	0.085	
	MCV	0.441	0.000	***				0.304	0.007	**	0.590	0.000	***	0.791	0.000	***	0.189	0.138	
	SF	0.540	0.000	***	0.304	0.007	**				0.430	0.004	**	0.259	0.063		0.046	0.396	
>22 months	Hb	0.622	0.000	***	0.590	0.000	***	0.430	0.004	**				0.660	0.000	***	0.259	0.058	
	MCV	0.376	0.012	*	0.791	0.000	***	0.259	0.063		0.660	0.000	***				0.083	0.311	
	SF	0.238	0.085		0.189	0.138		0.046	0.396		0.259	0.058		0.083	0.311				

*** Correlation is significant at the 0.001 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Table 6-3. Iron intake by sex for all the Saudi children

		Sex		Total
		Boys	Girls	
Daily Iron Intake (mg)	Mean	5.40	5.35	5.38
	Median	4.69	4.97	4.87
	Minimum	0.95	1.29	0.95
	Maximum	11.57	13.28	13.28
	Std Deviation	2.47	2.44	2.45
Iron Intake (mg per 1000 kcal)	Mean	6.24	6.57	6.40
	Median	5.23	5.20	5.22
	Minimum	2.52	2.44	2.44
	Maximum	14.87	18.95	18.95
	Std Deviation	3.06	3.72	3.39
Iron Intake (mg per kg body wt)	Mean	0.52	0.54	0.53
	Median	0.42	0.44	0.44
	Minimum	0.11	0.14	0.11
	Maximum	1.40	1.98	1.98
	Std Deviation	0.29	0.33	0.31

Table 6-4. Iron intake by sex and age in months for the Saudi children

		<16 Months Sex			16-22 Months Sex			>22 Months Sex		
		Boys	Girls	Total	Boys	Girls	Total	Boy	Girl	Total
Daily Iron Intake (mg)	Mean	6.55	6.46	6.50	4.50	4.25	4.38	4.96	5.39	5.14
	Median	6.61	6.24	6.31	4.07	4.00	4.01	4.74	5.40	4.92
	Minimum	1.95	1.70	1.95	1.32	1.29	1.29	2.88	2.71	2.71
	Maximum	11.57	13.28	13.28	9.51	8.89	9.51	7.51	8.56	8.56
	Std Deviation	2.92	2.96	2.92	2.09	1.61	1.85	1.27	1.57	1.40
Iron Intake (mg per 1000 kcal)	Mean	8.62	9.05	8.83	4.84	5.05	4.95	4.52	4.52	4.52
	Median	8.70	8.05	8.11	4.53	4.66	4.55	4.15	4.18	4.17
	Minimum	2.61	2.87	2.61	2.52	2.44	2.44	2.97	3.40	2.97
	Maximum	14.87	18.95	18.95	7.88	9.72	9.72	7.95	8.51	8.51
	Std Deviation	3.48	4.56	4.03	1.40	1.55	1.48	1.16	1.31	1.21
Iron Intake (mg per kg body wt)	Mean	0.71	0.74	0.73	0.41	0.39	0.40	0.39	0.45	0.42
	Median	0.69	0.63	0.69	0.35	0.37	0.37	0.39	0.42	0.40
	Minimum	0.11	0.17	0.11	0.11	0.14	0.11	0.26	0.19	0.19
	Maximum	1.40	1.98	1.98	0.83	0.87	0.87	0.63	0.81	0.81
	Std Deviation	0.34	0.41	0.37	0.18	0.15	0.17	0.10	0.17	0.13

Figure 6-5 shows that only 20% of children achieved the RNI of iron, 23% achieved less than 50% of the RNI. 114 (61.3%) of those who did not achieve the RNI were children aged more than 1 year, 66 children of them were aged between 16-22 months, 11 children were younger and 37 older. On another hand, of the 39 children (21%) who did not achieve the LRNI, 27 were from the second age group, 5 were children younger and 7 children older and 11 infant (5.9%) did not achieved LRNI.

Figure 6-4. Daily Iron Intake For Different Age Groups

Figure 6-5. Percentage of RNI for iron a chieved by children
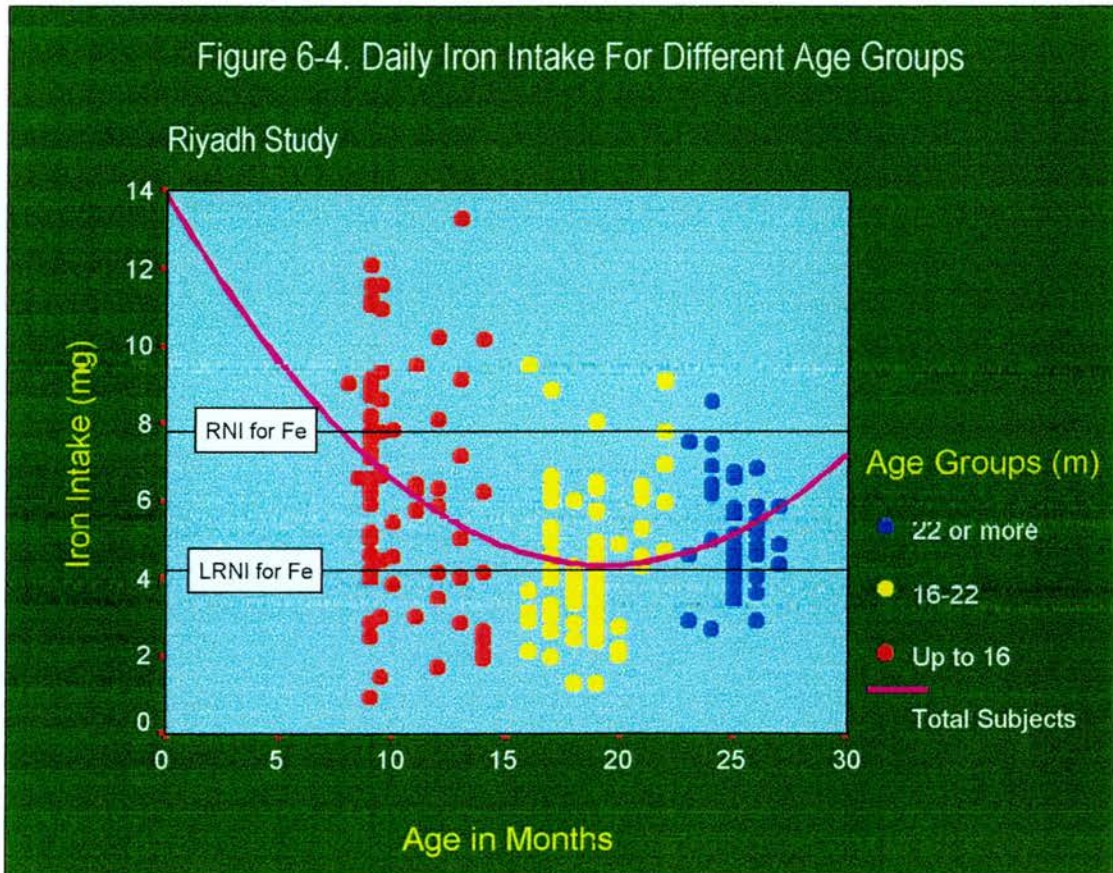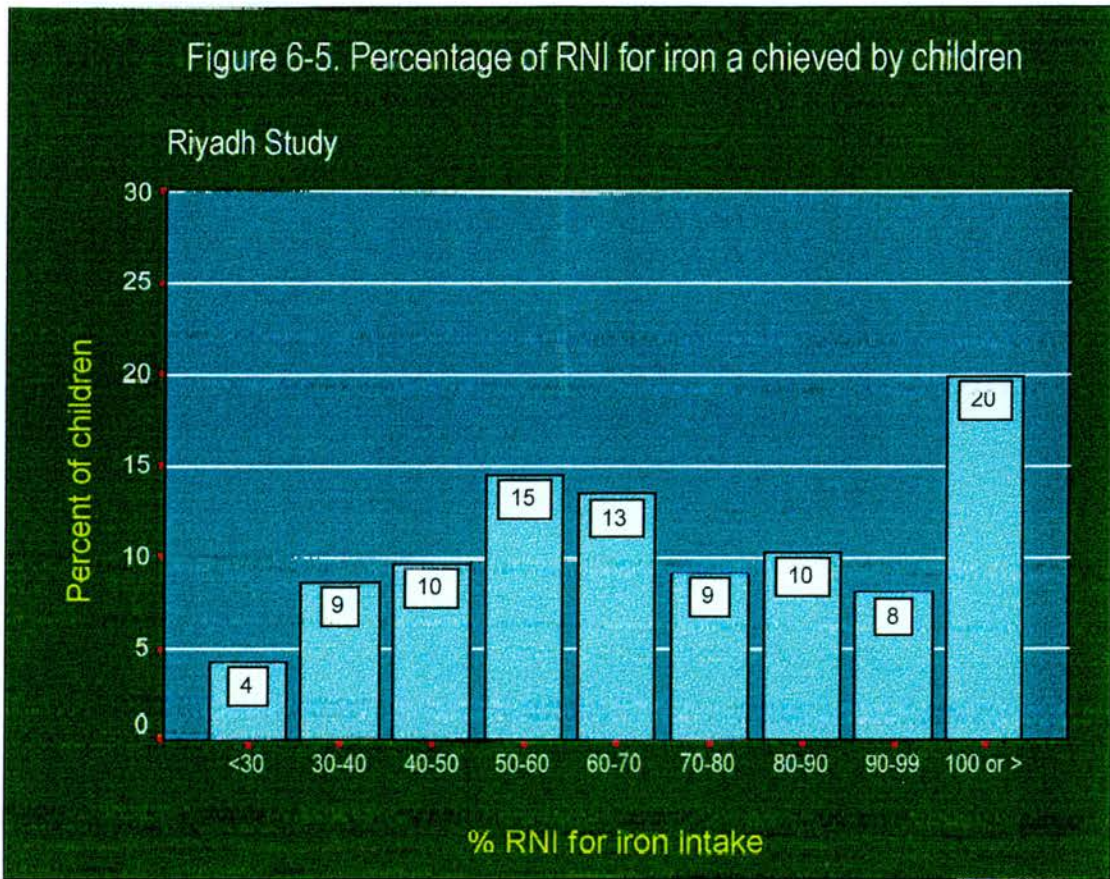
IRON INTAKE AND BLOOD RESULTS

Three children had low Hb concentration despite having sufficient iron intake. As shown in table 6-5, iron intake in the first age group was positively correlated with serum ferritin within that group, $r = 0.384$ $p < 0.001$ and a trend with HB $r = 0.183$ $p < 0.07$, and with Hb in the second and third age groups, $r = 0.495$ $p < 0.005$ and $r = 0.350$ $p < 0.05$ respectively.

Iron intake in the second age group only correlated with Hb and MCV in that group, $r = 0.267$ $p < 0.05$ and $r = 0.207$ $p < 0.05$ respectively. Iron intake in the third age group was correlated with Hb and MCV in both second and third age groups, $r = 0.278$ $p < 0.05$ and $r = 0.394$ $p < 0.01$ for Hb and MCV in the second age group, and $r = 0.374$ $p < 0.01$ and $r = 0.419$ $p < 0.005$ for the same parameters in the third age group (table 6-5).

A straight regression line in figure 6-6 shows a positive correlation between Hb and iron intake. 11 infants (20% of infant) and 3 children (23% of children) had low RNI and a low Hb, while only 2 infants and one child had an iron intake above the RNI with a low Hb

Table 6-5. Correlation between iron intake and blood results in different age groups

Age of children	Number of Subjects	Iron Intakes								
		<16 months n=67			16-22 months n=35			>22 months n=24		
		r	p	Sig	r	p	Sig	r	p	Sig
<16 months	Hemoglobin	0.183	0.069		0.092	0.299		0.059	0.392	
	MCV	0.015	0.453		0.038	0.414		-0.220	0.151	
	Serum Ferritin	0.384	0.001	**	0.099	0.291		0.188	0.195	
16-22 months	Hemoglobin	0.495	0.002	**	0.267	0.013	*	0.278	0.051	*
	MCV	0.207	0.132		0.207	0.044	*	0.394	0.010	**
	Serum Ferritin	0.265	0.078		0.011	0.464		0.141	0.209	
>22 months	Hemoglobin	0.350	0.047	*	-0.183	0.143		0.374	0.010	**
	MCV	0.297	0.079		-0.019	0.457		0.419	0.004	**
	Serum Ferritin	0.058	0.394		-0.102	0.279		0.123	0.233	

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Figure 6-6. Iron Intake Compared with Hb For Different Age Groups
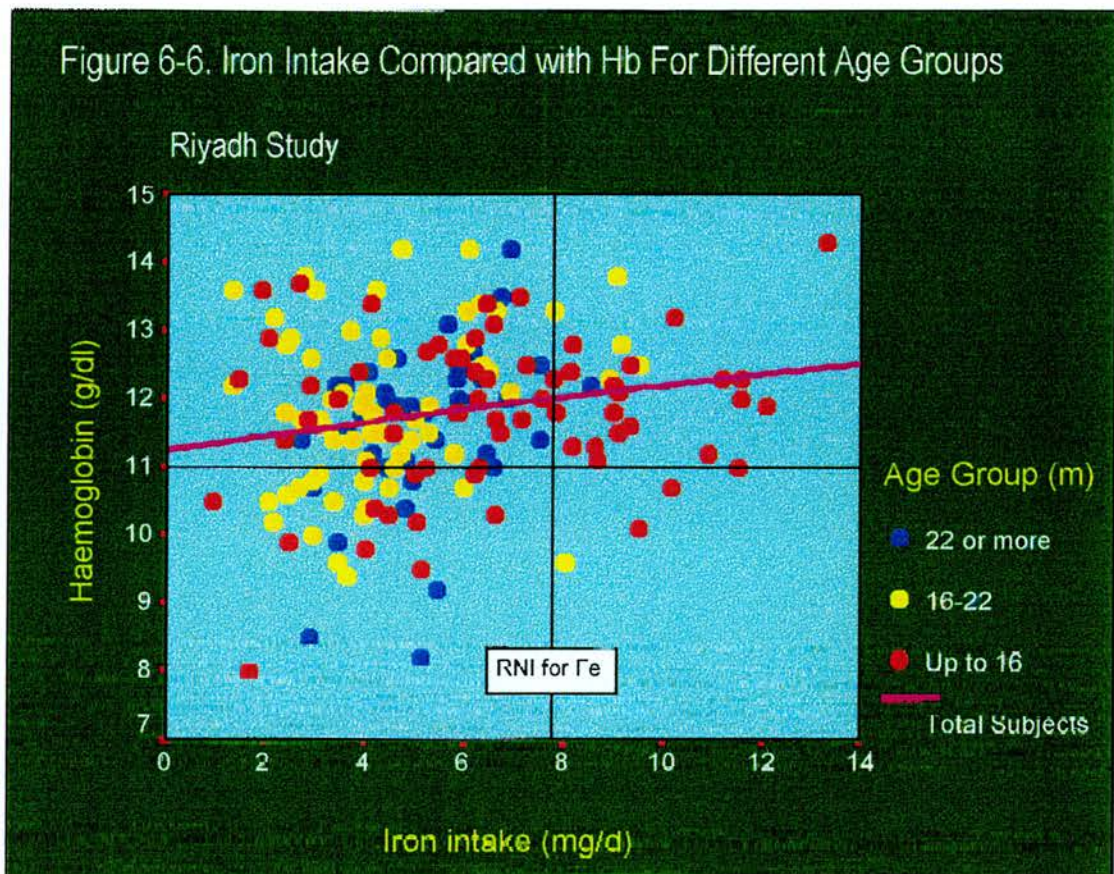
concentration as shown in table 6-6. 20 infants and 7 children had low Hb but normal RNI. For children in the second age group, 17 children (25%) had both low RNI and Hb, but only one child had a normal RNI with low Hb. On another hand, 45 children (67% of that age group) had low RNI and Normal Hb concentration. All children in the third age group with low RNI had low Hb concentration.

The regression curve showing the correlation between MCV and iron intake showed an increase then dropped again (figure 6-7). Most of the subjects (20 infants and 72 children) with low MCV had an iron intake below RNI, the majority (43 children, 64%) of these being aged between 16-22 months. More young children were below MCV cut off despite achieving the RNI for iron when compared with Hb and correlation, (figures 6-6 and 6-7). More details about this data are shown in table 6-6.

Iron intake was significantly positively correlated with serum ferritin as shown in figure 6-8. The second age group had the most children with an iron intake below the RNI and a low SF (35 children, 56% of that age group). 16 infants (30%) were also had low RNI and SF, whereas no older children with low SF achieved the RNI. 6, 22 and 24

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Figure 6-7. Iron Intake Compared with MCV For Different Age Groups

Riyadh Study
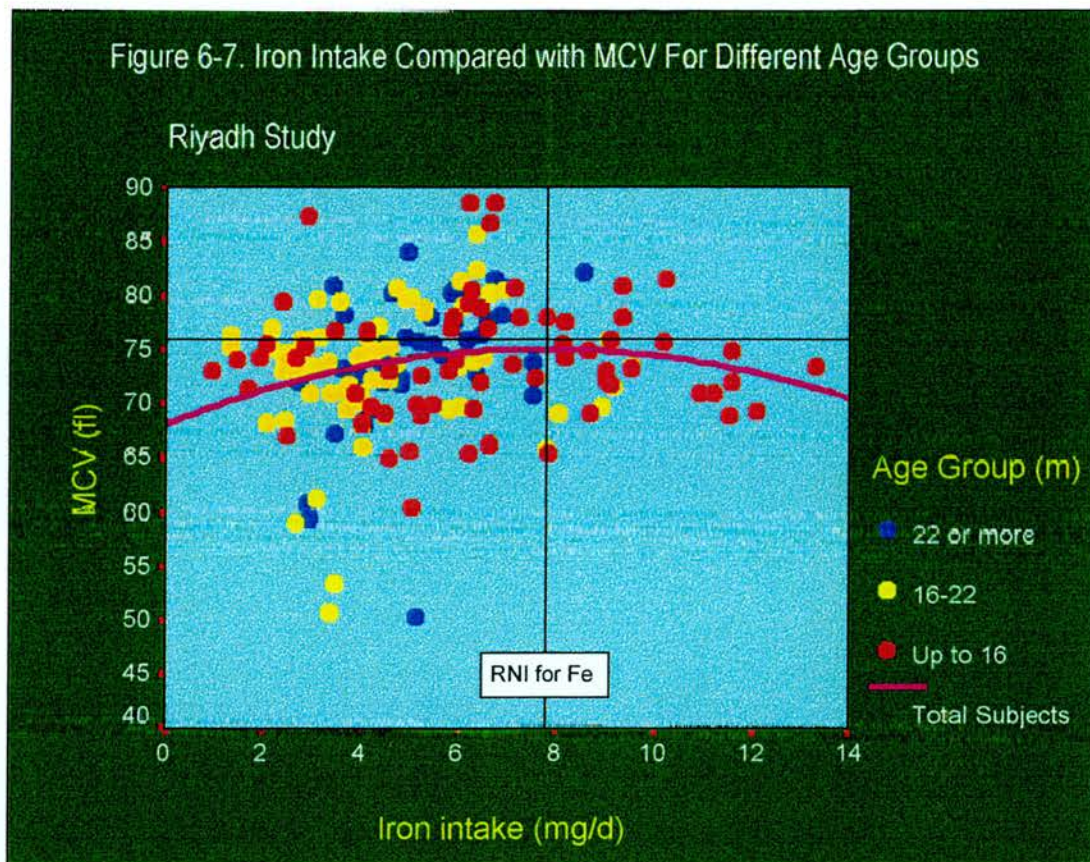
Figure 6-8. Iron Intake Compared with SF For Different Age Groups

Riyadh Study
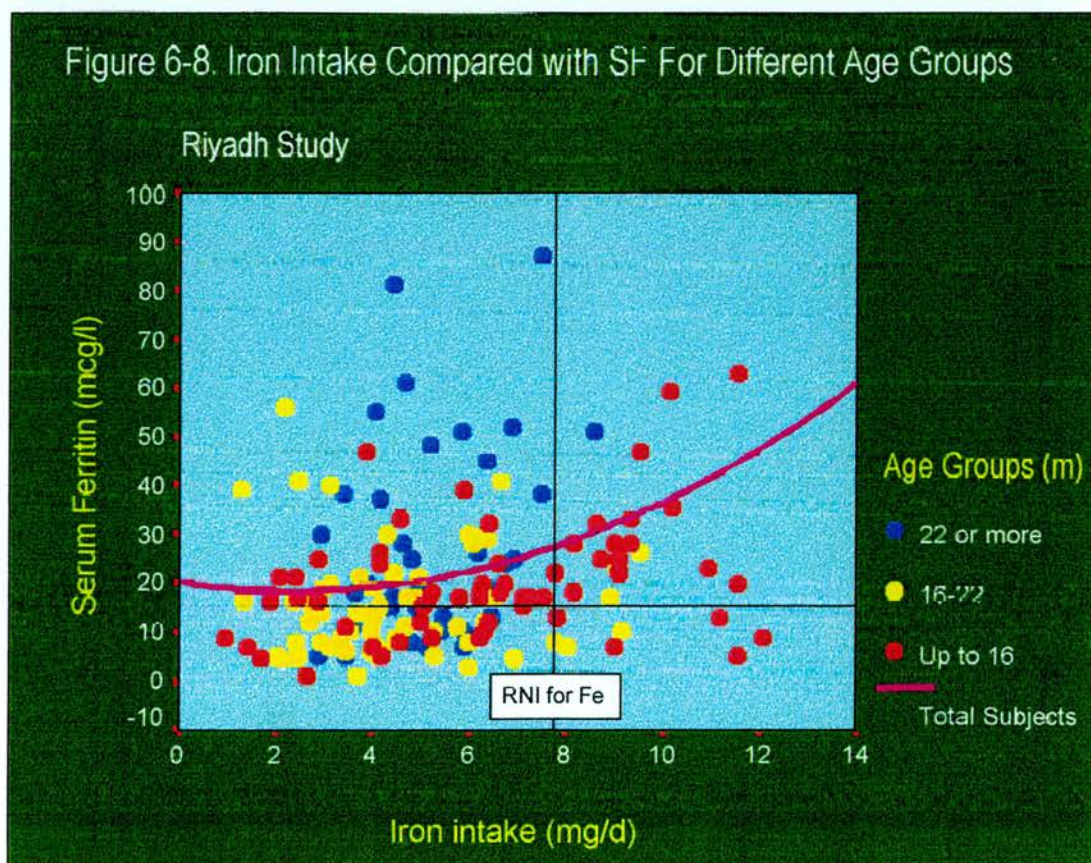
Table 6-6 Comparison between those achieving the RNIs for iron in different age groups and those having low blood parameters

(The Saudi study)

		Childrens' age groups in months							
		Up to 16 months				6-22 month		>22 months	
		<RNI		RNI>		<RNI	RNI>	<RNI	RNI>
		Infant	Children	Infant	Children				
Hb < 11g/dl	Total	54	13	54	13	67	67	38	38
	Low	11	3	2	1	17	1	9	0
	%	20	23	4	8	25	2	24	0
MCV < 76fl	Total	54	13	54	13	67	67	38	38
	Low	20	6	17	3	43	5	23	0
	%	37	46	32	23	64	8	61	0
SF < 15 mcg/l	Total	54	13	54	13	62	62	37	37
	Low	16	4	8	0	35	2	12	0
	%	30	31	15	0	56	3	32	0

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children from first, second and third age groups respectively had a normal SF with a iron intake below the RNI.

IRON SOURCES

Tables 6-7, 6-8 and 6-9 show the best sources of iron for the different age groups. A total amount of 7.72 mg/d was provided by food groups shown for the first age group. Baby foods especially baby cereal provided 37.66% of the total iron intake, followed by infant formula (25.2%) and cereals, mainly biscuits, rice and bread (13.2%). Milk and milk products provided 5.83%, and 4.41% came from meat and fish. Vegetables, eggs, fruits and juices, human milk, snacks, honey and sugars contributed 4.04, 3.63, 2.81, 2.44 and 0.54 respectively. Only 0.2% of total iron intake was provided by breakfast cereals for this age group.

Cereals, baby foods, milk and milk products and eggs provided 30.1, 13.9, 13.8 and 10.2% of iron intake respectively for the second age group. Vegetable, meat and fish, fruits and juices and snacks came after that with 8.07, 7.8, 7.9, and 3.1% respectively. Infant formulas dropped down to provide only 2.3% in this age group, breakfast cereals and human milk at the bottom of the list with 1.5 % for both.

The total iron intake dropped to 6.1 mg/d in the third age group. Cereals continued leading the list providing 41.1% of total iron intake. Eggs, milk and milk products, meat and fish, vegetables, baby foods, fruits and juices, and snacks provided 11.6%, 9.3%, 8.6%, 7.7%, 7.2%, 5.5% and 4.4% respectively. Breakfast cereals, infant formulas and human milk provided 2.5%. 2.0% and 0.1% of total iron intake.

Table 6-7. Sources of iron for children aged <16 months (The Saudi study)

Food Group	% of total intake
Baby Foods	37.66
Infant Formulas	25.24
Cereals	13.23
Milk & Products	5.83
Meats and Fish	4.41
Vegetables	4.04
Eggs	3.63
Fruits and Juices	2.81
Human Milk	2.44
Snacks, honey and sugars	0.54
Breakfast Cereals	0.20
Total	100.00

Table 6-8. Sources of iron for children aged 16-22 months (The Saudi study)

Food Group	% of total intake
Cereals	30.13
Baby Foods	13.90
Milk & Products	13.76
Eggs	10.15
Vegetables	8.07
Meats and Fish	7.79
Fruits and Juices	7.94
Snacks, honey and sugars	3.10
Infant Formulas	2.31
Breakfast Cereals	1.45
Human Milk	1.47
Total	100.00

Table 6-9. Sources of iron for children aged >22 months (The Saudi study)

Food Group	% of total intake
Cereals	41.05
Eggs	11.64
Milk & Products	9.29
Meats and Fish	8.64
Vegetables	7.69
Baby Foods	7.22
Fruits and Juices	5.45
Snacks, honey and sugars	4.44
Breakfast Cereals	2.48
Infant Formulas	1.96
Human Milk	0.14
Total	100.00

HAEM AND NON-HAEM IRON

Only as little as 0.20, 0.33 and 0.44 mg/d were the intake of haem iron for the three age group respectively. This contributed only 4.4, 8 and 8.4% of the total iron intake for each age group respectively. This means that non-haem iron intakes for the same age groups were 6.20 (95.6%), 4.04 (92%) and 4.90 (91.6%) respectively. Table 6-10 shows details of this data.

Table 6-10. Haem and non-haem iron intakes in different age groups of Saudi children

	Haem iron		Non-haem iron	
	Amounts mg/d	%	Amounts mg/d	%
< 16 Months n=72	0.20	4.40	6.30	95.60
16-22 Months n=73	0.33	8.02	4.05	91.88
> 22 Months n=37	0.44	8.43	4.80	91.57

Vitamin C

The highest intakes of vitamin C were among the oldest age group. The regression line dropped to the lowest level at the end of the second year of life, then increased. 18 children (10%) had intake below the RNI which is 25 mg/d. Figure 6-9 shows vitamin C plotted against age to show the development of it's intake.

Figure 6-9. Daily Intake of Vitamin C For Different Age Groups

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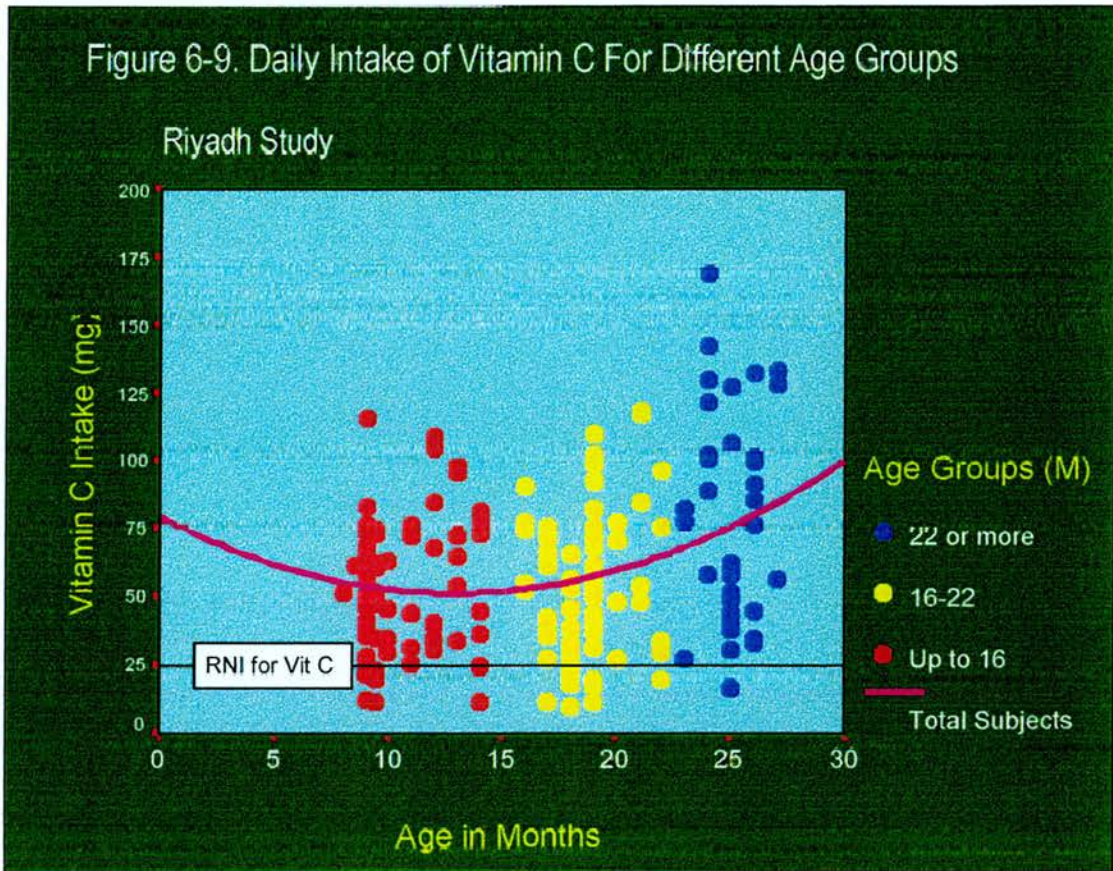
CORRELATIONS BETWEEN THE BLOOD PARAMETERS AND NUTRIENT INTAKE WITHIN DIFFERENT AGE GROUPS

Children aged up to 16 months

From data taken from actual weighed intake, only vitamin B1 and folate correlated positively with Hb concentration, $r= 0.272$ $p< 0.05$ and $r= 0.242$ $p<0.05$ respectively (table 6-11). Strong positive correlations were found between serum ferritin concentration and iron intake; $r=0.384$ $p<0.005$, copper $r=0.351$ $p<0.005$, vitamin B1 $r= 0.437$ $p<0.0005$, vitamin B12 $r= 0.514$ $p<0.0001$, vitamin A $r=0.422$ $p< 0.001$ and vitamin D $r=0.369$ $p<0.005$. Less strong positive correlations were found with energy intake (kcal) $r= 0.281$ $p< 0.05$, protein $r= 0.295$ $p< 0.05$, carbohydrate $r= 0.261$ $p< 0.05$, vitamin B2 $r= 0.267$ $p< 0.05$ and folate $r=0.267$ $p<0.05$.

Energy and carbohydrate intakes were negatively correlated with the children being iron deficient, $r= -0.246$ $p<0.05$ and $r= -0.242$ $p<0.05$. It was negatively correlated between zinc $r=-0.253$ $p<0.05$, copper $r= -0.274$ $p<0.05$, folate $r= -0.267$ $p<0.05$, vitamin A $r= -0.272$ $p<0.05$ and iron deficiency.

From the food frequency questionnaire data as shown in table 6-12, many foods correlated with blood parameters. Hb was correlated positively with chicken $r= 0.281$ $p<0.05$, fish fingers $r= 0.269$ $P< 0.05$. Green salad and mixed vegetables $r= 0.254$ $p<0.05$ and $r= 0.243$ $p<0.05$ respectively, also cake and fresh orange juice $r= 0.259$ $p<0.05$ and $r= 0.250$ $p<0.05$ respectively. Negative correlations were found with egg yolk and Merinda (carbonated drink similar to Fanta drink) $r= -0.244$ $p<0.05$ and $r= -0.036$ $p<0.05$.

MCV was correlated positively with mixed vegetables $r= 0.286$ $p<0.05$ and negatively with cheddar cheese and Mirenda, $r= -0.294$ $p<0.05$ and $r= -0.290$ $p<0.05$ respectively. Stronger correlations were found positively with mango and condensed milk, $r= 0.297$ $p<0.01$ and $r= 0.321$ $p<0.01$ respectively, and negatively with cola, $r= -0.305$ $p<0.01$. Serum ferritin correlated positively with processed cheese, fried eggs and full cream laban (buttermilk), $r= 0.272$ $p<0.05$, $r= 0.266$ $p<0.05$ and $r= 0.305$ $p< 0.05$ respectively. Brown bread, apples, cake, milk with chocolate, fresh orange juice

Table 6-11. Correlation between blood results and average daily nutrients intakes for the Saudi children < 16 months of age (From weighed intake data)

Correlations	Haemoglobin n=67			MCV n=67			Serum Ferritin n=62			Iron deficient n=64	
	r	p	Sig	r	p	Sig	r	p	Sig	r	p
Energy (kcal)	0.194	0.116		0.078	0.529		0.281	0.027 *		-0.246	0.050 *
Protein (g)	0.217	0.077		0.140	0.258		0.295	0.020 *		-0.177	0.162
Carbohydrate (g)	0.222	0.071		0.017	0.890		0.261	0.041 *		-0.242	0.054 *
Sodium (mg)	0.129	0.297		-0.029	0.818		0.247	0.053 *		-0.080	0.528
Iron (mg)	0.183	0.138		0.015	0.907		0.384	0.002 **		-0.151	0.233
Zinc (mg)	0.174	0.159		0.040	0.746		0.162	0.210		-0.253	0.043 *
Copper (mg)	0.212	0.085		-0.028	0.822		0.351	0.005 **		-0.274	0.028 *
Vitamin B1 (mg)	0.272	0.026 *		0.064	0.607		0.437	0.000 ***		-0.166	0.191
Vitamin B2 (mg)	0.173	0.161		0.033	0.790		0.296	0.020 *		-0.136	0.284
Vitamin B12 (mcg)	0.210	0.088		0.007	0.956		0.514	0.000 ***		-0.167	0.186
Folate (mcg)	0.242	0.049 *		0.050	0.690		0.267	0.036 *		-0.267	0.033 *
Vitamin A (mcg)	0.199	0.107		0.162	0.191		0.422	0.001 ***		-0.272	0.030 *
Vitamin D (mcg)	0.229	0.062		0.028	0.821		0.369	0.003 **		-0.201	0.112

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Table 6-12. Correlation between blood results and average intakes of specific foods for the Saudi children < 16 months of age (from FFQ data)

Correlations	Haemoglobin n=68			MCV n=68			Serum Ferritin n=63			Iron intake n=73		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Infant formula	0.137	0.266		0.006	0.962		0.222	0.081		0.386	0.001	**
Chicken	0.281	0.020	*	0.039	0.751		0.148	0.248		-0.288	0.013	*
Fish fingers	0.269	0.027	*	0.014	0.911		0.018	0.891		0.043	0.719	
Cerelac with Wheat	0.073	0.554		-0.095	0.440		0.181	0.157		0.282	0.016	*
Rusks	-0.040	0.746		-0.122	0.320		-0.056	0.661		0.312	0.007	**
Sweet Biscuits	-0.098	0.425		-0.092	0.454		-0.074	0.567		-0.351	0.002	**
Spaghetti	0.127	0.301		0.027	0.826		0.016	0.899		-0.287	0.014	*
Brown Bread	0.173	0.159		0.012	0.925		0.393	0.001	**	-0.054	0.650	
Green Salad	0.254	0.036	*	-0.044	0.723		0.012	0.926		-0.092	0.439	
Mixed Vegetables	0.243	0.045	*	0.286	0.018	*	0.078	0.541		-0.078	0.510	
Lentil Soup	0.085	0.489		-0.041	0.738		-0.075	0.557		0.227	0.050	*
Processed Cheese	-0.004	0.976		-0.129	0.293		0.272	0.031	*	0.006	0.960	
Cheddar Cheese	-0.174	0.155		-0.294	0.015	*	-0.049	0.701		-0.059	0.619	
Yogurt semi-skimmed	0.203	0.097		0.093	0.449		-0.155	0.225		-0.280	0.016	*
Apples	0.129	0.295		-0.091	0.458		0.324	0.010	**	0.090	0.449	
Mango	-0.056	0.649		0.297	0.010	**	-0.035	0.788		-0.005	0.964	
Egg Yolk	-0.244	0.045	*	-0.145	0.238		-0.026	0.839		0.063	0.598	
Fried Eggs	0.020	0.869		0.038	0.761		0.266	0.035	*	0.145	0.221	
Cake	0.259	0.033	*	0.028	0.818		0.470	0.000	**	0.209	0.076	
Crisps	0.079	0.522		-0.077	0.532		-0.100	0.435		-0.257	0.028	*
Laban full cream	0.127	0.302		0.021	0.865		0.305	0.015	*	-0.057	0.630	
Dry full cream milk	-0.028	0.824		0.098	0.425		-0.088	0.492		-0.413	0.000	***
Condensed milk	0.068	0.580		0.321	0.008	**	-0.034	0.788		-0.012	0.917	
Milk with Chocolate	0.025	0.841		0.101	0.412		0.413	0.001	**	0.032	0.786	
Fresh Orange Juice	0.250	0.040	*	0.164	0.182		0.397	0.001	**	-0.037	0.759	
Canned Orange Juice	0.036	0.769		-0.015	0.906		-0.092	0.475		-0.297	0.011	*
Cola	-0.036	0.772		-0.305	0.011	**	0.056	0.664		-0.012	0.921	
Merinda	-0.269	0.027	*	-0.290	0.017	*	-0.141	0.271		-0.113	0.341	
Lemonade	-0.099	0.421		-0.044	0.722		0.371	0.003	**	-0.021	0.857	

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

and lemonade were correlated strongly positively with serum ferritin, r= 0.393 p<0.001, r= 0.324 p< 0.01, r= 0.470 p<0.0001, r=0.413 p<0.001, r= 0.397 p<0.001 and r= 0.371 p<0.005 respectively. Frequency of intake infant formula, Cerelac wheat (baby cereals), rusks, and lentil soup were correlated with iron intake r= 0.386 p<0.01, r= 0.282 p<0.05, r= 0.312 p<0.01 and r= 0.227 p<0.05. Some negative correlation were found with chicken, sweet biscuits, spaghetti, semi-skimmed yoghurt, crisps, dry full cream milk and canned orange juice r=0.288 p<0.05, r= -0.351 p<0.005, r= -0.287 p<0.05, r= -0.280 p<0.05, r= 0.257 p<0.05, r= -0.413 p<0.001 and r= -0.297 p<0.05 respectively.

Children aged 16-22 months

Table 6-13 shows the correlations between blood results and daily average nutrient intakes which had been measured by weighed intake. Hb was correlated positively with energy, protein, fat, monounsaturated fatty acids (MUFA), total saturated fatty acids and carbohydrate with a significance values of p<0.05 and r values for these nutrients were: 0.292, 0.261, 0.300, 0.260, 0.300, 0.234 respectively.

Some minerals such as calcium, phosphorus, magnesium, sodium, potassium, iron and iodine had the same value of significance, p<0.05 with r= 0.333, r= 0.299, r= 0.260, r= 0.280, r= 0.313, r= 0.267 and r= 0.324 respectively. Chloride and zinc were even more strongly correlated with Hb r= 0.347 p< 0.005 and r= 0.335 p< 0.005. Vitamins B1 and E had a significant value of p<0.05 with r= 0.305 and r= 0.235 respectively. Vitamins B2 and B6 had stronger correlations, r= 0.330 p<0.01 and r= 0.342 p<0.005 respectively.

Only vitamin E had a strong positive correlation with MCV r= 0.354 p<0.005, and only iodine had a positive correlation with serum ferritin r= 0.279 p<0.05. Calcium, iodine and vitamin B2 had negative correlations with iron deficiency, r= -0.247 p<0.05, r= -0.263 p<0.05, and r= -0.273 p<0.05 respectively.

Some foods generated from the FFQ are shown in table 6-14 with the correlations between blood parameters and iron intake. Those with positive correlations with Hb

Table 6-13. Correlation between blood results and average daily nutrients intakes for the Saudi children between 16-22 months of age (From weighed intake data)

Correlations	Haemoglobin n=69			MCV n=69			Serum Ferritin n=64			Iron deficient n=67		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Energy (kcal)	0.292	0.015	*	0.087	0.478		0.048	0.706		-0.029	0.817	
Protein (g)	0.261	0.030	*	0.036	0.767		0.047	0.711		-0.084	0.498	
Fat (g)	0.300	0.012	*	0.109	0.374		0.050	0.696		-0.007	0.953	
MUFA (g)	0.260	0.031	*	0.057	0.639		0.063	0.621		0.008	0.947	
Total Saturates (g)	0.300	0.012	*	0.052	0.673		0.093	0.464		-0.040	0.747	
Carbohydrate (g)	0.234	0.053	*	0.057	0.640		0.034	0.791		-0.020	0.870	
Calcium (mg)	0.333	0.005	*	0.073	0.552		0.164	0.196		-0.247	0.044	*
Phosphorus (mg)	0.299	0.012	*	0.107	0.383		0.082	0.518		-0.190	0.123	
Magnesium (mg)	0.260	0.031	*	0.145	0.233		0.122	0.336		-0.166	0.178	
Sodium (mg)	0.280	0.020	*	0.121	0.322		0.028	0.824		-0.064	0.607	
Potassium (mg)	0.313	0.009	*	0.064	0.601		0.139	0.275		-0.165	0.181	
Chloride (mg)	0.347	0.003	**	0.111	0.362		0.148	0.242		-0.127	0.306	
Iron (mg)	0.267	0.027	*	0.207	0.089		0.011	0.929		-0.124	0.318	
Zinc (mg)	0.335	0.005	**	0.134	0.272		0.090	0.479		-0.173	0.161	
Iodine (mcg)	0.324	0.007	*	0.158	0.195		0.279	0.026	*	-0.263	0.032	*
Vitamin B1 (mg)	0.305	0.011	*	0.113	0.354		0.053	0.677		-0.142	0.252	
Vitamin B2 (mg)	0.330	0.006	**	0.067	0.587		0.197	0.119		-0.273	0.025	*
Vitamin B6 (mg)	0.342	0.004	***	0.152	0.211		0.198	0.117		-0.225	0.067	
Vitamin E (mg)	0.235	0.052	*	0.354	0.003	**	0.009	0.943		-0.099	0.424	

*** Correlation is significant at the 0.005 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

Table 6-14. Correlation between blood results and average intakes of specific foods for the Saudi children between 16-22 months of age (from FFQ data)

Correlations	Haemoglobin n=69			MCV n=69			Serum Ferritin n=64			Iron intake n=73		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Beef	0.132	0.280		-0.016	0.895		-0.066	0.602		0.278	0.018	*
Chicken	0.332	0.005	**	0.251	0.037	*	0.129	0.311		0.126	0.291	
Fish fingers	0.071	0.565		-0.006	0.961		0.053	0.676		0.354	0.002	**
Tuna fish	0.127	0.297		0.049	0.691		-0.127	0.317		0.320	0.006	**
Rusks	0.078	0.526		-0.054	0.659		0.044	0.732		0.455	0.000	***
Biscuits with chocolate	-0.016	0.893		0.030	0.809		-0.191	0.130		0.317	0.007	**
Sweet Biscuits	-0.114	0.352		0.011	0.929		-0.137	0.282		0.322	0.006	**
Macaroni	-0.004	0.974		-0.048	0.694		-0.099	0.438		0.275	0.019	*
Spaghetti	0.114	0.349		0.034	0.780		-0.093	0.465		0.243	0.040	*
Arabic Bread	0.257	0.033	*	0.059	0.628		-0.053	0.678		0.381	0.001	***
Mixed Vegetables	0.170	0.164		0.298	0.013	*	-0.001	0.997		0.102	0.393	
Potatoe Soup	-0.079	0.517		-0.259	0.032	*	-0.081	0.524		0.062	0.607	
Courgette Soup	0.161	0.188		0.134	0.273		-0.059	0.643		-0.240	0.043	*
Chickpeas	0.143	0.240		-0.135	0.270		-0.125	0.323		0.282	0.016	*
Cream	0.141	0.247		0.115	0.346		-0.066	0.602		0.246	0.038	*
Yoghurt full cream	0.236	0.051		0.195	0.108		0.114	0.369		0.248	0.036	*
Honey	-0.326	0.006	**	-0.152	0.213		-0.270	0.031		0.026	0.828	
Oranges	0.371	0.002	**	0.159	0.191		0.219	0.082		0.000	0.999	
Pears	-0.127	0.298		-0.368	0.002	**	-0.140	0.271		0.078	0.514	
Boiled Eggs	-0.173	0.155		-0.158	0.195		-0.181	0.153		-0.235	0.047	*
Scrambled Eggs	-0.220	0.069		-0.225	0.063		-0.232	0.065		0.072	0.549	
Ice cream	0.251	0.037	*	0.075	0.541		-0.048	0.709		0.313	0.007	**
Pizza with meat	0.288	0.016	*	0.130	0.288		-0.019	0.881		0.092	0.441	
Meat Sandwiches	0.126	0.303		0.011	0.930		-0.104	0.412		0.340	0.003	**
Eggs Sandwiches	-0.113	0.354		-0.255	0.034	*	-0.061	0.633		-0.092	0.442	
Laban full cream	0.133	0.275		-0.027	0.825		0.053	0.676		0.261	0.027	*
Full cream milk	-0.267	0.027	*	-0.017	0.888		-0.148	0.243		0.098	0.414	
Pineapple Canned Juice	-0.167	0.170		-0.246	0.041	*	-0.102	0.424		-0.085	0.476	
Tea	0.283	0.019	*	0.174	0.152		0.161	0.205		-0.053	0.656	

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

were: chicken r= 0.332 p<0.005, Arabic bread r= 0.257 p<0.05, oranges r= 0.371 p<0.005, ice cream r= 0.251 p<0.05, pizza with meat r= 0.288 p<0.05 and tea 0.283 p<0.05. Other foods had negative correlations i.e. honey r= -0.326 p<0.01 and full cream milk r= -0.167 p<0.05. MCV was correlated positively with chicken r= 0.251 p<0.05, mixed vegetables r= 0.298 p<0.05 and with negative correlations with potato soup r= -0.259 p<0.05, pears r= -0.368 p<0.005, sandwich with egg r= -0.255 p<0.05 and pineapple canned juice r= -0.246 p<0.05.

Iron intake had more significant correlations in this age group than the younger children. Beef, fish fingers, tuna fish were correlated positively with iron intake, r= 0.278 p<0.05, r= 0.354 p<0.005 and r= 0.320 p<0.01 respectively. Rusks were highly positively correlated, r= 0.455 p<0.001, sweet biscuits and biscuits with chocolate, macaroni, spaghetti, Arabic bread, chickpeas, cream, full cream yoghurt, ice cream, sandwiches with meat and full cream laban were positively correlated with iron intake r and p values were: r= 0.322 p<0.01, r= 0.317 p<0.01, r= 0.275 p<0.05, r= 0.243 p<0.05, r= 0.381 p<0.001, r= 0.282 p<0.05, r= 0.246 p<0.05, r= 0.248 p<0.05, r= 0.313 p<0.01, r= 0.340 p<0.005, and r= 0.261 p<0.05. Some other foods were negatively correlated with iron intake, courgette soup and boiled eggs r= -0.240 p<0.05 and r= -0.235 p<0.05 respectively.

Children aged more than 22 months

Nutrient intake and their association to blood parameters are shown in table 6-15. Positive correlation between Hb and some nutrients were found. Energy, fat, carbohydrate, starch were correlated positively with Hb, r= 0.379 p<0.05, r= 0.337 p<0.05, r= 0.355 p<0.05 and r=0.319 p<0.05 respectively. Some minerals such as phosphorus, magnesium, sodium, iron were also correlated positively with Hb too, r= 0.326 p<0.05, r= 0.321 p<0.05, r= 0.328 p<0.05 and r= 0.374 p<0.05 respectively. Folate, vitamin E and cholesterol had positive correlations also, r= 0.326 p<0.05, r= 0.327 p<0.05 and r= 0.355 p<0.05 respectively.

MCV was correlated positively with protein r= 0.371 p<0.05, iron intake r= 0.419 p<0.01, zinc r= 0.366 p<0.05, selenium r= 0.333 p<0.05, vitamin B1 r= 0.348 p<0.05, nicotinic acid r= 0.435 p<0.01, vitamin B6 r= 0.403 p<0.05, folate r= 0.450

Table 6-15. Correlation between blood results and average daily nutrients intakes for the Saudi children more than 22 months of age (From weighed intake data)

Correlations	Haemoglobin n=38			MCV n=38			Serum Ferritin n=37			Iron deficient n=38		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Energy (kcal)	0.379	0.019	*	0.310	0.058		0.246	0.141		-0.432	0.007	**
Protein (g)	0.294	0.073		0.371	0.022	*	0.319	0.050	*	-0.477	0.002	***
Fat (g)	0.337	0.039	*	0.300	0.067		0.267	0.110		-0.366	0.024	*
Carbohydrate (g)	0.355	0.029	*	0.212	0.202		0.130	0.443		-0.375	0.020	*
Total Sugar (g)	0.234	0.157		0.237	0.152		0.144	0.396		-0.406	0.011	*
Starch (g)	0.319	0.050	*	0.056	0.739		0.051	0.763		-0.059	0.725	
Calcium (mg)	0.225	0.175		0.178	0.286		0.370	0.024	*	-0.400	0.013	*
Phosphorus (mg)	0.326	0.046	*	0.290	0.077		0.367	0.025	*	-0.453	0.004	***
Magnesium (mg)	0.321	0.050	*	0.324	0.047		0.242	0.149		-0.474	0.003	***
Sodium (mg)	0.328	0.044	*	0.183	0.272		0.273	0.102		-0.219	0.186	
Potassium (mg)	0.294	0.073		0.313	0.056		0.242	0.148		-0.531	0.001	***
Iron (mg)	0.374	0.021	*	0.419	0.009	**	0.123	0.467		-0.338	0.038	*
Zinc (mg)	0.277	0.092		0.366	0.024	*	0.236	0.159		-0.368	0.023	*
Selenium (mcg)	0.309	0.059		0.333	0.041	*	0.201	0.232		-0.363	0.025	*
Iodine (mcg)	0.218	0.189		0.203	0.222		0.366	0.026	*	-0.288	0.079	
Vitamin B1 (mg)	0.312	0.056		0.348	0.032	*	0.089	0.599		-0.376	0.020	*
Vitamin B2 (mg)	0.239	0.149		0.272	0.099		0.304	0.067		-0.407	0.011	*
Nicotinic acid (mg)	0.300	0.068		0.435	0.006	**	0.190	0.260		-0.473	0.003	**
Vitamin B6 (mg)	0.299	0.068		0.403	0.012	**	0.065	0.701		-0.458	0.004	**
Folate (mcg)	0.326	0.046	*	0.450	0.005	**	-0.016	0.924		-0.373	0.021	*
Vitamin C (mg)	0.290	0.078		0.348	0.032	*	-0.119	0.483		-0.347	0.033	*
Vitamin D (mcg)	0.293	0.075		0.420	0.009	**	0.104	0.541		-0.240	0.147	
Vitamin E (mg)	0.327	0.045	*	0.226	0.172		0.305	0.066		-0.311	0.057	
Cholesterol (mg)	0.355	0.029	*	0.339	0.038	*	0.363	0.027	*	-0.361	0.026	*
Water (g)	0.108	0.519		0.181	0.275		0.238	0.156		-0.339	0.037	*

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

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p<0.005, vitamin C r= 0.348 p<0.05, vitamin D r= 0.420 p<0.01,and cholesterol r= 0.339 p<0.05.

Serum ferritin was positively correlated with protein r= 0.319 p<0.05, calcium r= 0.370 p<0.05, phosphorus r= 0.367 p<0.05, iodine r= 0.366 p<0.05 and cholesterol r= 0.363 p<0.05.

All the following nutrients had negative correlation with iron deficient subjects. Energy r= -0.432 p<0.01, protein r= -0.477 p<0.005, fat r= -0.366 p<0.05, carbohydrate r= -0.375 p<0.05, calcium r= -0.400 p<0.05, phosphorus r= -0.453 p<0.005, magnesium r= -0.474 p<0.005, potassium r= -0.531 p<0.005, iron r= -0.338 p<0.05, zinc r= -0.368 p<0.05, selenium r= -0.363 p<0.05, vitamin B1 r= -0.376 p<0.05, vitamin B2 r= -0.407 p<0.05, nicotinic acid r= -0.473 p<0.005,vitamin B6 r= -0.458 p<0.005, folate r= -0.373 p<0.05, vitamin C r= -0.347 p<0.05, cholesterol r= 0.361 p<0.05, and interestingly, water r= 0.339 p<0.05.

As shown in table 6-16, lamb was positively correlated with both Hb and MCV r= 0.481 p<0.005 and r= 0.414 p<0.01 respectively, chicken was correlated positively with MCV r= 0.320 p<0.05, hashi (young camels) correlated positively with iron intake r= 0.335 p<0.05 and other poultry correlated with serum ferritin r= 0.643 p<0.001. Rusks correlated positively with Hb r= 0.333 p<0.05, brown biscuits correlated negatively with MCV r= -0.369 p<0.05 and macaroni correlated positively with iron intake r= 0.398 p<0.05. Some vegetables had different correlations, mixed vegetables correlated positively with Hb r= 0.336 p<0.05, carrot soup correlated positively with iron intake r= 0.525 p<0.005, molokheah (green leafy vegetable) correlated positively with both Hb and MCV r= 0.412 p<0.01 and r= 0.330 p<0.05, lentil soup correlated negatively with Hb r= -0.489 p<0.005 and with MCV r= -480 p<0.005, butter was also negatively correlated with MCV r= -0.346 p<0.05. Oranges had positive correlations with both MCV and iron intake r= 0.337 p<0.05 and r= 0.331 p<0.05. Fried eggs, cream cake, ice cream and candy had positive correlations with serum ferritin r= 0.335 p<0.05, r= 0.338 p<0.05, r= 0.835 p<0.001 and r= 0.788 p<0.001 respectively. Pizza with cheese positively correlated with iron intake r= 0.350 p<0.05 but sandwiches with cheese had a negative correlation with MCV r= -0.402 p<0.05. Semi-skimmed laban was also negative correlated with MCV

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Table 6-16. Correlation between blood results and average intakes of specific foods for the Saudi children more than 22 months of age (from FFQ data)

Correlations	Haemoglobin n=40			MCV n=40			Serum Ferritin n=40			Iron intake n=40		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Lamb	0.481	0.002	**	0.414	0.008	**	0.198	0.234		0.030	0.857	
Chicken	0.297	0.062		0.320	0.044	*	0.138	0.410		-0.139	0.405	
Hashi	0.175	0.280		0.064	0.693		0.266	0.107		0.335	0.040	*
Poultry	0.043	0.794		0.028	0.863		0.643	0.000	***	-0.038	0.819	
Rusks	0.333	0.036	*	0.146	0.367		-0.020	0.906		0.245	0.138	
Brown Biscuits	-0.121	0.458		-0.369	0.019	*	-0.016	0.925		-0.264	0.109	
Macaroni	0.032	0.846		-0.076	0.640		0.105	0.531		0.398	0.013	*
Mixed Vegetables	0.336	0.034	*	0.103	0.526		-0.005	0.976		0.160	0.338	
Carrot Soup	0.242	0.132		0.172	0.287		0.105	0.530		0.525	0.001	**
Molokheah	0.412	0.008	**	0.330	0.037	*	0.091	0.585		0.181	0.277	
Lentil Soup	-0.489	0.001	***	-0.480	0.002	**	-0.205	0.218		-0.120	0.471	
Butter	-0.102	0.531		-0.346	0.029	*	0.297	0.070		-0.270	0.101	
Jam	0.132	0.418		0.005	0.973		0.025	0.884		0.363	0.025	*
Oranges	0.298	0.062		0.332	0.037	*	0.181	0.278		0.331	0.042	*
Fried Eggs	0.051	0.756		-0.172	0.289		0.335	0.040	*	-0.049	0.771	
Cream Cake	0.297	0.063		0.054	0.742		0.338	0.038	*	0.313	0.056	
Ice cream with chocolate	0.118	0.467		-0.014	0.930		0.835	0.000	***	0.147	0.377	
Candy	0.129	0.427		0.010	0.953		0.788	0.000	***	-0.053	0.753	
Pizza with cheese	0.045	0.784		-0.093	0.567		0.234	0.157		0.350	0.031	*
Pizza with meat	0.055	0.737		-0.074	0.649		0.232	0.161		0.307	0.061	
Cheese Sandwiches	-0.226	0.161		-0.402	0.010	*	0.096	0.566		0.102	0.543	
Crisps	0.112	0.493		-0.210	0.193		0.082	0.624		0.366	0.024	*
Laban semi-skimmed	-0.121	0.458		-0.369	0.019	*	-0.016	0.925		-0.264	0.109	
Sterilised full cream milk	-0.086	0.602		0.086	0.605		0.602	0.000	***	-0.028	0.870	
Canned Mango Juice	0.082	0.613		0.034	0.835		0.619	0.000	***	-0.114	0.496	
Canned Apple Juice	0.144	0.374		0.018	0.911		0.186	0.263		0.355	0.029	*
Cola	-0.360	0.023	*	-0.190	0.240		-0.067	0.690		-0.049	0.772	

*** Correlation is significant at the 0.005 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

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r=-0.369 p<0.05. Both sterilised full cream milk and canned mango juice were strongly positively correlated with serum ferritin r= 0.602 p<0.001 and r= 0.619 p<0.001 respectively. Canned apple juice positively correlated with iron intake r= 0.355 p<0.05 and cola negatively correlated with Hb r= -0.360 p<0.05.

CORRELATIONS BETWEEN THE BLOOD PARAMETERS AND NUTRIENT INTAKE WITH EACH CHILD INCLUDED ONLY ONCE

In the community study, 137 children were studied once, 30 children were studied twice and 22 three times. In order to avoid any possible bias, Dr Elton, the statistical consultant, suggested that the data be re-analysed into two groups, younger and older children so that each child was included once only in each group. Thus for children who were seen more than once, their first set of data was included in the younger children group and their second or third set of data was included in the older children group. For children seen three times, the data at their oldest age was used. Many positive correlations were reported when the data was analysed in this way.

The younger children

The data under this heading consists of the first (and hence youngest) data available on any child. Table 6-17 shows good positive correlations between Hb and some nutrients. Energy, protein and carbohydrate had the following correlations: r=0.255 p<0.01, r= 0.225 p<0.05 and r= 0.249 p<0.05 respectively. Minerals such as calcium, phosphorus, sodium, potassium chloride, iron, zinc and iodine had the following significant values: r=0.218 p<0.05, = 0.208 p<0.05, r= 0.199 p<0.05, r= 0.236 p<0.05, r= 0.206 p<0.05, r= 0.200 p<0.05, r= 0.226 p<0.05 and r= 0.213 p<0.05 respectively. Vitamins B1, B2, B6 and B12 correlated with values of r= 0.297 p<0.005, r= 0.229 p<0.05, r= 0.241 p<0.05 and r= 0.236 p<0.05 respectively.

Strong correlations were found between serum ferritin and iron intake r= 0.347 p<0.001, vitamin B1 r= 0.377 p<0.001, vitamin B12 r= 0.311 p<0.005, vitamin A r= 0.313 p<0.005 and vitamin D r= 0.366 p<0.001, with folate showing weaker correlation r= 0.208 p<0.05.

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Table 6-17. Correlation between blood results and average daily nutrient intakes for the younger Saudi children(From weighed intake data)

Correlations	Haemoglobin n=103			MCV n=103			Serum Ferritin n=94			Iron deficient n=97		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Energy (kcal)	0.255	0.009	**	0.069	0.490		0.152	0.145		-0.140	0.085	
Protein (g)	0.225	0.023	*	0.081	0.415		0.182	0.079		-0.136	0.092	
Carbohydrate (g)	0.249	0.011	*	0.025	0.801		0.141	0.175		-0.139	0.087	
Calcium (mg)	0.218	0.027	*	0.030	0.762		0.133	0.202		-0.160	0.059	
Phosphorus (mg)	0.208	0.035	*	0.044	0.659		0.115	0.271		-0.102	0.161	
Sodium (mg)	0.199	0.044	*	0.002	0.981		0.068	0.515		-0.045	0.331	
Potassium (mg)	0.236	0.016	*	0.021	0.831		0.113	0.277		-0.127	0.107	
Chloride (mg)	0.206	0.037	*	-0.034	0.729		0.029	0.779		-0.067	0.259	
Iron Intake (mg/d)	0.200	0.043	*	0.116	0.245		0.347	0.001	***	-0.184	0.036	*
Zinc (mg)	0.226	0.022	*	0.062	0.535		0.039	0.708		-0.185	0.035	*
Iodine (mcg)	0.213	0.030	*	0.041	0.678		0.018	0.864		-0.189	0.032	*
Vitamin B1 (mg)	0.297	0.002	**	0.101	0.312		0.377	0.000	***	-0.161	0.058	
Vitamin B2 (mg)	0.229	0.020	*	-0.006	0.949		0.186	0.073		-0.190	0.031	*
Vitamin B6 (mg)	0.241	0.014	*	0.059	0.551		0.195	0.059		-0.087	0.198	
Vitamin B12 (mcg)	0.236	0.016	*	-0.008	0.934		0.311	0.002	**	-0.142	0.082	
Folate (mcg)	0.190	0.055		0.102	0.305		0.208	0.045	*	-0.164	0.055	
Vitamin C (mg)	0.039	0.698		0.013	0.895		0.142	0.171		-0.183	0.036	*
Vitamin A (mcg)	0.112	0.262		0.164	0.098		0.313	0.002	**	-0.080	0.218	
Vitamin D (mcg)	0.166	0.094		0.099	0.321		0.366	0.000	***	-0.191	0.031	*

*** Correlation is significant at the 0.005 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

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Table 6-18. Correlation between blood results and average intakes of specific foods for the younger Saudi children (from FFQ data)

Correlations	Haemoglobin n=105			MCV n=105			Serum Ferritin n=95			Iron Intake (mg/d) n=108		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Infant formula	0.082	0.405		0.049	0.618		0.256	0.012	*	0.428	0.000	***
Lamb	0.207	0.034	*	0.133	0.177		0.060	0.563		-0.061	0.531	
Chicken	0.347	0.000	***	0.136	0.167		0.070	0.503		-0.219	0.023	*
Cerelac with Wheat	0.099	0.314		-0.034	0.732		0.229	0.025	*	0.298	0.002	**
Rusks	0.001	0.994		-0.091	0.354		-0.031	0.766		0.369	0.000	***
Rusks with chocolate	-0.147	0.135		-0.103	0.295		-0.091	0.379		0.183	0.059	
Rusks, wholemeal	-0.047	0.635		-0.047	0.632		-0.005	0.958		0.207	0.032	*
Sweet Biscuits	-0.053	0.590		-0.061	0.533		-0.093	0.370		-0.247	0.009	**
Roll White Bread	-0.023	0.814		-0.245	0.012	*	-0.119	0.249		-0.076	0.434	
Arabic Bread	0.238	0.015	*	0.002	0.983		-0.042	0.684		0.078	0.425	
Green Salad	0.201	0.040	*	0.069	0.486		-0.037	0.722		-0.063	0.514	
Mixed Vegetables	0.217	0.026		0.349	0.000	***	-0.035	0.734		-0.132	0.172	
Courgette Soup	0.237	0.015	*	0.045	0.651		-0.101	0.328		0.108	0.264	
Cheddar Cheese	-0.140	0.155		-0.272	0.005	**	-0.061	0.556		-0.047	0.633	
Apples	0.161	0.101		0.040	0.686		0.295	0.004	***	0.059	0.541	
Pears	-0.116	0.239		-0.195	0.046	*	-0.062	0.552		0.087	0.372	
Egg Yolk	-0.221	0.023	*	-0.100	0.309		-0.008	0.941		0.107	0.270	
Cake	0.160	0.104		-0.034	0.734		0.341	0.001	***	0.129	0.185	
Pizza with meat	0.216	0.027	*	0.065	0.508		-0.011	0.913		-0.004	0.970	
Eggs Sandwiches	-0.064	0.517		-0.217	0.026	*	-0.051	0.623		-0.113	0.244	
Crisps	0.226	0.021	*	0.117	0.236		-0.062	0.550		-0.202	0.036	*

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

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Table 6-18 *(Continued)*. Correlation between blood results and average intakes of specific foods for the younger Saudi children (from FFQ data)

Correlations	Haemoglobin n=105		MCV n=105		Serum Ferritin n=95		Iron Intake (mg/d) n=108	
	r	p	r	p	r	p	r	p
Laban full cream	0.193	0.049 *	0.064	0.515	0.203	0.048 *	-0.064	0.511
Semi-skimmed milk	0.000	0.998	-0.037	0.707	-0.011	0.919	0.201	0.037 *
Dry full cream milk	-0.067	0.499	-0.098	0.318	-0.086	0.408	-0.393	0.000 ***
Milk with Chocolate	-0.034	0.729	0.001	0.992	0.344	0.001 ***	0.108	0.267
Fresh Orange Juice	0.152	0.123	0.000	0.998	0.232	0.024 *	-0.007	0.947
Canned Orange Juice	0.077	0.437	-0.097	0.323	-0.150	0.146	-0.244	0.011 *
Pineapple Canned Juice	-0.192	0.049 *	-0.243	0.013 *	-0.084	0.419	-0.151	0.118
Merinda	-0.204	0.037 *	-0.181	0.064	-0.127	0.222	-0.048	0.621
Lemonade	-0.028	0.778	0.034	0.730	0.312	0.002 **	-0.005	0.957
Meat and fish	0.313	0.001 **	0.124	0.208	0.033	0.749	-0.158	0.102
Followup formulas	0.133	0.176	-0.067	0.496	0.197	0.056	0.301	0.002 **
Baby foods	-0.040	0.683	-0.145	0.140	-0.054	0.603	0.349	0.000 ***
Cows milk	-0.068	0.493	-0.052	0.596	-0.053	0.608	-0.253	0.008 **
Milk and it's products	-0.047	0.635	-0.023	0.820	-0.060	0.562	-0.263	0.006 **
Vegetables	0.228	0.019 *	0.154	0.117	-0.050	0.628	-0.034	0.725
Canned juice	0.122	0.213	-0.088	0.371	-0.167	0.106	-0.222	0.021 *
Juice, fresh and canned	0.155	0.115	-0.049	0.620	0.014	0.893	-0.191	0.048 *

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

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From FFQ data as shown in table 6-18, positively correlations were found with Hb, lamb r= 0.207 p<0.05, chicken r= 0.347 p<0.001, Arabic bread r= 0.238 p<0.05, green salad r= 0.201 p<0.05, courgette soup r= 0.237 p<0.05, crisps r= 0.226 p<0.05, pizza with meat r= 0.216 p<0.05 and full cream laban r= 0.193 p<0.05. Egg yolk and pineapple canned juice correlated negatively with Hb r= -0.221 p<0.05 and r= -0.192 p<0.05 respectively. Meat and fish food group was correlated positively with Hb r= 0.313 p<0.05 and vegetable group r= 0.228 p<0.05.

Mixed vegetables were strongly positively correlated with MCV r= 0.349 p<0.001, but white rolls, cheddar cheese, pears, eggs sandwiches and pineapple canned juice were correlated negatively with MCV r=-0.245 p<0.05, r= -0.272 p<0.005, r= -0.195 p<0.05, r= -0.217 p<0.05 and r= -0.243 p<0.05 respectively.

Frequency of taking infant formula, Cerelac with wheat (baby cereals), full cream laban and fresh orange juice were correlated positively with serum ferritin r= 0.256 p<0.05, r= 0.070 p<0.05, r= 0.203 p<0.05 and r= 0.232 p<0.05 respectively. More strong significant correlations were found with cheddar cheese, cake, milk with chocolate and lemonade r= 0.295 p<0.005, r= 0.314 p<0.005, r= 0.344 p<0.005, and r= 0.312 p<0.005 respectively.

The frequency of infant formula, rusks and Cerelac wheat were all strongly positively correlated with iron intake, r= 0.428 p<0.001, r= 0.369 p<0.001, r= 0.298 p<0.005 respectively. Sweet biscuits, crisps, dry full cream milk and canned orange juice were correlated negatively r= -0.247 p<0.01, r= -0.202 p<0.05, r= -0.393 p<0.005, r= -0.244 p<0.05 respectively. Meat and fish group food and baby foods were also strongly positively correlated with iron intake, r= 0.301 p<0.005 and r= 0.349 p<0.001 respectively. Cows milk group, milk and milk products, canned juice and all kinds of juice were correlated negatively r= -0.253 p<0.01, r= -0.263 p<0.01, r= -0.222 p<0.05 and r= -0.191 p<0.05 respectively.

The older children

The data under this heading consists of the last (and the oldest) data available in each child. Table 6-19 shows the different correlation between blood results and

Table 6-19. Correlation between blood results and average daily nutrients intakes for older Saudi children (From weighed intake data)

Correlations	Haemoglobin n=99			MCV n=99			Serum Ferritin n=90			Iron deficient n=92		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Energy (kcal)	0.308	0.002	**	0.191	0.058		0.201	0.057		-0.279	0.007	**
Protein (g)	0.186	0.065		0.153	0.130		0.251	0.017	*	-0.228	0.029	*
Fat (g)	0.265	0.008	**	0.232	0.021	*	0.192	0.070		-0.257	0.014	*
PUFA (g)	0.207	0.040	*	0.134	0.186		0.057	0.594		-0.081	0.444	
MUFA (g)	0.205	0.042	*	0.179	0.076		0.155	0.146		-0.203	0.052	
Carbohydrate (g)	0.328	0.001	***	0.127	0.209		0.160	0.131		-0.261	0.012	*
Starch (g)	0.236	0.018	*	0.077	0.451		0.093	0.384		-0.188	0.072	
Dietary Fibre (g)	0.238	0.017	*	0.131	0.196		0.041	0.704		-0.168	0.109	
Calcium (mg)	0.197	0.050		0.073	0.473		0.287	0.006	**	-0.253	0.015	*
Phosphorus (mg)	0.213	0.034	*	0.122	0.230		0.269	0.010	*	-0.217	0.038	*
Magnesium (mg)	0.192	0.057		0.161	0.112		0.210	0.047	*	-0.241	0.021	*
Sodium (mg)	0.274	0.006	**	0.135	0.182		0.168	0.114		-0.175	0.095	
Potassium (mg)	0.253	0.011	*	0.155	0.126		0.236	0.025	*	-0.278	0.007	**
Chloride (mg)	0.290	0.004	**	0.137	0.175		0.186	0.078		-0.223	0.032	*
Iron (mg/d)	0.352	0.000	***	0.237	0.018	*	0.151	0.155		-0.270	0.009	**
Zinc (mg)	0.277	0.005	**	0.228	0.023	*	0.116	0.278		-0.249	0.017	*
Copper (mg)	0.197	0.051		0.192	0.057		0.007	0.948		-0.200	0.056	
Selenium (mcg)	0.141	0.165		0.130	0.200		0.144	0.177		-0.206	0.048	*
Iodine (mcg)	0.129	0.203		0.145	0.152		0.291	0.005	**	-0.261	0.012	*
Vitamin B1 (mg)	0.369	0.000	***	0.168	0.096		0.169	0.112		-0.280	0.007	**
Vitamin B2 (mg)	0.225	0.025	*	0.128	0.207		0.238	0.024	*	-0.253	0.015	*
Nicotinic acid (mg)	0.176	0.081		0.223	0.026	*	0.189	0.074		-0.253	0.015	*
Vitamin B6 (mg)	0.282	0.005	**	0.215	0.032	*	0.177	0.096		-0.292	0.005	**
Vitamin B12 (mcg)	0.216	0.031	*	0.136	0.180		0.108	0.312		-0.167	0.112	
Folate (mcg)	0.258	0.010	**	0.257	0.010	*	0.104	0.329		-0.282	0.007	**
Vitamin C (mg)	0.211	0.036	*	0.222	0.027	*	0.018	0.869		-0.292	0.005	**
Vitamin D (mcg)	0.242	0.016	*	0.164	0.104		0.101	0.342		-0.202	0.054	
Vitamin E (mg)	0.219	0.029	*	0.203	0.044	*	0.107	0.314		-0.244	0.019	*
Cholesterol (mg)	0.077	0.450		0.167	0.099		0.279	0.008	**	-0.163	0.121	

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

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some nutrients. All correlations with Hb were positive. Energy correlated with r=0.308 p<0.005, fat r= 0.265, PUFA r= 0.207 p<0.05, MUFA r= 0.205 p<0.05, carbohydrate r= 0.328 p<0.005, starch r= 0.236 p<0.05, and dietary fibre r= 0.238 p<0.05. phosphorus, sodium, potassium, chloride, iron and zinc had r= 0.213 p<0.05, r= 0.274 p<0.01, r=0.253 p<0.05, r= 0.290 p<0.005, r= 0.352 p<0.001 and r= 0.277 p<0.005. Vitamins B1, B2, B12, C, D, E and folate had the following values r= 0.369 p<0.005, r= 0.225 p<0.005, r= 0.216 p<0.05, r= 0.211 p<0.05, r= 0.242 p<0.05, r= 0.219 p<0.05 and r= 0.258 p<0.01 respectively. MCV correlated positively with fat, iron, zinc, nicotinic acid, vitamin B6, folate, vitamin C and vitamin E, with values of r= 0.232 p<0.05, r= 0.237 p<0.05, r= 0.228 p<0.05, r= 0.233 p<0.05, r= 0.215 p<0.05, r= 0.257 p<0.05, r= 0.222 p<0.05 and r= 0.203 p<0.05 respectively.

Protein, calcium, phosphorus, magnesium, potassium, iodine, vitamin B6 and cholesterol were correlated positively with serum ferritin, r= 0.251 p<0.05, r= 0.287 p<0.01, r= 0.269 p<0.05, r= 0.210 p<0.05, r= 0.236 p<0.05, r= 0.291 p<0.01, r= 0.238 p<0.05 and r= 0.279 p<0.01 respectively.

All the following nutrients correlated negatively with a diagnosis of iron deficiency: energy r= -0.279 p<0.01, protein r= -0.228 p<0.05, fat r= -0.257 p<0.05, carbohydrate r= -0.261 p<0.05, calcium r= -0.253 p<0.05, phosphorus r= -0.217 p<0.05, magnesium r= -0.241 p<0.05, potassium r= -0.278 p<0.01, chloride r= -0.23 p<0.05, zinc r= -0.249 p<0.05, selenium r= -0.206 p<0.05, iodine r= -0.261 p<0.05, vitamin B6 r= -0.292 p<0.005, vitamin C r= -0.282 p<0.01, and vitamin E r= -0.244 p<0.05.

Table 6-20 shows the association between blood results and some foods. Lamb, chicken, saleeq (rice with milk), white beans, cream cake, fresh orange juice, meat and fish group, and all fresh juice were correlated positively with Hb, r= 0.263 p<0.01, r= 0.285 p<0.005, r= 0.204 p<0.05, r= 0.231 p<0.005, r= 0.207 p<0.05, r= 0.216 p<0.05, r= 0.288 p<0.01 and r= 0.0195 p<0.05 respectively. Lentil soup correlated negatively with Hb and MCV r= -0.285 p<0.005 and r= -0.280 p<0.005 respectively. Lamb, chicken again correlated positively with MCV r= 0.294 p<0.005 and r= 0.294 p<0.05 respectively. Brown biscuits, white rolls (bread) and cheese

Table 6-20. Correlation between blood results and average intakes of specific foods for older Saudi children (from FFQ data)

Correlations	Haemoglobin n=102			MCV n=102			Serum Ferritin n=92			Iron Intake (mg/d) n=108		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Infant formula	0.134	0.178		0.015	0.881		0.033	0.755		0.428	0.000	***
Lamb	0.263	0.008	**	0.294	0.003	**	0.063	0.553		-0.091	0.349	
Chicken	0.285	0.004	**	0.197	0.047	*	0.042	0.688		-0.067	0.490	
Hashi	0.077	0.441		0.050	0.619		0.290	0.005	**	0.072	0.458	
Fish fingers	0.103	0.301		-0.006	0.956		0.264	0.010	**	0.170	0.079	
Tuna fish	0.083	0.409		-0.035	0.725		0.246	0.018	*	0.106	0.275	
Cerelac with Wheat	0.079	0.429		-0.075	0.456		0.032	0.759		0.336	0.000	***
Rusks	0.092	0.359		-0.047	0.638		-0.037	0.727		0.408	0.000	***
Rusks with chocolate	0.067	0.504		-0.001	0.990		0.242	0.020	*	0.085	0.381	
Rusks, wholemeal	-0.050	0.615		-0.048	0.634		-0.014	0.891		0.224	0.020	*
Sweet Biscuits	-0.084	0.401		-0.103	0.303		0.034	0.748		-0.240	0.012	*
Brown Biscuits	-0.096	0.337		-0.237	0.016	*	0.014	0.898		-0.110	0.255	
Seleeq	0.204	0.039	*	0.100	0.319		0.134	0.205		0.133	0.168	
Jareesh	0.155	0.119		0.048	0.632		0.244	0.019	*	-0.080	0.413	
Roll White Bread	0.028	0.777		-0.311	0.001	**	0.048	0.648		0.006	0.948	
Mixed Vegetables	0.170	0.088		0.204	0.040	*	0.061	0.566		-0.044	0.648	
White Beans	0.231	0.019	*	0.122	0.221		0.036	0.731		0.009	0.930	
Lentil Soup	-0.285	0.004	**	-0.280	0.004	**	-0.114	0.278		0.069	0.480	
Oranges	0.193	0.051		0.189	0.057		0.210	0.044	*	0.155	0.109	
Grapes	0.079	0.432		0.028	0.777		0.243	0.020	*	-0.113	0.244	
Boiled Eggs	-0.012	0.906		-0.144	0.148		0.011	0.915		-0.216	0.025	*
Egg Yolk	0.014	0.887		0.045	0.656		0.007	0.947		0.261	0.006	**

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

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Table 6-20 (Continued). Correlation between blood results and average intakes of specific foods for older Saudi children (from FFQ data)

Correlations	Haemoglobin n=102			MCV n=102			Serum Ferritin n=92			Iron Intake (mg/d) n=108		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Cream Cake	0.207	0.037	*	0.020	0.845		0.257	0.013	*	0.088	0.365	
Ice cream with chocolate	-0.082	0.410		-0.076	0.448		0.494	0.000	***	-0.095	0.329	
Candy	-0.009	0.932		-0.032	0.749		0.620	0.000	***	-0.026	0.787	
Vegetables Pizza	-0.064	0.525		-0.035	0.730		0.259	0.013	*	0.006	0.952	
Pizza with cheese	0.014	0.885		-0.051	0.611		0.251	0.016	*	0.084	0.385	
Pizza with meat	0.063	0.530		-0.023	0.820		0.232	0.026	*	0.072	0.462	
Sandwich with cheese	-0.159	0.111		-0.217	0.028	*	0.127	0.229		-0.015	0.874	
Sandwich with Eggs	0.056	0.576		0.084	0.402		0.210	0.044	*	-0.015	0.880	
Corn snack	0.040	0.693		-0.013	0.894		0.205	0.050	*	-0.017	0.860	
Semi-skimmed milk	0.028	0.781		-0.035	0.723		0.000	0.998		0.255	0.008	**
Dry full cream milk	-0.080	0.425		-0.069	0.490		-0.024	0.821		-0.220	0.022	*
Sterilised full cream milk	-0.070	0.488		0.073	0.470		0.230	0.028	*	-0.161	0.098	
Fresh Orange Juice	0.216	0.029	*	0.085	0.397		0.011	0.916		0.122	0.209	
Canned Mango Juice	0.005	0.961		0.069	0.491		0.470	0.000	***	-0.126	0.195	
Meat and fish	0.288	0.003	**	0.207	0.037	*	0.128	0.225		-0.032	0.739	
Followup formulas	0.110	0.272		-0.044	0.658		-0.003	0.981		0.302	0.001	**
Baby foods	0.106	0.291		-0.039	0.696		0.111	0.291		0.372	0.000	***
Milk and its' products	-0.005	0.958		-0.030	0.765		0.221	0.035	*	-0.132	0.176	
Fresh juice	0.195	0.049	*	0.058	0.564		0.013	0.901		0.033	0.733	
Snacks	0.046	0.648		-0.037	0.710		0.413	0.000	***	-0.040	0.683	
Sandwiches	0.004	0.968		-0.076	0.447		0.264	0.011	*	0.071	0.467	

*** Correlation is significant at the 0.005 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

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sandwiches correlated negatively with MCV r= -0.237 p<0.05, r= -0.311 p<0.005 and r= -0.217 p<0.05 respectively..

Hashi, fish fingers, tuna fish, Cerelac wheat, chocolate rusks, jareesh (wheat and milk based dish), oranges, grapes, cream cake, candy, canned mango juice were all correlated positively with serum ferritin r= 0.290 p<0.005, r= 0.264, r= 0.246 p<0.05, p<0.01, r= 0.242 p<0.05, r= 0.244 p<0.05, r= 0.210 p<0.05, r= 0.243 p<0.05, r= 0.257 p<0.05, r= 0.494 p<0.001, r= 0.620 p<0.001 and r= 0.480 p<0.001 respectively. Similarly, vegetable pizza, pizza with cheese, pizza with meat, eggs sandwiches, sterilised full cream milk, canned mango juice, milk and milk products, snacks and sandwiches had positive correlations r= 0.244 p<0.05, r= 0.259 p<0.05, r= 0.251 p<0.05, r= 0.232 p<0.05, r= 0.210 p<0.05, r= 0.230 p<0.05, r= 0.470 p<0.005, r= 0.221 p<0.05, r= 0.413 p<0.005 and r= 0.413 p<0.05 respectively.

Infant formula, Cerelac wheat and rusks were strongly positive correlated with iron intake r= 0.428 p<0.001, r= 0.336 p<0.001 and r= 0.408 p<0.001 respectively. Wholemeal rusks had a weaker significant correlation r= 0.244 p<0.05. sweet biscuits, boiled eggs and dry full cream milk were correlated negatively with iron intake r= -0.240 p<0.05, r= -216 p<0.05, and r= -0.220 p<0.05 respectively, but egg yolk correlated positively, r= 0.261 p<0.01.

FREQUENCY OF THE MOST COMMON FOOD CONSUMED BY DIFFERENT AGE GROUPS

Table 6-21 shows the most common foods consumed by the total group of children studied (n=185) over of four days period when their food intake was weighed . Kapsa (red rice with meat, chicken or vegetable) was the most common food for all subjects of the study, the frequency was 382 times. (This food was eaten, on average, by 52% of children each day followed by dried whole milk with a frequency of 303 times (41% of children each day), then white bread with frequency of 291 (39%). Whole milk yoghurt, oranges, plain biscuits, human milk were the next most frequent foods with percentages of 31, 28, 27 and 25% children eating the food each day.

Table 6-22 details the common foods for the first age group. Human milk and white bread were the most common foods with a frequency of 121 (16%) and 120 time (16%) respectively. Kapsa, Cerelac with wheat, yoghurt (14%) then Similac with iron (infant formula), mashed potatoes, dried whole milk were next most common foods with percentage of 11, 10 9 and 9% respectively. More baby foods then appeared in the list of foods for this age group i.e. Cerelac wheat with 4 fruits and Cerelac wheat with honey with 6% and 5 % a day each.

For the second age group between 16-22 months of age, dried whole milk, kapsa and white bread top the list with frequency of 145, 138 and 120 times respectively. Baby formulas and baby food disappeared from this list in terms of frequent use and were compensated by milk and milk products i.e. whole sterilised milk 8%, pasteurised milk 8%, processed cheese &% and spread cheese 7%. Details of these foods shown in table 6-23.

For the third and oldest age group, dried whole milk and kapsa still top the list as they were in the second age group. Sterilised whole milk, plain biscuits, whole milk yoghurt and corn snacks follow them with percentage of 10, 10, 9 and 9 % a day for each food. The frequency of the most 20 common foods in this age group became less than both the first and the second groups as a wider range of foods were eaten by these children as they get older.

Table 6-21. Frequency of the most common food eaten by all children and percentage of daily consumption of each food

Riyadh Study   (n=185)

	Food	Frequency	%/day *
1 -	Kapsa	382	52
2 -	Dried whole milk	303	41
3 -	White bread, average	291	39
4 -	Whole milk yoghurt, 'organic'	230	31
5 -	Oranges	210	28
6 -	Plain biscuits	201	27
7 -	Red rice, boiled	200	27
8 -	Human milk, mature	187	25
9 -	Cerelac wheat	158	21
10 -	Mixed vegetables, frozen, boiled in salted water	154	21
11 -	Eggs, chicken, boiled	153	21
12 -	Whole milk, sterilised	136	18
13 -	Whole milk, pasteurised	126	17
14 -	Cheese spread, plain	119	16
15 -	Bananas	112	15
16 -	Corn snacks	103	14
17 -	Fruit juice drink, ready to drink	102	14
18 -	Apples, eating, average, raw	100	14
19 -	Pitta bread, white	97	13
20 -	Whole milk yoghurt, plain	97	13

* %/day is the percentage of children who eat the food each day

Table 6-22. Frequency of the most common food eaten by children age up to 16 months and percentage of daily consumption of each food

Riyadh Study   (n=72)

Food	Frequency	%/day *
1 - Human milk, mature	121	16
2 - White bread, average	120	16
3 - Kapsa	105	14
4 - Cerelac wheat	104	14
5 - Whole milk yoghurt, 'organic'	103	14
6 - Oranges	82	11
7 - Similac with iron	75	10
8 - New potatoes, boiled in unsalted water	68	9
9 - Dried whole milk	67	9
10 - Plain biscuits	56	8
11 - Carrots, young, boiled in unsalted water	53	7
12 - Cerelac wheat-4 fruits	46	6
13 - Mixed vegetables, frozen, boiled in salted water	46	6
14 - Bananas	41	6
15 - Cerelac wheat-honey	40	5
16 - Orange juice, freshly squeezed	33	4
17 - Eggs, chicken, boiled	33	4
18 - Chicken Kapsa	32	4
19 - Lamb Kapsa	30	4
20 - Honey	30	4

* %/day is the percentage of children who eat the food each day

Table 6-23. Frequency of the most common food eaten by children age between 16 and 22 months and percentage of daily consumption of each food Riyadh Study   (n=74)

Food	Frequency	%/day *
1 - Dried whole milk	145	20
2 - Kapsa	138	19
3 - White bread, average	120	16
4 - Human milk, mature	113	15
5 - Whole milk yogurt, 'organic'	110	15
6 - Plain biscuits	72	10
7 - Eggs, chicken, boiled	67	9
8 - Oranges	65	9
9 - Whole milk, UHT	61	8
10 - Whole milk, pasteurised	60	8
11 - Mixed vegetables, frozen, boiled in salted water	52	7
12 - Cheese spread, plain	52	7
13 - Processed cheese, plain	49	7
14 - Corn and starch snacks	47	6
15 - Chicken, boiled, meat only	46	6
16 - Bananas	45	6
17 - Pitta bread, white	44	6
18 - Orange juice, unsweetened	44	6
19 - Eggs, chicken, fried in vegetable oil	43	6
20 - Orange juice, freshly squeezed	41	6

* %/day is the percentage of children who eat the food each day

Table 6-24. Frequency of the most common food eaten by children age 22 months ro
more and percentage of daily consumption of each food

Riyadh Study   (n=38)

	Food	Frequency	%/day *
1 -	Dried whole milk	87	12
2 -	Kapsa	82	11
3 -	Whole milk, sterilised	73	10
4 -	Plain biscuits	71	10
5 -	Whole milk yoghurt, 'organic'	68	9
6 -	Corn snacks	63	9
7 -	Oranges	61	8
8 -	Mixed vegetables, frozen, boiled in salted water	55	7
9 -	Eggs, chicken, boiled	52	7
10 -	White bread, average	48	6
11 -	Pitta bread, white	47	6
12 -	Cheese spread, plain	46	6
13 -	Fruit juice drink, ready to drink	43	6
14 -	Whole milk, pasteurised	42	6
15 -	Orange juice, unsweetened	37	5
16 -	Tea, black, infusion, weak	34	5
17 -	Dates, raw	29	4
18 -	Chicken, boiled, meat only	29	4
19 -	Broad beans, boiled in salted water	26	4
20 -	Bananas	26	4

* %/day is the percentage of children who eat the food each day

ANTHROPOMETRIC AND SOCIAL DETAILS

The mean age for the age group up to 16 months was 11 months, 19 months for the group aged (between 16-22 months) and 25 months for the oldest group (22 months or more) respectively. The number of boys was equal to number of girls (37) in the first age group, and girls number were higher (38) than boys (34) in the second age group, and lower (17) than boys (23) in the third age group (22 months or more). 22 children (13.3%) were singles where the majority (86.7%) had siblings.

A positive correlation was found between Hb and the triceps skinfold thicknesses r= 0.159 p<0.05.

THE SOCIAL DETAILS

Non-parametric correlations were found between blood results and some social aspects. Both Hb and serum ferritin negatively correlated with place of living r= -0.180 p<0.05 and r= -0.190 p<0.05 respectively. Fathers' occupation was correlated with Hb r= 0.311 p<0.01, and his educational level correlated with Hb, MCV and serum ferritin r= 0.311 p<0.001, r= 0.152 p<0.05 and r= 0.165 p<0.05 respectively, but the mothers' education level was correlated only with Hb r= 0.166 p<0.05. Children of parents whose choice of baby food was not influenced by cost had a better Hb, r= 0.175 p<0.05

Mothers' practices in babies feeding

Figure 6-10 shows the time of starting or stopping baby foods. The mean did not differ from median in this group. The mean age when the mothers stopped breast feeding was 10 months, with a range between 1-24 months. Mothers in this study who were giving infant formulas started giving it on average in the beginning of the fourth month, although the range was from 1-15 months. Infant formula was stopped at the age of 13 months, range 5-24 months. Follow-up formulas were started at a mean age of 5 months, range 2-14 months and stopped at 15 months range 2-24 months. Fresh milk and powder milk were introduced at 11 and 12 months on average range 3-20 and 2-24 months respectively. Family food was started at the

seven months, range 3-14 months. The mothers thought the suitable time for introducing food fortified with iron the fifth months, range 2-5 month.

66% of those who gave infant formula were reconstituting the infant formula according to the information written on the tin, whilst 25% reconstituted infant formula according to their own guesswork.

Breast feeding

Figure 6-11 shows the cumulative survival curve for breast feeding durations. Despite the fact that all mothers were breast fed at some stage of the child life, 7.5, 11.3 and 4.8 % of mothers stopped breast feeding in the first, second and third months. The second, ninth and the nineteenth months of age were the peaks showing the highest percentage of stopping breast feeding. The minimum duration for breast feeding was 1 month and the maximum was 24 months. 22 mothers were continuing breast feeding when the study was carried out.

Table 6-25 shows reasons given by those who stopped breast feeding. Using contraceptive tablets was the most common reason with a percentage of 16.2%. 15.4% said the time provided was sufficient for breast feeding; most of those breast fed for a long time.

Figure 6-10. Mothers' Practices Regarding Their Babies Feeding

Riyadh Study
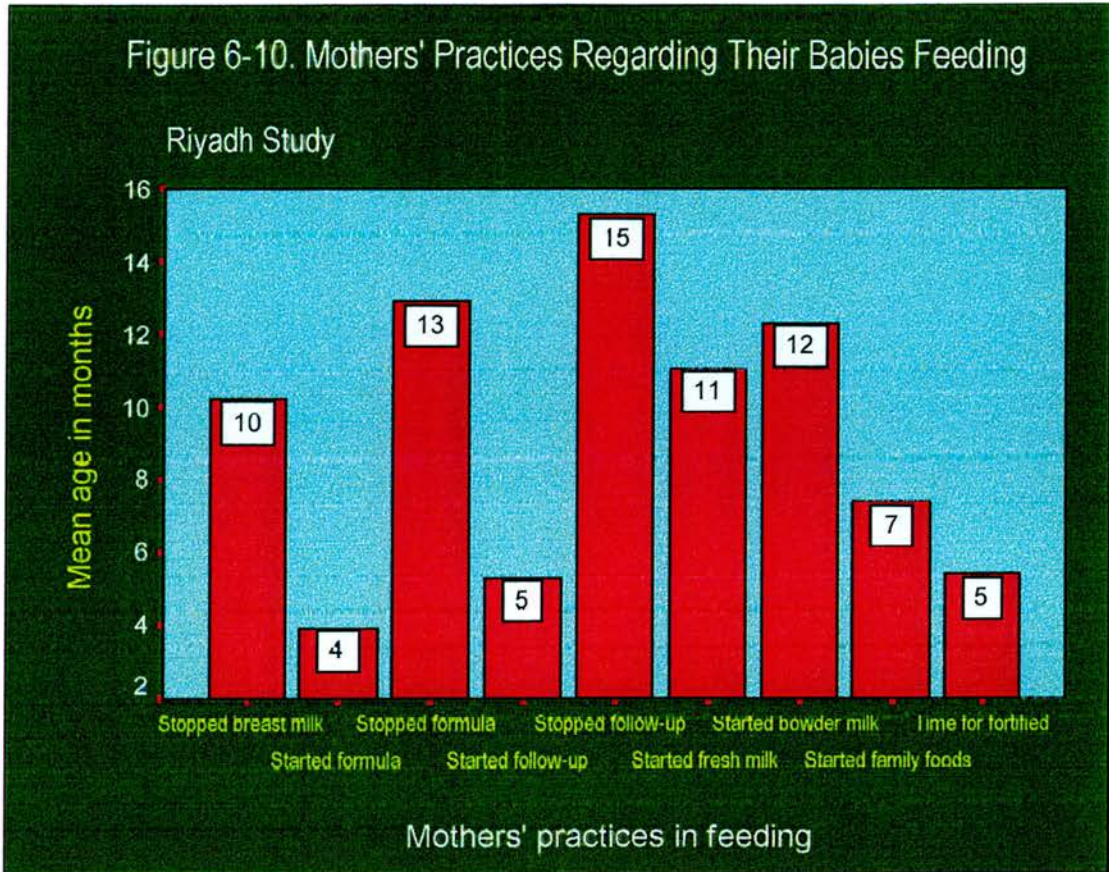
Figure 6-11. Breast Feeding Durations

Riyadh Study
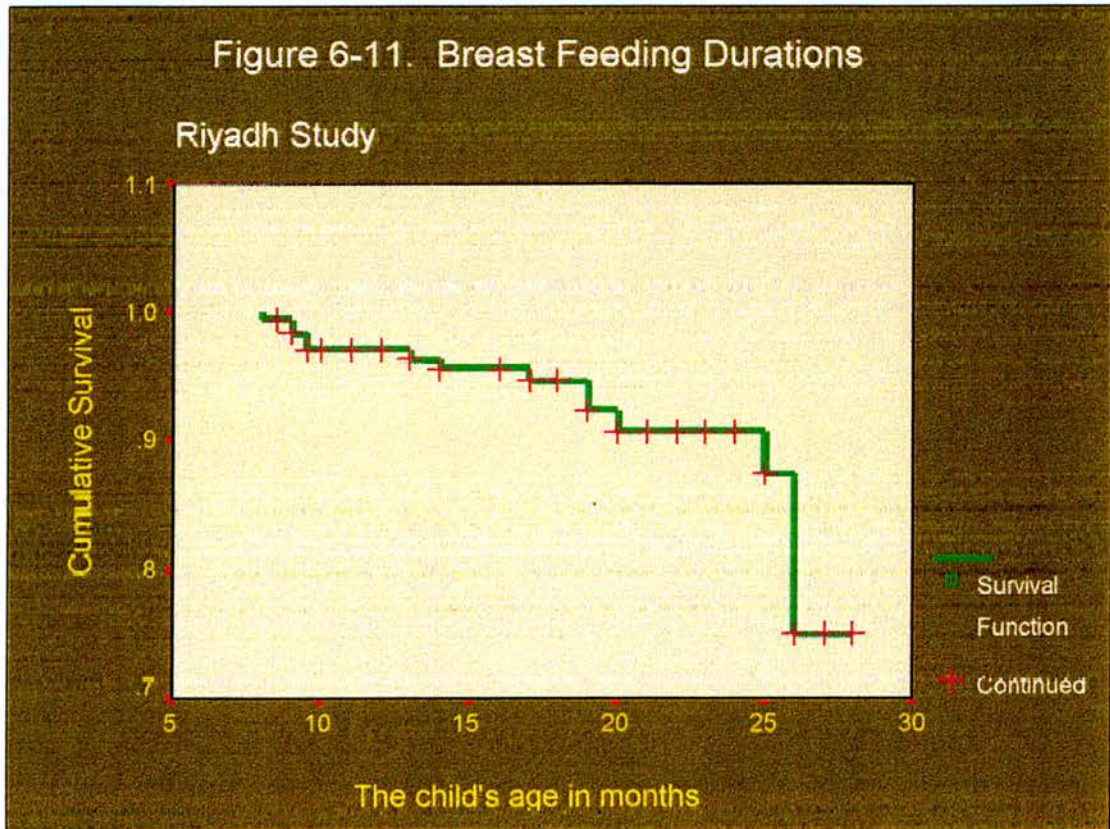
Table 6-25. Reasons for stopping breast-feeding

	Frequency	Percent	Valid Percent *
Taking contraceptives	19	10.2	16.2
Enough time to breast fed	18	9.7	15.4
Not enough milk	18	9.7	15.4
New pregnancy	17	9.1	14.5
Refused by the child	16	8.6	13.7
Study or work	7	3.8	6.0
The mother's health problem	6	3.2	5.1
Other	6	3.2	5.1
Continuing	10	5.4	8.5
Total	117	62.9	100.0
Never	22	11.8	
	186	100.0	

* From those mothers who stopped breast feeding

THE ANAEMIC CHILDREN

Haematological data for the 24 anaemic children who were initially anaemic is summarised in table 6-26. Mean Hb was extremely low with a mean of 8.3 g/dl range 4.3-10.2 g/dl, it was lowest on average 6.94 g/dl in older children aged 22 months or more. Boys had a higher mean Hb than girls 8.44 and 8.11 g/dl respectively.

MCV values were also low with mean of 60.45 fl range 14.6-80 fl. The older children had also the lowest value of MCV, on average 52.4 fl. Boys were higher than girls in MCV values 61.1 and 59.4 fl respectively.

The median of serum ferritin was low, 10 µg/l with a range between 3.5-58 µg/l. The oldest children had the lowest values of serum ferritin, median 6 µg/l followed by the youngest children with median of 10 µg/l. Girls were higher than boys with a median of 13 µg/l compared to 7 µg/l for the boys.

Table 6-26   Blood concentrations of haemoglobin, MCV and serum ferritin for different age groups for the anaemic Saudi children

| | | Age in months | | | Sex | | n=24 |
		Up to 16	16-22	22 or more	Boys	Girls	Total
Haemoglobin (g/dl)	Mean	8.39	8.97	6.94	8.44	8.11	8.30
	Maximum	10.00	10.20	10.20	10.20	10.20	10.20
	Median	8.65	9.40	5.90	9.00	8.90	8.95
	Minimum	5.60	5.60	4.30	5.10	4.30	4.30
MCV (fl)	Mean	61.47	63.76	52.48	61.17	59.45	60.45
	Maximum	73.30	80.00	69.20	73.30	80.00	80.00
	Median	61.05	60.60	58.60	60.00	61.30	60.00
	Minimum	50.90	53.20	14.60	50.90	14.60	14.60
Serum Ferritin (mcg/l)	Mean	15.40	30.00	22.17	16.28	26.64	19.98
	Maximum	58.00	49.00	57.00	58.00	57.00	58.00
	Median	10.00	35.00	6.00	7.00	13.00	10.00
	Minimum	4.20	6.00	3.50	3.50	4.20	3.50

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Haemoglobin was positively correlated with MCV r= 0.643 p<0.05, Haematocrit r= 0.763 p<0.001, MCH r= 041. P<0.05 and with MCHC r= 0.558 p<0.005. MCV was positively correlated with haematocrit r= 0.440 p<0.05 and with MCH r= 0.818 p<0.001. Serum ferritin was also positively correlated with MCH r= 0.754 p<0.005.

Haemoglobin had negatively correlations with the chest circumference r= -0.426 p<0.05, was positively correlated with the fathers' occupation r= 0.405 p<0.05 and with early introduction of follow-up formulas r= 0.473 p<0.05.

MCV was negatively correlated with both chest circumference and triceps skinfold thicknesses r= -0.445 p<0.05 and r= -0.493 p<0.05 respectively. Early introduction of follow-up formulas was positively correlated with MCV r= 0.495 p<0.05.

Serum ferritin was negatively correlated with weight and head circumference r= -0.623 p<0.05 and r= -0.525 p<0.05 respectively.

Blood results and food consumption

Haemoglobin had negative correlations with some food intakes. Kana'd fish, biscuits with chocolates, creams, white cheese, full cream milk and dry full cream milk, r= -0.479 p<0.05, r= -0.719 p<0.005, r= -0.479 p<0.05, r= -0.468 p<0.05, r= -0.427 p<0.05 and r= -0.449 p<0.05 respectively.

MCV showed similar correlation to those with Hb. Chicken and herring were negatively correlated with MCV, r= 0.242 p<0.05 and r= -0.791 p<0.01. biscuits with chocolate was also correlated negatively with MCV, r= -0.469 p<0.05. Broad beans, processed cheese, white cheese, spread cheese and cheddar cheese were negatively correlated with MCV r= -0.760 p<0.005, r= -0.791 p<0.005, r= -0.524 p<0.01, r= -0.636 p<0.005 respectively. Dates, oranges, bananas and scrambled eggs had similar negative correlations, r= -0.580 p<0.005, r= -0.436 p<0.05, r= -0.530 p<0.01 and r= -0.742 p<0.005 respectively. Table 6-27 summarises the data.

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Mothers' practices in babies feeding

Figure 6-12 shows means of childs' age when the mother introduced or stopped some baby foods. Most mothers of the anaemic children had stopped breast feeding at 5 months but 7 mothers (29%) were continuing breast feeding at the time of the study. The range for breast feeding was 1-14 months.

Figure 6-12. Mothers' Practices Regarding Their Babies Feeding
The anaemic Saudi children
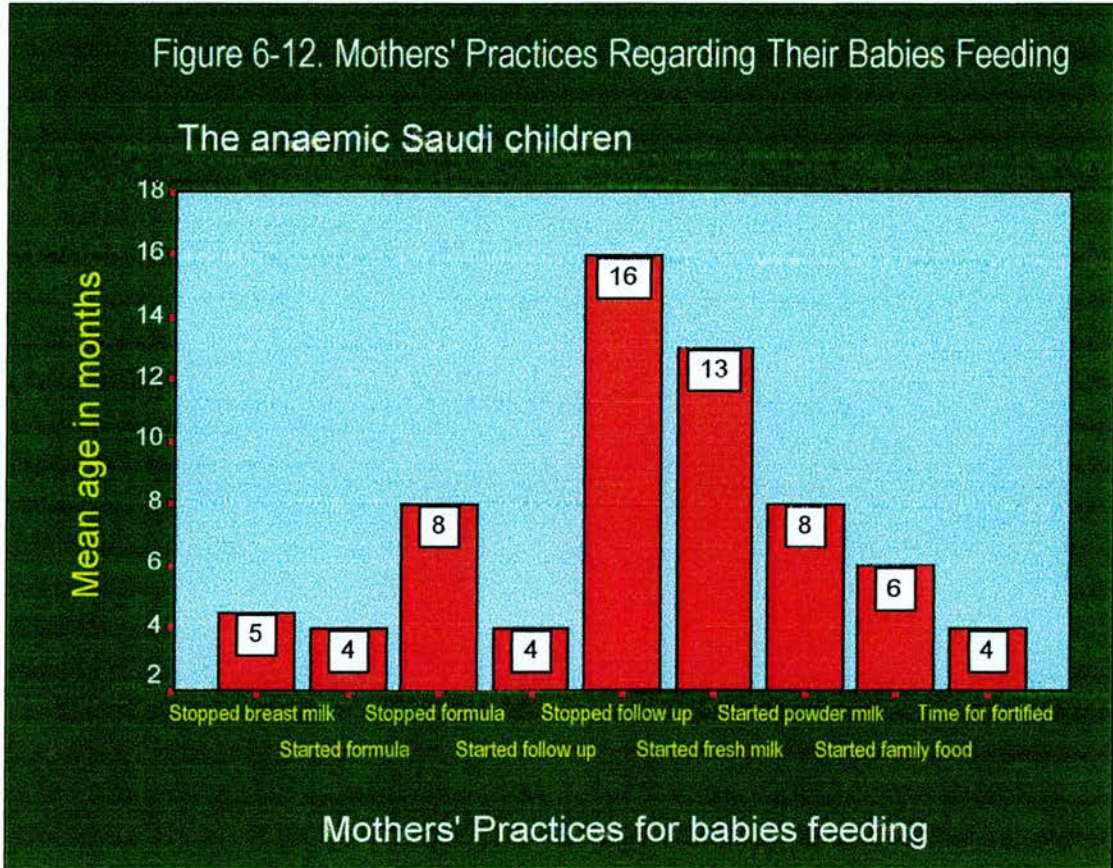
Mothers were starting infant formula between the ages 4 and stopped on average at 8 months, the range was for starting giving from birth to 10 months formula and range from 2-13 months for stopping infant formula.

The mean for introducing follow-up formula was 4 months range between 4-12 months and for stopping the mean was 16 months range 12-20 months. Starting giving powder milk was early 8 months range 2-12 months. Family foods were started at 6 months of age range 4-12 months. Most mothers knew that the most suitable time for introducing fortified milk with iron was 4.5 months with range 4-7 months.

Table 6-27. Correlation between blood results and average intakes of specific foods for the anaemic Saudi children (from FFQ data)

Correlations	Haemoglobin n=24			MCV n=24			Serum Ferritin n=14		
	r	p	Sig	r	p	Sig	r	p	Sig
Chicken	-0.180	0.399		-0.424	0.039	*	-0.020	0.945	
Kan'ad fish	-0.479	0.018	*	-0.791	0.000	**			
Biscuits with chocolate	-0.719	0.000	***	-0.469	0.021	*	0.084	0.776	
Sweet Biscuits	-0.030	0.888		0.413	0.045	*	0.260	0.370	
Foul (Broad Beans)	-0.345	0.099		-0.760	0.000	***	0.212	0.467	
Cream	-0.479	0.018	*	-0.791	0.000	***			
triangle Cheese	-0.274	0.195		-0.524	0.009	**	-0.015	0.960	
White Cheese	-0.468	0.021	*	-0.784	0.000	***			
Cheese spread	-0.252	0.235		-0.636	0.001	***	0.212	0.467	
Cheddar Cheese	0.047	0.826		-0.049	0.819				
Dates	-0.286	0.176		-0.580	0.003	***	0.078	0.792	
Oranges	-0.153	0.475		-0.436	0.033	*	-0.468	0.091	
Bananas	-0.319	0.129		-0.530	0.008	**	-0.183	0.531	
Scrambled Eggs	-0.393	0.057		-0.742	0.000	***	-0.197	0.499	
Full cream milk	-0.427	0.037	*	-0.094	0.663		-0.129	0.660	
Dry full cream milk	-0.449	0.028	*	-0.280	0.186		-0.054	0.855	

*** Correlation is significant at the 0.001 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

CHAPTER

RESULTS OF THE

EDINBURGH STUDY

7
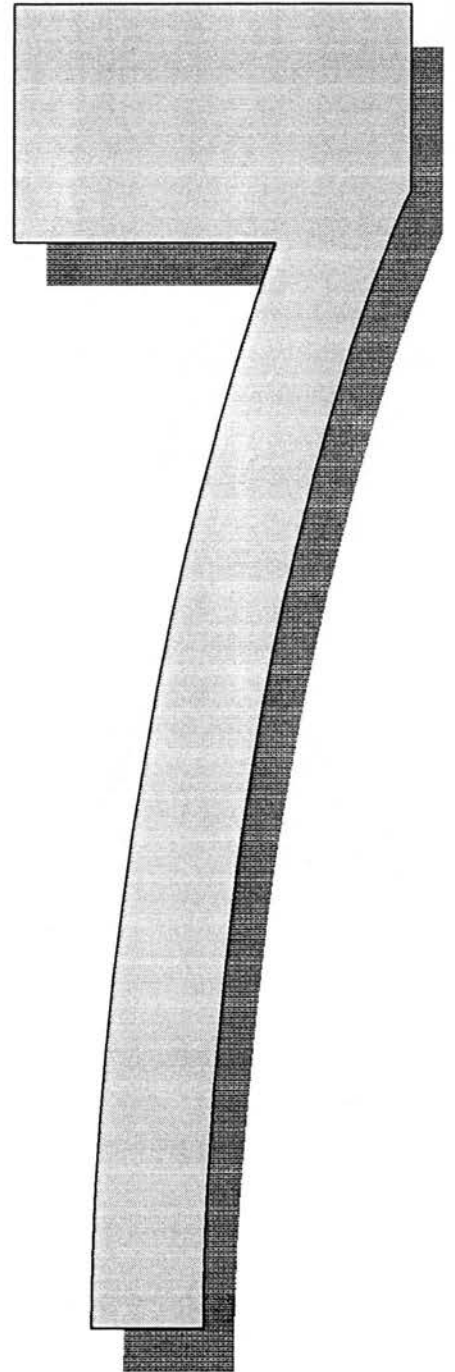
RESULTS OF THE EDINBURGH STUDY

HAEMATOLOGICAL RESULTS

Figure 7-1 shows haemoglobin concentrations for the different age groups. Hb was lowest in the youngest children then increased with the increasing age of the children then dropped down after the end of the second year of life. Only 2 children had low Hb concentrations (<11g/dl), a child aged 12 months and the other aged 23 months. As shown in table 7-1 mean Hb concentrations were 12.3 for all children and 11.6, 12.2 and 12.8 g/dl for the first, second and the third age group respectively. Boys had a mean Hb higher than girls, and the range of values was 10.3-14.8 g/dl. The prevalence of anaemia was low probably reflecting the nature of the sample of children studied and a population in which 63% of the mothers breast-fed their children.

Figure 7-1. Haemoglobin Concentrations For Different Age Groups
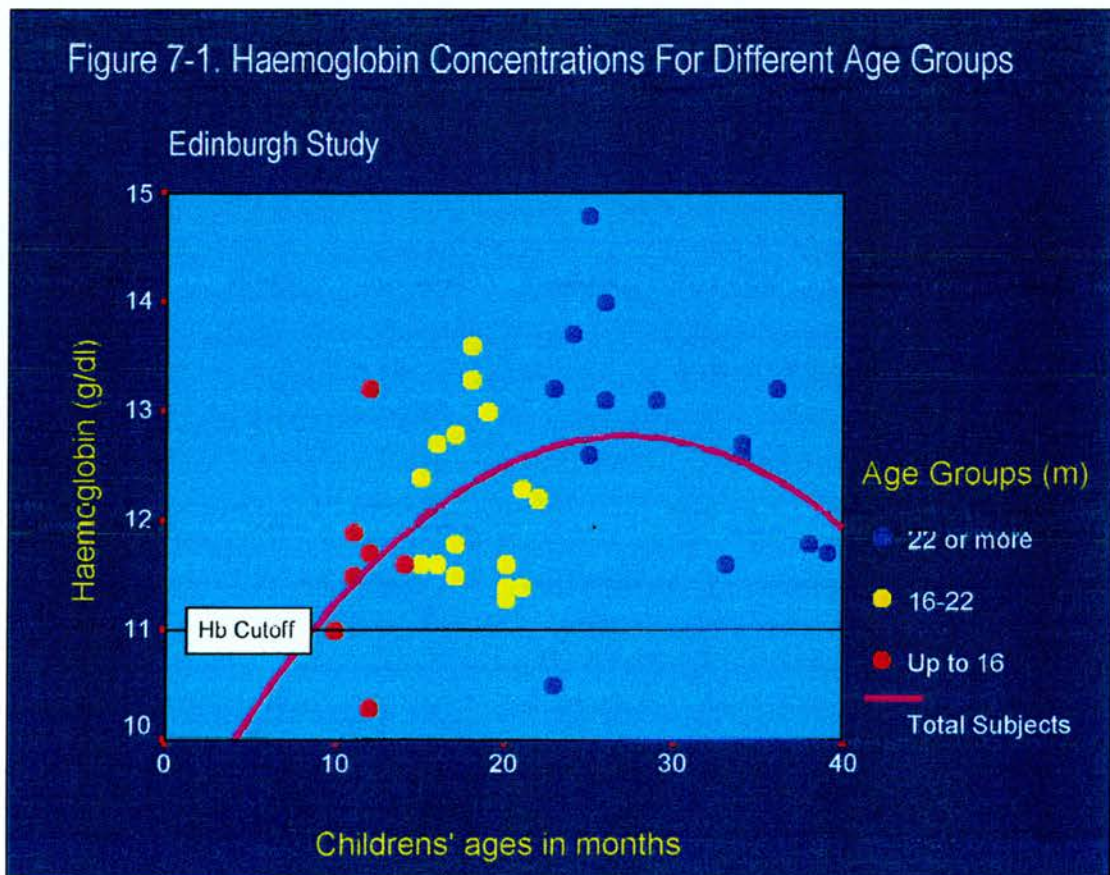
Table 7-1. Blood results by age groups and sex

		Children ages in months			Sex		
		< 16	16-22	22 or >	Boy	Girl	Total
Haemoglobin	Mean	11.6	12.2	12.8	12.4	12.1	12.3
(g/dl)	Median	11.6	12.0	12.9	12.4	11.7	12.2
n=37	Minimum	10.3	11.3	10.5	10.5	10.3	10.3
	Maximum	13.2	13.6	14.8	14.8	13.7	14.8
	< Cut off	1	0	1	1	1	2
MCV	Mean	77.9	78.4	79.2	78.3	79.5	78.6
(fl)	Median	77.4	78.0	80.7	77.7	78.5	78.0
n =37	Minimum	75.4	73.5	72.0	72.0	76.1	72.0
	Maximum	82.0	84.5	83.5	83.5	84.5	84.5
	< Cut off	1	3	2	6	0	6
Serum	Mean	21.0	18.1	17.2	17.6	20.0	18.2
Ferritin	Median	17.0	13.0	16.0	16.0	16.0	16.0
(mcg/l)	Minimum	4.0	5.0	2.0	2.0	12.0	2.0
n=28	Maximum	48.0	53.0	32.0	53.0	48.0	53.0
n=28	Maximum	48.0	53.0	32.0	53.0	48.0	53.0
	< Cut off	2	6	4	9	3	12
	< Cut off	2	6	4	9	3	12
Iron deficient*		3	1	2	3	0	3

* Defined as 2 or more blood parameters (Hb, MCV or SF) below the cut off

There were more children with low MCV (<76fl) than with low Hb. One child from the first age group (up to 16 months), 3 from the second age group (between 16-22 months) and 2 from the third age group (22 months or more). The regression line for MCV against age decreased within the first age group then increased smoothly from about 18 months (see figure 7-2). The mean MCV value was 78.6 fl and range 72-84.5 fl. The older children had higher MCVs, 77.9, 78.4 and 79.2 being the mean for the three age groups respectively.

Figure 7-2. MCV Concentrations For Different Age Groups
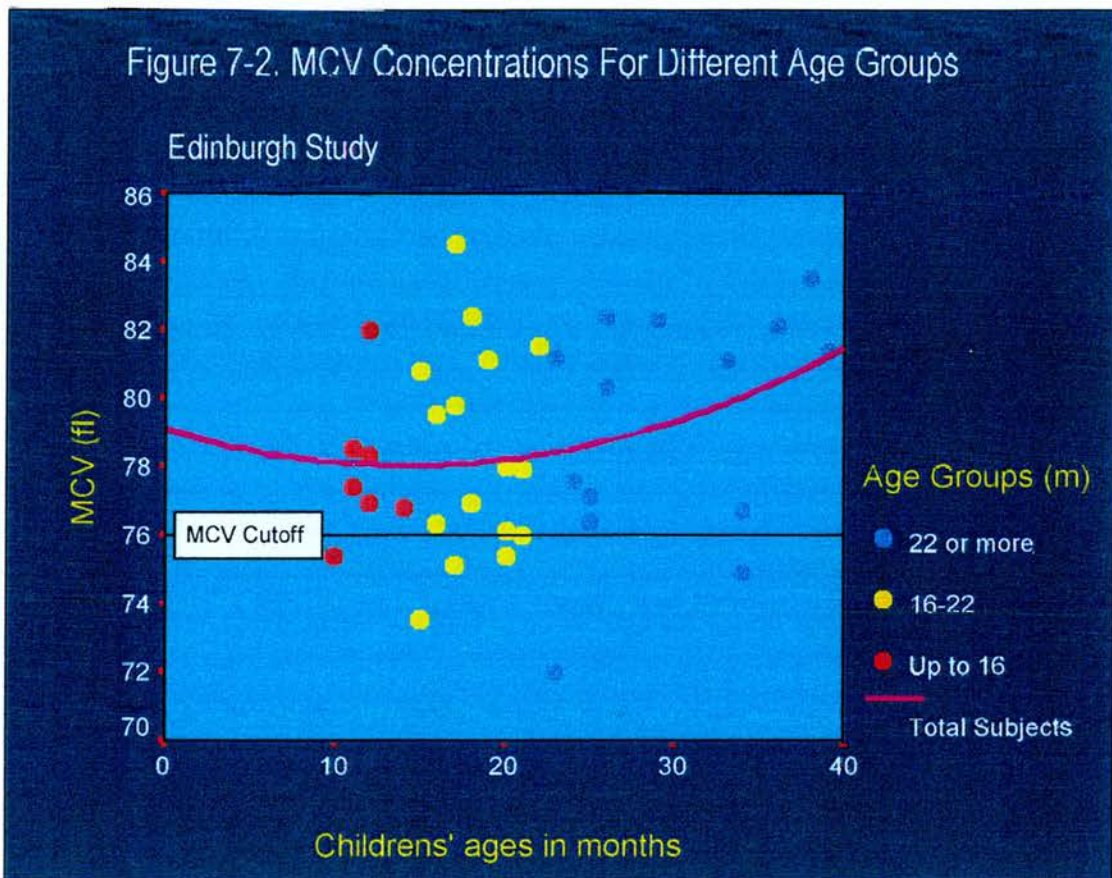
12 children were below the cut off for serum ferritin (< 15 µg/l) as shown in figure 7-3. 6 of them were from the second age group, with only 2 from the youngest and 4 from the oldest age groups. Contrary to Hb regression line, the serum ferritin against age regression line was highest initially then became lowest at the end of the second year of life. The median serum ferritin value 16 µg/l was just above the cut off and the range was 2- 53 µg/l. The highest mean was for the first age group, 17 µg/l. The mean

then dropped to 13 µg/l in the second age group and increased to 16 µg/l for the third age group.

Figure 7-3. Serum Ferritin Concentrations For Different Age Groups
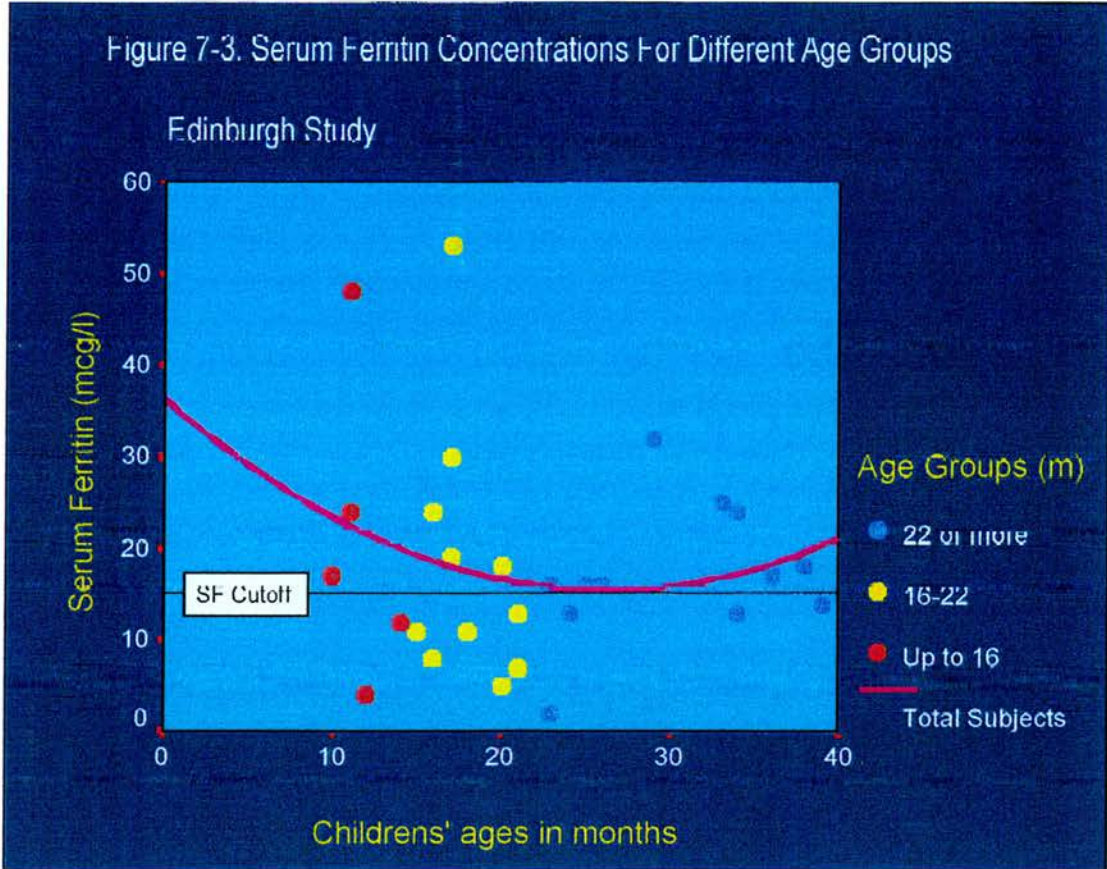
Only three boys were iron deficient, with both low MCV and SF for a child in the second age group, and two from the third age group; one had low Hb, MCV and SF and the another had low MCV and SF.

IRON INTAKE

Only 19% of all children achieved their RNIs of iron for their age. 21, 11 and 13% of the total children achieved between 50-60%, 60-70% and 60-70% respectively, and 8% were below 30% of the RNI. Figure 7-4 shows details of the percentage of RNI achieved.

Figure 7-5 summarised daily iron intake for different age groups compared with RNI and LRNI for infants. For the first age group, 9 infant; 4 boys and 5 girls had low RNI and 5 children; 2 boys and 3 girls were below the RNI. Only 1 boy and 1 girl were lower than LRNI. In the second age group, 12 boys and 8 girls intakes below the RNI, and 8

boys and 2 girls had intakes below the LRNI. 12 boys and 9 girls had intakes below the RNI in the third age group whilst 4 boys and 1 girl had intakes below the level of LRNI.

Figure 7-4. Percentage of RNI for Iron Achieved by Children

Edinburgh Study

Figure 7-5. Daily Iron Intake For Different Age Groups

Edinburgh Study
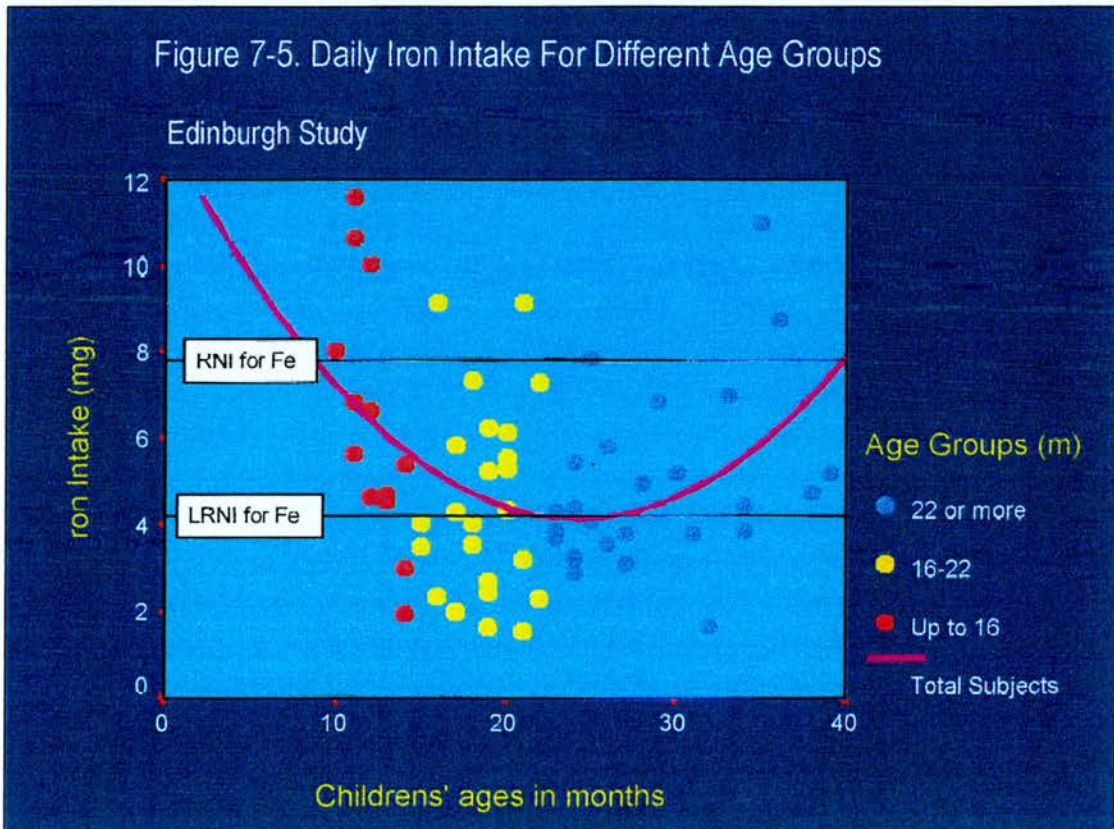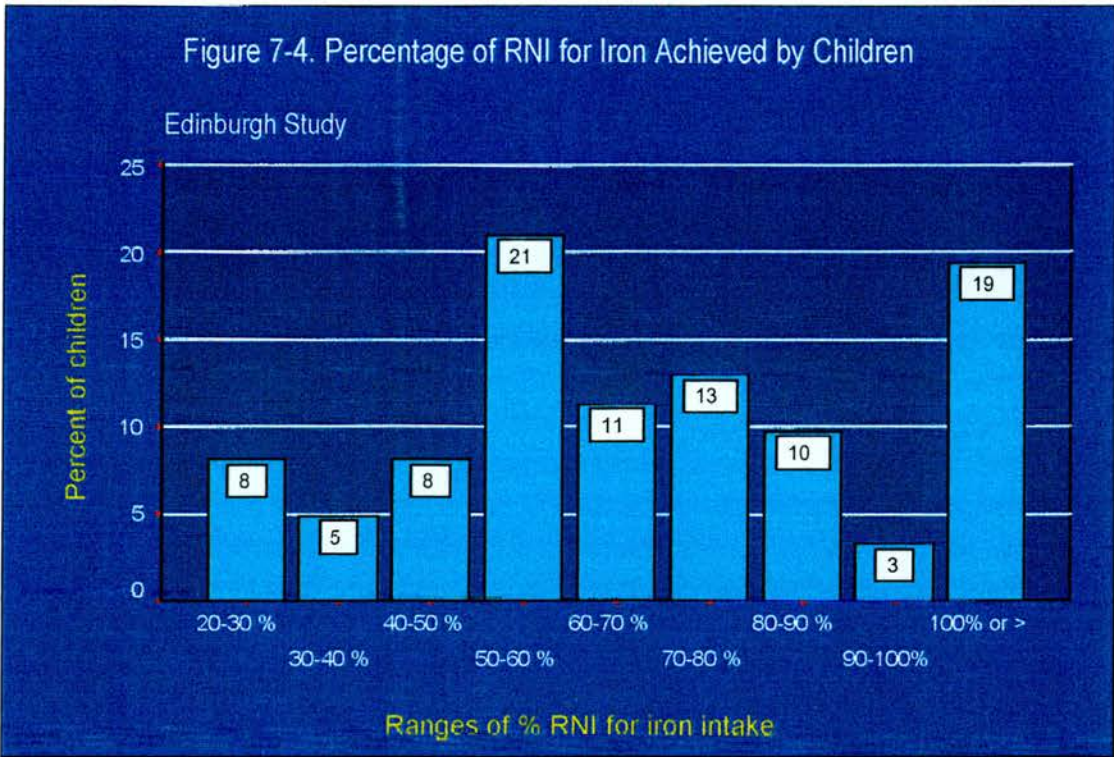
Table 7-2 shows mean, median, minimum, maximum and standard deviation for iron daily intake in mg/d, iron intake in mg per 100 kcal and in mg per kg body weight for all children by sex. The mean daily intake was 5.1 mg/d, range 1.56-11.62 mg/d, Boys were being higher than girls. When iron intake was expressed as mg/100 kcal, mean, min and max were, 5.58 mg/d, 1.88 and 13.22 mg/d respectively, with reduced differences between boys and girls became less. 0.43 mg/kg body weight per day was the mean ranged between 0.12 to 1.14 mg/kg/d. Girls had higher mean and median values than boys using this index.

Table 7-2. Iron intake by sex for all children in Edinburgh study

		Sex		Total
		Boys	Girls	
Daily Iron	Mean	5.22	4.93	5.10
Intake (mg)	Median	4.59	4.58	4.58
	Minimum	1.56	1.63	1.56
	Maximum	11.62	11.02	11.62
	Std Deviation	2.52	2.21	2.39
Iron Intake mg	Mean	5.60	5.55	5.58
per 1000 kcal	Median	5.33	5.28	5.31
	Minimum	1.88	1.94	1.88
	Maximum	12.24	13.22	13.22
	Std Deviation	2.35	2.40	2.35
Iron Intake mg	Mean	0.42	0.43	0.43
per kg body wt	Median	0.33	0.40	0.37
	Minimum	0.12	0.12	0.12
	Maximum	1.14	1.07	1.14
	Std Deviation	0.23	0.20	0.22

The highest iron intake was 6.44 mg/d in the first age group followed by 4.56 and 4.94 mg/d for the second and the third age groups respectively. A similar sequence was found for iron intake per 100 kcal. 7.57 mg/100 kcal was the mean for the first age group, 5.02 and 5.08 for the second and the third age groups respectively. 0.63 mg/kg/d in the first age group was the highest with means of 0.39 and 0.35 mg/kg/d in the second and third age groups respectively. More details of these data is shown in table 7-3.

IRON INTAKE AND BLOOD RESULTS

MCV results of all children were correlated positively with the percentage of haem iron intakes, r= 0.284 p<0.05. Serum ferritin was correlated positively with iron intake in mg/d, r= 0.364 p<0.05, with iron intake mg/1000 kcal per day r= 0.372 p<0.05, with iron intake mg/kg body weight per day r= 0.311 p<0.05 and with percentage of haem iron r= 0.365 p<0.05 see table 7-4.

In the first age group, haemoglobin and MCV were positively correlated with both iron intake in mg/d and in mg/100kcal/d, Hb correlations were r= 0.702 p<0.05 and r= 0.652 p<0.05 respectively, and MCV correlations were r= 0.858 p<0.05 and r= 0.847 p<0.05 respectively.

In the second age group, Hb was positively correlated with iron intake in mg/1000 kcal/d, r= 0.480 p<0.05 and serum ferritin was correlated with haem iron r= 0.573 p<0.05. In the third age group haem iron was correlated with r= 0.484 p<0.05. (see table 7-5)

Figure 7-6 shows the correlation between haemoglobin and iron intake in mg/d. Only two children both had low Hb and an iron intake below the RNI. One child had low Hb but normal iron intake (above the RNI). The vast majority (27) had low iron intakes with concentrations of Hb above the cut off. 7 had normal Hb concentration and iron intake. The regression line between Hb and iron intake increases with age.

5 children had low MCV and low iron intake. 1 child had low MCV with normal iron intake, 5 children had a normal MCV and iron intake and the majority (24) had low iron intake (below the RNI) with normal MCV, (see figure 7-7).

Table 7-3. Iron intake by sex and age in months for children in Edinburgh study

| | | <16 Months | | | 16-22 Months | | | >22 Months | | |
| | | Sex | | | Sex | | | Sex | | |
		Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
Daily Iron Intake (mg)	Mean	7.12	5.64	6.44	4.71	4.50	4.56	5.00	4.84	4.94
	Median	6.86	5.01	5.64	4.03	4.80	4.17	4.47	4.33	4.38
	Minimum	1.93	3.00	1.93	1.56	1.65	1.56	2.88	1.63	1.63
	Maximum	11.62	10.63	11.62	9.16	6.26	9.16	8.75	11.02	11.02
	Std Deviation	3.24	2.61	2.95	2.51	1.73	2.22	1.84	2.43	2.05
Iron Intake mg per 1000 kcal	Mean	7.82	7.28	7.57	5.39	4.54	5.02	4.91	5.32	5.08
	Median	8.52	6.84	7.59	5.27	5.04	5.10	4.60	4.66	4.60
	Minimum	2.87	3.28	2.87	1.88	1.94	1.88	3.14	3.18	3.14
	Maximum	12.24	13.22	13.22	10.81	6.41	10.81	8.04	9.53	9.53
	Std Deviation	2.92	3.31	2.99	2.31	1.58	2.07	1.49	1.93	1.65
Iron Intake mg per kg body wt	Mean	0.68	0.58	0.63	0.40	0.41	0.39	0.34	0.36	0.35
	Median	0.70	0.50	0.58	0.32	0.45	0.38	0.30	0.35	0.32
	Minimum	0.19	0.35	0.19	0.12	0.15	0.12	0.22	0.12	0.12
	Maximum	1.14	1.07	1.14	0.84	0.59	0.84	0.58	0.72	0.72
	Std Deviation	0.30	0.25	0.27	0.22	0.16	0.20	0.11	0.15	0.13

Table 7-4. Correlations between blood results and iron intake for all children in Edinburgh study

		mg/d			mg/1000 kcal/d			mg/kg/d			Haem Iron (%)	
		r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Haemoglobin (g/dl)	n=37	0.212	0.104		-0.005	0.488		-0.049	0.387		0.063	0.355	
MCV (fl)	n=37	0.133	0.216		0.099	0.281		0.034	0.420		0.284	0.044	*
Serum Ferritin (mcg/l)	n=28	0.364	0.028	*	0.372	0.026	*	0.311	0.050	*	0.365	0.028	*

* Correlation is significant at the 0.05 level.

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Table 7-5. Correlations between blood results and iron intake for Edinburgh study

		mg/d		mg/1000 kcal/d		mg/kg/d		Haem Iron (%)	
		r	p Sig	r	p Sig	r	p Sig	r	p Sig
Children aged up to 16 months									
Haemoglobin (g/dl)	n=7	0.702	0.039 *	0.652	0.050 *	0.22	0.312	-0.149	0.375
MCV (fl)	n=7	-0.145	0.378	0.141	0.382	0.00	0.493	-0.277	0.274
Serum Ferritin (µg/l)	n=5	0.858	0.032 *	0.847	0.035 *	0.68	0.103	0.458	0.219
Children aged 16-22 months									
Haemoglobin (g/dl)	n=16	0.292	0.136	0.480	0.030 *	0.19	0.230	-0.201	0.227
MCV (fl)	n=16	0.204	0.224	0.268	0.158	0.22	0.197	0.154	0.285
Serum Ferritin (µg/l)	n=11	0.155	0.324	0.171	0.307	0.15	0.326	0.573	0.033 *
Children aged 22 months or more									
Haemoglobin (g/dl)	n=14	0.402	0.077	0.097	0.371	0.42	0.065	-0.128	0.332
MCV (fl)	n=14	0.327	0.127	0.366	0.099	0.13	0.326	0.402	0.077
Serum Ferritin (µg/l)	n=12	0.421	0.086	0.160	0.310	0.23	0.231	0.484	0.050 *

* Correlation is significant at the 0.05 level

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Figure 7-6. Iron Intake Compared with Hb For Different Age Groups
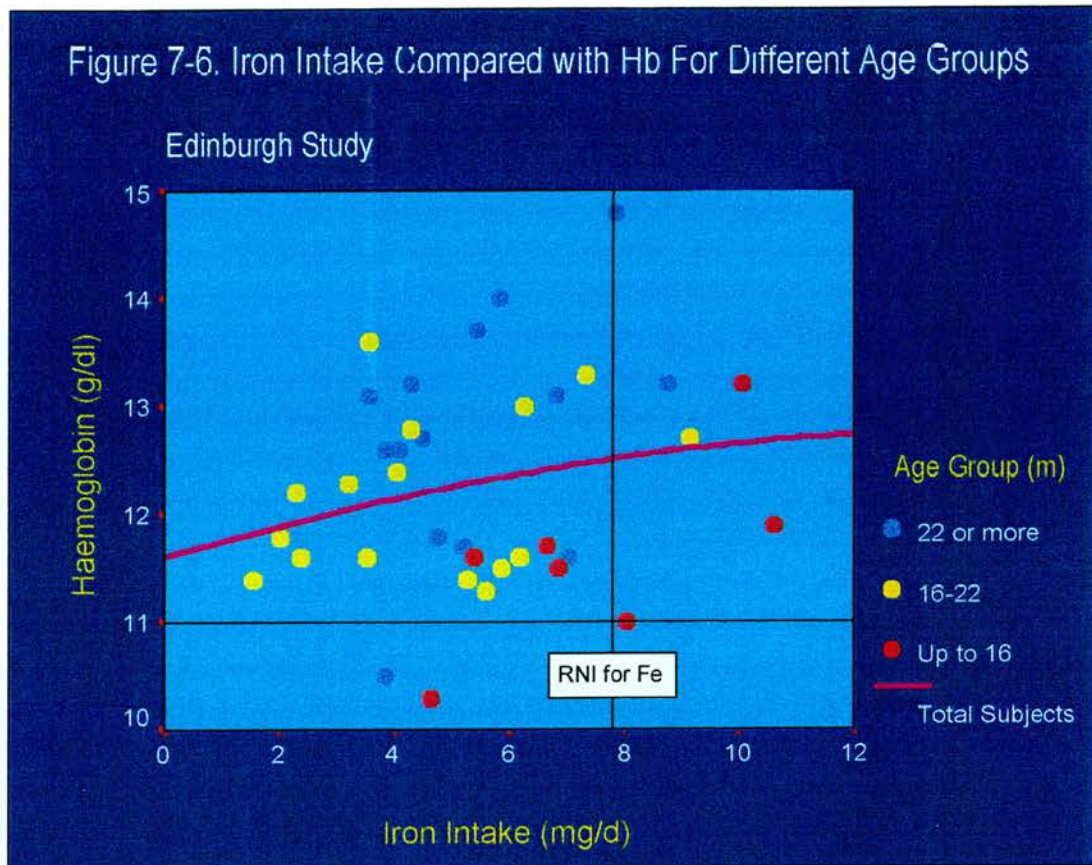
Figure 7-7. Iron Intake Compared with MCV For Different Age Groups
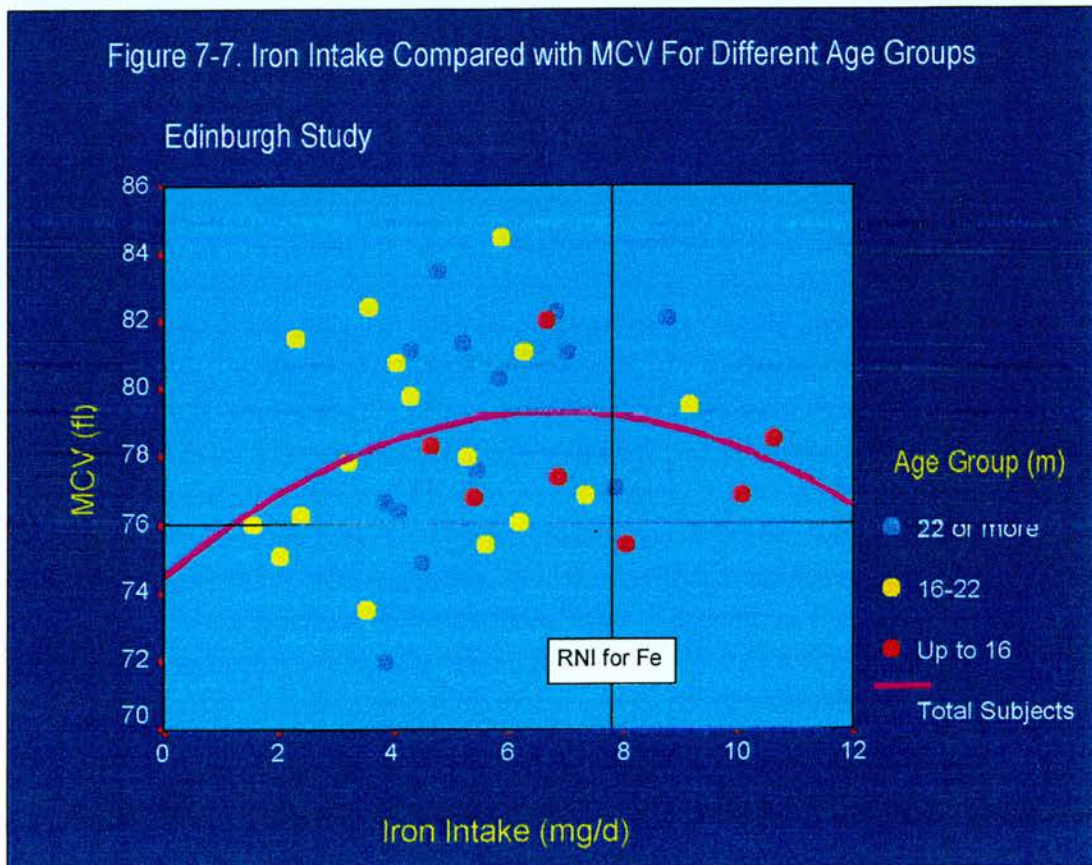
Figure 7-8 shows the association between serum ferritin and iron intake. 10 children were under the cut off line for both serum ferritin and had an iron intake below the RNI. Equal number (10) had a low iron intake with normal serum ferritin values. Two children had low Hb despite iron intakes above the RNI, and 6 children had normal serum ferritin and iron intake above the RNI. Due to high value of serum ferritin for two children i.e. above 200, they are not shown in the graph, in order to show clearly data for the rest of the children .

Figure 7-8. Iron Intake Compared with SF For Different Age Groups
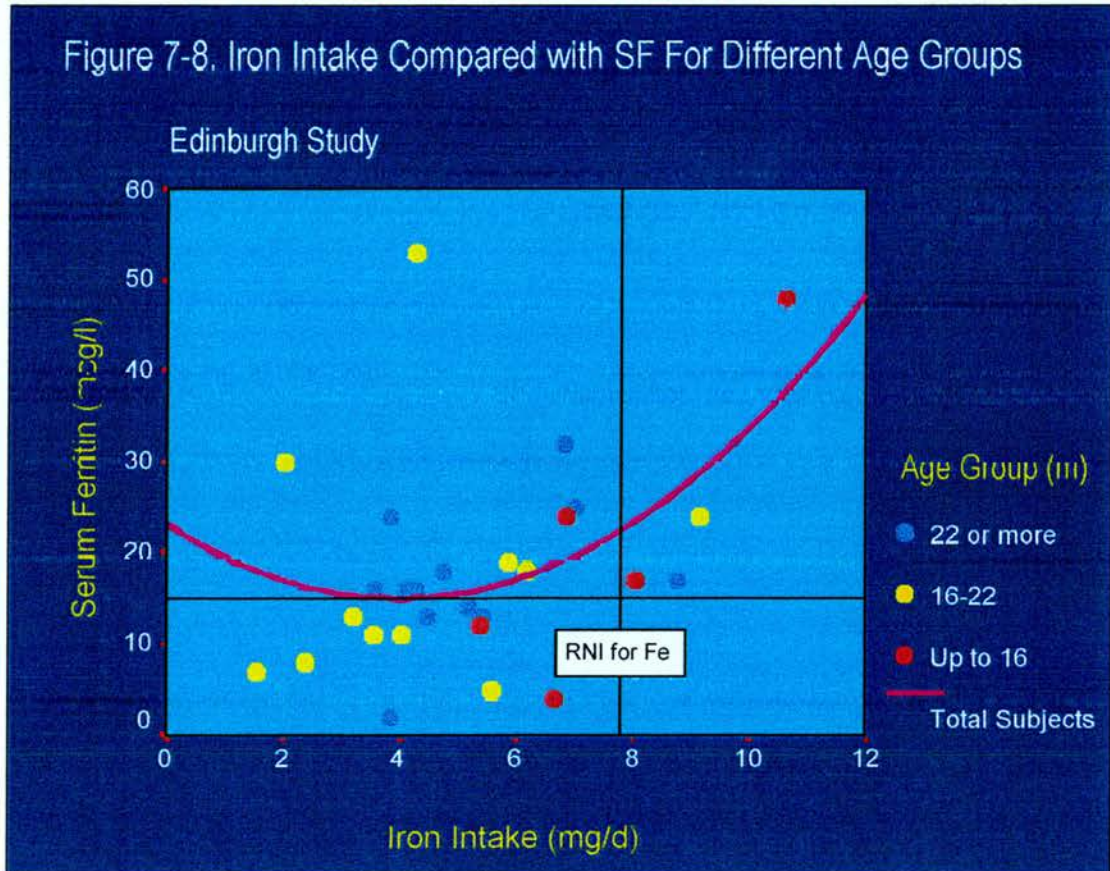
IRON SOURCES

Tables 7-6 and 7-7 show the sources of iron for infants having infant formula in their diet and those who did not. Separating these groups is important because of the effect of iron in infant formulas on the total amount of iron intake.

44.6% of iron was provided by infant formulas in the group of children taking these foods. Cereals, breakfast cereals and baby cereals including rusks made the next important contribution with percentages of 12.5%, 12% and 9% respectively.

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Meat and fish provided 5.2 % followed by vegetables with 5%. Milk and milk products were at the bottom of the list providing 3.8% of the total iron intake.

Table 7-7 shows sources of iron for those children not taking infant formulas. Breakfast cereals and cereals were on the top of the list providing 26.3% and 24 % of the total iron intake respectively. Meat and fish provided 12% and vegetables 8.8%.

Baby cereals, jams and honey and sugars provided 3.7% and 0.12 % respectively.

Table 7-6 Sources of iron for infants and children taking infant formulas

Children Taking Infant Formulas	%
Infant Formulas	44.60
Cereals	12.47
Breakfast Cereals	11.56
Baby Cereals	8.87
Meat and fish	5.18
Vegetables	5.15
Snacks including Biscuits	4.49
Fruits and Juice	3.86
Milk & Products	3.82
Total	100.00

Table 7-7 Sources of iron for children not taking infant formulas

Children Not Taking Infant Formulas	%
Breakfast Cereals	26.34
Cereals	24.02
Meat and Fish	12.16
Vegetables	8.82
Snacks including Biscuits	8.42
Fruits and Juice	8.41
Milk & Products	7.97
Baby Cereals	3.74
Honey, Jams and Sugars	0.12
Total	100.00

HAEM AND NON HAEM IRON

Haem iron intake averaged 0.31 mg/d for all children. Girls were higher than boys, 0.318 mg/d versus 0.302 mg/d respectively. It was higher in children not taking infant formulas (0.021 mg/kg body weight) than those having infant formulas (0.004 mg/kg body weight). Girls haem intakes were higher than boys in both groups. Table 7-8 shows mean, median, minimum , maximum and standard deviation of haem iron intake expressed as a percentage of total iron intake for all children. Median haem iron intakes were 1.7%, 5.2% and 6.9 % in the three age groups. Boys showed higher haem iron intakes than girls in the first and the second age groups. The maximum percentage was 35.2% for a boy in the third age group.

Figure 7.9 shows the haem iron intake as a percentage of the total iron intake plotted against age. The regression line shows an increase with age increase. The older the children were the higher was the percentage of haem iron. However, the percentage of iron as haem iron is in general small, as is shown in table 7.8.

Figure 7-9. Daily Haem Iron Intake For Different Age Groups
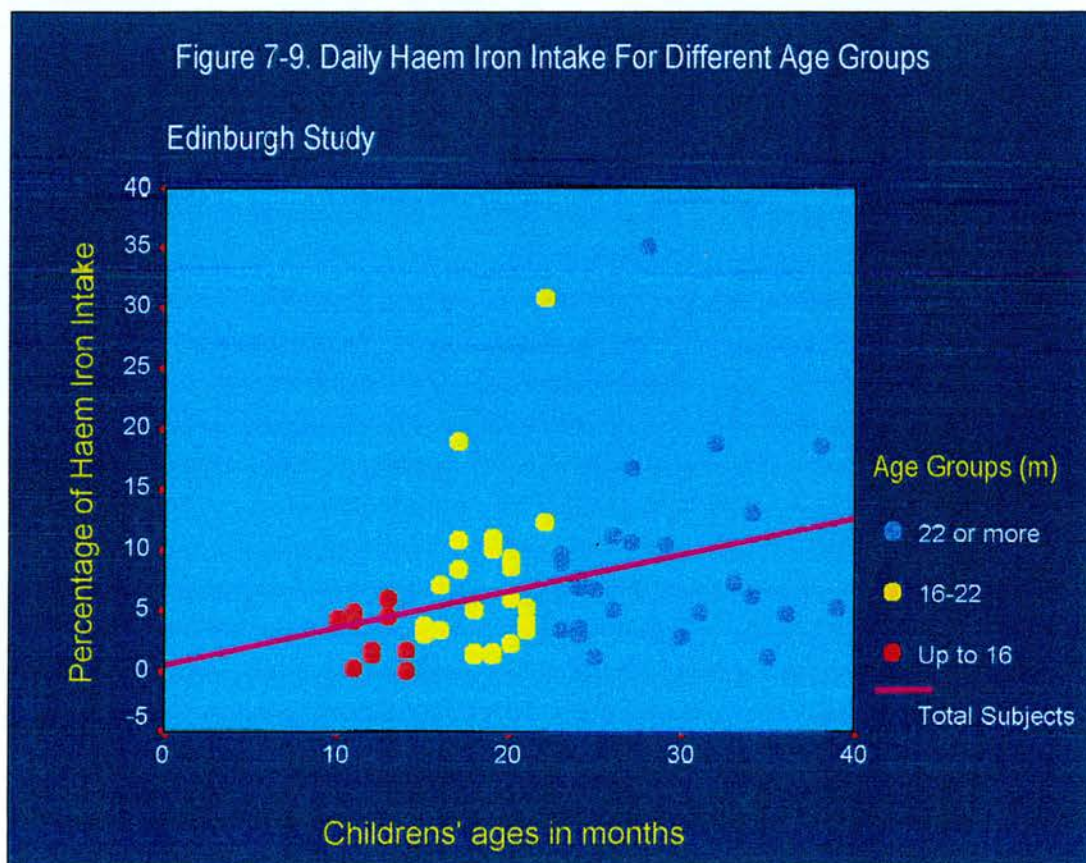
Table 7-8. Percentage of haem iron intake for all children in Edinburgh study

| | <16 Months | | | 16-22 Months | | | > 22 Months | | |
| | Sex | | | Sex | | | Sex | | |
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
Mean	2.36	3.07	2.68	7.86	6.44	7.37	9.59	7.87	8.90
Median	1.40	2.90	1.70	5.10	7.60	5.20	6.90	6.40	6.90
Minimum	0.00	0.00	0.00	1.60	1.40	1.40	1.10	1.20	1.10
Maximum	4.70	6.00	6.00	30.90	11.00	30.90	35.20	18.80	35.20
Std Deviation	2.08	2.29	2.12	7.81	4.41	6.74	8.36	5.88	7.38

Vitamin C

The potential affect of vitamin C on the absorption of iron, Figure 7-10 shows the daily intake of vitamin C plotted against age. The regression curve showed vitamin C intake was high at amongst the youngest children then dropped down the reach the lowest point at the end of the second year of life. After that it increased. 13 (21%) children had an intake below the RNI for vitamin C. The median value was 53 mg/d which is very high compared with RNI for vitamin C which is 25 mg/d.

Figure 7-10. Daily Intake of Vitamin C For Different Age Groups
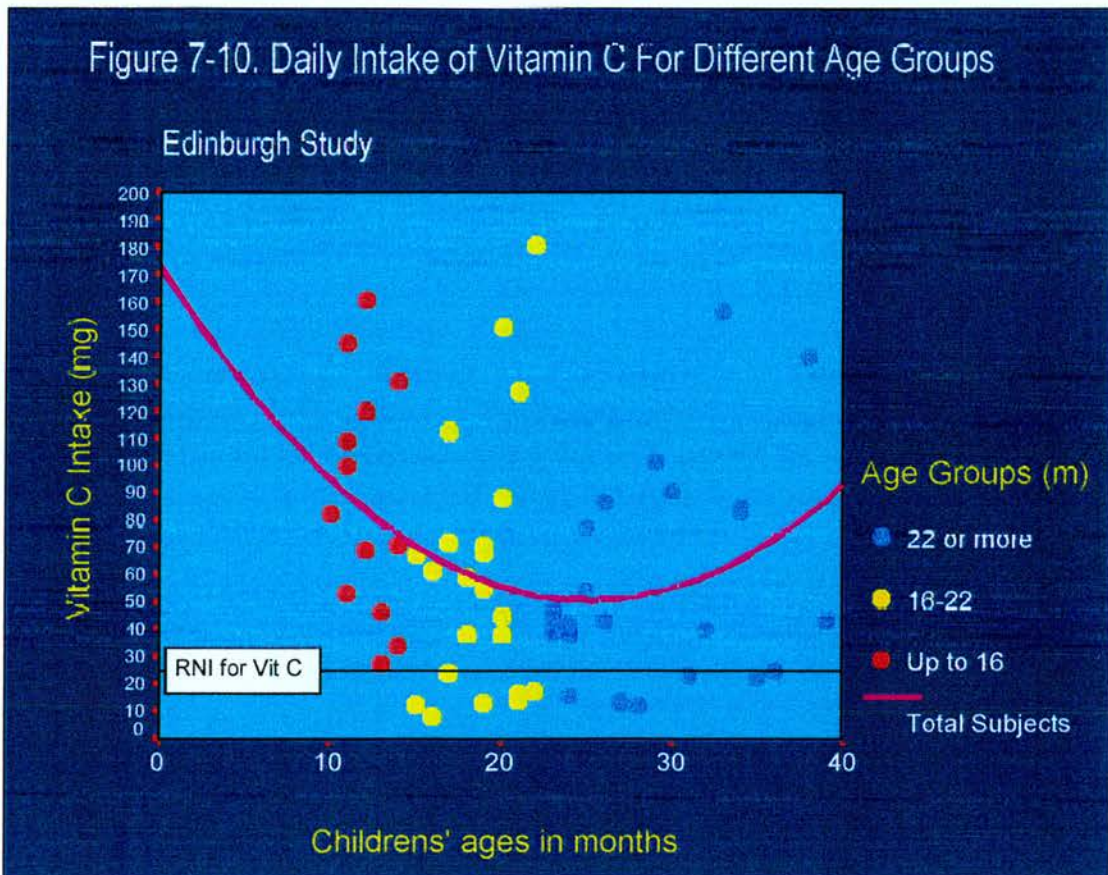
THE CORRELATIONS BETWEEN BLOOD RESULTS AND NUTRIENT AND FOOD INTAKES

Table 7-9 shows the correlations between blood results and the average daily intakes of some nutrients for all children. Energy intake in kcal was positively correlated with Hb r= 0.405 p<0.01. Protein had a significant correlation at the p<0.05 level, r= 0.371 and fat at the p<0.01 level, r= 0.394. Monounsaturated fatty acids and saturated fatty acids were correlated with Hb r= 0.311 p<0.05 and r= 0.393 p<0.01

Table 7-9. Correlation between blood results and average daily nutrients intakes for the children in Edinburgh study (From weighed intake data)

Correlations	Haemoglobin n=37			MCV n=37			Serum Ferritin n=28			Iron deficient n=28		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Energy (kcal)	0.405	0.006	**	0.047	0.391		0.056	0.388		0.090	0.325	
Protein (g)	0.371	0.012	*	-0.210	0.106		-0.007	0.485		0.090	0.324	
Fat (g)	0.394	0.008	**	-0.120	0.239		-0.206	0.146		0.136	0.245	
PUFA (g)	0.122	0.236		0.184	0.138		0.098	0.311		-0.130	0.254	
MUFA (g)	0.311	0.031	*	-0.140	0.205		-0.256	0.094		0.160	0.208	
Total Saturates (g)	0.393	0.008	**	-0.272	0.052		-0.265	0.087		0.169	0.194	
Carbohydrate (g)	0.303	0.034	*	0.267	0.055		0.275	0.079		0.009	0.482	
Starch (g)	0.389	0.009	**	0.341	0.019	*	0.014	0.471		-0.080	0.342	
Dietary Fibre (g)	0.620	0.000	**	0.193	0.127		0.286	0.070		-0.022	0.456	
Phosphorus (mg)	0.337	0.021	*	-0.340	0.020	*	0.033	0.435		0.163	0.204	
Magnesium (mg)	0.427	0.004	**	-0.082	0.315		0.192	0.164		0.125	0.263	
Calcium (mg)	0.241	0.075		-0.358	0.015	*	0.000	0.499		0.126	0.262	
Sodium (mg)	0.373	0.011	*	0.138	0.208		-0.094	0.318		-0.014	0.471	
Potassium (mg)	0.466	0.002	**	-0.066	0.349		0.226	0.124		0.093	0.319	
Chloride (mg)	0.420	0.005	**	0.175	0.149		-0.063	0.375		-0.016	0.467	
Iron (mg)	0.212	0.104		0.133	0.216		0.364	0.028	*	-0.102	0.303	
Haem Iron	0.063	0.355		0.284	0.044	*	0.365	0.028	*	-0.201	0.153	

* Correlation is significant at the 0.05 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

Table 7-9 (continued). Correlation between blood results and average daily nutrients intakes for the children in Edinburgh study (From weighed intake data)

Correlations	Haemoglobin n=37			MCV n=37			Serum Ferritin n=28			Iron deficient n=28		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Zinc (mg)	0.240	0.076		-0.224	0.092		0.191	0.166		0.043	0.414	
Copper (mg)	0.187	0.134		0.083	0.313		0.357	0.031	*	0.045	0.410	
Selenium (mcg)	0.379	0.010	*	-0.026	0.439		-0.008	0.483		0.326	0.045	*
Iodine (mcg)	0.033	0.424		-0.351	0.017	*	0.046	0.408		0.133	0.250	
Vitamin A (Ret.eq.) (mcg)	0.240	0.077		-0.335	0.021	*	0.214	0.137		0.135	0.247	
Vitamin B1 (mg)	0.232	0.083		0.044	0.397		0.407	0.016	*	-0.067	0.367	
Vitamin B6 (mg)	0.542	0.000	**	0.182	0.140		0.222	0.128		-0.009	0.482	
Vitamin B12 (mcg)	0.287	0.042		-0.331	0.023	*	-0.171	0.193		0.135	0.247	
Folate (mcg)	0.442	0.003	**	0.163	0.168		0.320	0.049	*	0.000	0.499	
Nicotinic acid (mg)	0.406	0.006	**	-0.065	0.352		0.052	0.396		0.055	0.391	
Vitamin D (mcg)	-0.207	0.110		-0.001	0.497		0.433	0.011	*	-0.115	0.279	
Vitamin E (mg)	-0.038	0.412		0.097	0.283		0.371	0.026	*	-0.186	0.171	
Cholesterol (mg)	0.260	0.060		-0.456	0.002	**	-0.234	0.116		0.413	0.014	*

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

respectively. Carbohydrate, starch and dietary fibre were also correlated with Hb r= 0.303 p<0.05, r= 0.389 p<0.01 and r= 0.620 p<0.005. Some minerals had correlations with Hb. Phosphorus, magnesium, sodium, potassium, chloride and selenium had the following values r= 0.337 p<0.05, r= 0.427 p<0.005, r= 0.373 p<0.05, r= 0.466 p<0.005 and r= 0.420 p<0.005, r= 0.379 p<0.01 respectively.

Vitamins B6, folate and nicotinic acid had values, r= 0.542 p<0.001, r= 0.442 p<0.005 and r= 0.406 p<0.01 respectively.

MCV was positively correlated with starch r= 0.341 p<0.05 and haem iron r= 0.284 p<0.05. Negative correlations were found between MCV and calcium r= -0.358 p<0.05, iodine r= -0.351 p<0.05, vitamin B12 r= -0.331 p<0.05 and cholesterol r= -0.456 p<0.005.

Serum ferritin was correlated with both iron and haem iron intakes r= 0.364 p<0.05 and r= 0.365 p<0.05 and also with copper, vitamin B1, folate, vitamin D and vitamin E, r= 0.357 p<0.05, r= 0.407 p<0.05, r= 0.320 p<0.05, r= 0.433 p<0.05 and r= 0.371 p<0.05 respectively.

The association between food intake and blood results is shown in table 7-10. The infant formula SMA Gold was correlated with MCV r= 0.329 p<0.05 and the follow-up formula of the same manufacturer correlated with serum ferritin r= 0.429 p<0.05. Corn flakes correlated negatively with both Hb and MCV r= -0.369 p<0.05 and r= -0.319 p<0.05 respectively. Sugar coated cereals correlated positively with Hb r= 0.500 p<0.001. Fresh fruit juice were correlated with SF value r= 0.438 p<0.01 and apple fresh juice was correlated with Hb r= 0.302 p<0.05. Coffee had negative correlations with both Hb and MCV r= -0.303 p<0.05 and r= -0.371 p<0.05 respectively.

Beef strongly correlated with MCV r= 0.429 p<0.005, pork was correlated with Hb r= 0.365 p<0.05 and with SF r= 0.367 p<0.05. Bacon, sausages, and ham sandwiches had correlations with Hb r= 0.284 p<0.05, r= 0.291 p<0.05 and r= 0.311 p<0.05 respectively. Fruit flavour yoghurt was correlated with SF r= 0.550 p<0.001, and milk pudding was correlated with Hb r= 0.278 p<0.05. Peaches had correlations with Hb r= 0.379 p<0.01 and with SF r= 0.412 p<0.05.

Table 7-10. Correlation between blood results and avereage intakes of specific foods the children in Edinburgh study (from FFQ data)

Correlations	Haemoglobin n=37			MCV n=37			Serum Ferritin n=28			Iron intake n=62		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
SMA (Gold)	-0.133	0.217		0.329	0.023	*	0.013	0.474		0.050	0.351	
SMA follow up formula	-0.060	0.363		-0.061	0.361		0.429	0.011	*	0.364	0.002	**
Weaning food with meat	0.163	0.167		-0.180	0.143		0.004	0.492		0.282	0.013	*
Other comm. weaning foods	-0.218	0.098		-0.180	0.143		-0.020	0.459		0.363	0.002	**
Cornflakes	-0.369	0.012	*	-0.319	0.027	*	-0.021	0.458		-0.220	0.043	*
Sugar coated cereals	0.500	0.001	**	0.091	0.297		-0.101	0.305		0.022	0.432	
Fresh apple juice	0.302	0.035	*	0.119	0.241		-0.206	0.146		0.269	0.017	*
Other fresh juice	0.148	0.191		0.125	0.230		0.438	0.010	**	0.397	0.001	**
Cola	-0.003	0.492		-0.161	0.171		0.197	0.157		-0.257	0.022	*
Coffee	-0.303	0.034	*	-0.371	0.012	*	-0.271	0.081		-0.067	0.302	
Beef	0.184	0.138		0.429	0.004	**	-0.175	0.187		0.087	0.250	
Pork	0.365	0.013	*	0.229	0.087		0.367	0.027	*	-0.055	0.337	
Bacon	0.284	0.044	*	0.256	0.063		-0.048	0.404		-0.073	0.286	
Sausage	0.291	0.040	*	0.172	0.155		0.227	0.122		-0.200	0.060	
Ham sandwiches	0.311	0.030	*	0.162	0.169		0.084	0.335		-0.062	0.316	
Sardines or Salmon	0.197	0.121		0.038	0.412		0.196	0.158		0.368	0.002	***
Fruit or flavored yogurt	0.237	0.079		0.226	0.089		0.550	0.001	**	0.255	0.023	*
Milk pudding	0.278	0.048	*	0.263	0.058		0.178	0.182		0.280	0.014	*
Peaches	0.379	0.010	**	0.224	0.091		0.412	0.015	*	0.320	0.006	**
Baked potatoes	0.327	0.024	*	0.273	0.051		-0.043	0.414		-0.137	0.145	
Cauliflower	0.173	0.154		0.164	0.166		0.431	0.011	*	0.480	0.000	***
Broccoli	0.255	0.064		0.247	0.070		0.557	0.001	**	0.194	0.066	*

*** Correlation is significant at the 0.005 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

Table 7-10. *(Continued)* Correlation between blood results and average intakes of specific foods the children in Edinburgh study (from FFQ data)

Correlations	Haemoglobin n=37			MCV n=37			Serum Ferritin n=28			Iron intake n=62		
	r	p	Sig	r	p	Sig	r	p	Sig	r	p	Sig
Peas	0.405	0.006	**	0.312	0.030	*	0.017	0.465		-0.017	0.449	
Lentils	0.135	0.213		-0.112	0.255		-0.097	0.313		0.278	0.014	*
Cucumber	-0.029	0.432		0.035	0.418		-0.165	0.201		0.298	0.009	**
Other vegetables	-0.317	0.028	*	-0.168	0.160		-0.349	0.034	*	0.196	0.064	*
Scones and pancakes	0.190	0.131		0.167	0.161		0.432	0.011	*	-0.021	0.435	
Ice cream	0.110	0.259		-0.036	0.416		-0.163	0.204		0.241	0.030	*
Pizza	0.029	0.433		0.043	0.400		-0.022	0.456		0.246	0.027	*
White bread	-0.115	0.248		0.112	0.254		-0.175	0.187		-0.329	0.004	**
Wholemeal bread	0.183	0.140		-0.101	0.276		0.304	0.058		0.422	0.000	***
Biscuits	0.275	0.050	*	0.166	0.163		-0.142	0.236		0.038	0.385	
Infant Formulas	-0.175	0.149		0.016	0.463		0.045	0.410		0.427	0.000	***
Follow-up Formulas	-0.168	0.161		-0.064	0.353		0.429	0.011	*	0.338	0.004	***
Weaning Foods	0.070	0.339		-0.234	0.082		0.025	0.450		0.339	0.004	***
Fresh Milk	0.197	0.122		-0.179	0.145		-0.119	0.273		-0.323	0.005	**
All Cows Mlik	0.194	0.125		-0.185	0.136		-0.126	0.261		-0.309	0.007	**
Milk Products	0.317	0.028	*	0.149	0.190		0.113	0.283		0.175	0.087	
Milk and Milk Products	0.353	0.016	*	-0.055	0.373		-0.036	0.427		-0.123	0.170	
Meats and Fish	0.287	0.043	*	0.150	0.188		0.109	0.290		0.027	0.418	
Cereals	0.336	0.021	*	0.019	0.456		0.075	0.351		0.214	0.049	*
Fruit Juices	-0.014	0.467		0.133	0.215		0.035	0.430		0.302	0.008	**
Vegetables	0.316	0.028	*	0.252	0.066		0.032	0.435		0.235	0.034	*
Sandwichs	0.249	0.069		0.307	0.032	*	0.022	0.455		-0.088	0.249	

*** Correlation is significant at the 0.005 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

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Baked potatoes was correlated with Hb r= 0.327 p<0.05, cauliflower with SF r= 0.431 p<0.05, proccoli with SF too r= 0.557 p<0.005, peas with both Hb and MCV r= 0.405 p<0.01 and r= 0.312 p<0.05 respectively, and other vegetables were correlated negatively with both MCV and SF r= -0.317 p<0.05 and r= -0.349 p<0.05. Scones and pancakes were correlated with SF r= 0.432 p<0.05, fresh apple juice was correlated with Hb r= 0.302 p<0.05 and biscuits r= 0.275 p<0.05.

Meat and fish group was correlated with Hb r= 0.287 p<0.05, follow-up formulas were correlated with SF r= 0.429 p<0.05, vegetables , cereals, milk and milk products groups were correlated with Hb r= 0.316 p<0.05, r= 0.336 p<0.05 and r= 0.353 p<0.05 respectively.

FREQUENCY OF THE MOST COMMON FOODS CONSUMED BY THE CHILDREN

Whole pasteurised milk was the most common food for all the children. It was consumed average more than once a day with a total frequency of 296 times over a period of four days. Canned fruit juice was in the second rank with frequency of 86 time (this food was eaten by 38% of all children each day) weetabix, fromage frais, orange juice, bananas and butter had frequencies of 67, 65, 64, 54 and 49 (30, 29, 29, 24 and 22% of all children were eaten these foods each day) respectively. Fresh orange juice and plain biscuits were at the bottom of the list with 10%/day each (see table 7-11).

Table 7-12 shows the frequency of common food eaten by the youngest children. Whole pasteurised milk then human milk were on the top of the list with frequency of 56 and 22 times 25 and 10% a day respectively. Fromage frais, bananas, whole milk yoghurt had 8, 7, 7%/day respectively. Vegetable soup and milky way had 3% for each of them. Progress follow-up formula and Aptamil formula had 4% each. Breakfast cereals such as ready brek and weetabix had 7 and 4 % a day respectively.

For children aged between 16-22 months, whole pasteurised milk was the most common drink with 50%/day as shown in table 7-13. Canned fruit juice, weetabix, unsweetened orange juice had frequencies of 39, 25 and 23 time 17, 11 and 10%/day

respectively. New food were found in the list of this group e.g. margarine 6%, potato crisps 5%, ham 4% and tea 4%. SMA formula was found in this list with 4%/day.

Table 7-11. Frequency of the most common food eaten by all children and percentage of daily consumption of each food

Edinburgh Study   (n=56)

Food	Frequency	%/day *
1 - Whole milk, pasteurised	296	132
2 - Fruit juice drink, ready to drink	86	38
3 - Weetabix	67	30
4 - Fromage frais, fruit	65	29
5 - Orange juice, unsweetened	64	29
6 - Bananas	54	24
7 - Butter	49	22
8 - White bread, toasted	43	19
9 - Whole milk yoghurt, fruit flavoured	41	18
10 - White bread, sliced	37	17
11 - Margarine	37	17
12 - Potato crisps	34	15
13 - High juice drink, concentrated, made up	32	14
14 - Blackcurrant juice drink, concentrated, made up	31	14
15 - Semi-skimmed milk, pasteurised	28	13
16 - Grapes, average	26	12
17 - Wholemeal bread, average	26	12
18 - Spaghetti, canned in tomato sauce	25	11
19 - Orange juice, freshly squeezed	23	10
20 - Digestive biscuits, plain	22	10

* %/day is the percentage of children who eat the food each day

Table 7-12. Frequency of the most common food eaten by children aged up to 16 monthsand percentage of daily consumption of each food

Edinburgh Study   (n=15)

Food	Frequency	%/day *
1 - Whole milk, pasteurised	56	25
2 - Human milk, mature	22	10
3 - Fromage frais, fruit	20	9
4 - Bananas	17	8
5 - Whole milk yoghurt, fruit	15	7
6 - Orange juice, unsweetened	15	7
7 - Ready Brek	15	7
8 - Fruit juice drink, ready to drink	14	6
9 - Whole milk, average	13	6
10 - Fruit desserts, canned/bottled	10	4
11 - High juice drink, concentrated, made up	10	4
12 - Progress, reconstituted	10	4
13 - Honey	10	4
14 - Weetabix	9	4
15 - Aptamil, reconstituted	8	4
16 - White bread, sliced	8	4
17 - White bread, toasted	8	4
18 - Wholemeal bread, average	8	4
19 - Vegetable soup	7	3
20 - Milky Way	7	3

* %/day is the percentage of children who eat the food each day

Table 7-13. Frequency of the most common food eaten by children aged 16-22 months and percentage of daily consumption of each food

Edinburgh Study   (n=20)

	Food	Frequency	%/day *
1 -	Whole milk, pasteurised	112	50
2 -	Fruit juice drink, ready to drink	39	17
3 -	Weetabix	25	11
4 -	Orange juice, unsweetened	23	10
5 -	Blackcurrant juice drink, concentrated, made up	22	10
6 -	Bananas	20	9
7 -	White bread, toasted	20	9
8 -	White bread, sliced	14	6
9 -	Margarine	14	6
10 -	Wholemeal bread, average	14	6
11 -	Fromage frais, fruit	13	6
12 -	Butter	13	6
13 -	White bread, average	13	6
14 -	Potato crisps	12	5
15 -	Whole milk yoghurt, fruit flavoured	11	5
16 -	Baked beans, canned in tomato sauce	10	4
17 -	Ham	8	4
18 -	Tea, infusion, average, with whole milk	8	4
19 -	Gold Cap SMA, reconstituted	8	4
20 -	Peanut butter, smooth	8	4

* %/day is the percentage of children who eat the food each day

Table 7-14. Frequency of the most common food eaten by children aged 22 months or more and percentage of daily consumption of each food Edinburgh Study   (n=27)

	Food	Frequency	%/day *
1 -	Whole milk, pasteurised	145	65
2 -	Orange juice, unsweetened	40	18
3 -	Fruit juice drink, ready to drink	37	17
4 -	Fromage frais, fruit	34	15
5 -	Weetabix	33	15
6 -	Butter	29	13
7 -	Bananas	26	12
8 -	Potato crisps	23	10
9 -	High juice drink, concentrated, made up	22	10
10 -	Semi-skimmed milk, pasteurised	22	10
11 -	Orange juice, freshly squeezed	21	9
12 -	White bread, sliced	21	9
13 -	Whole milk yoghurt, fruit flavoured	19	8
14 -	White bread, toasted	19	8
15 -	Digestive biscuits, plain	17	8
16 -	Margarine	16	7
17 -	Tea, infusion, average, with whole milk	15	7
18 -	Lemonade	15	7
19 -	Cream crackers	15	7
20 -	Grapes, average	14	6

* %/day is the percentage of children who eat the food each day

Whole pasteurised milk on the top of the list for older children with 145 frequency and 65% a day as shown in table 7-14. Unsweetened orange juice and canned fruit juice were followed milk with 40 and 37 times 17 and 15 % respectively. Semi-skimmed milk, lemonade, cream crakers and grapes were new foods in this list.

ANTHROPOMETRIC MEASUREMENTS AND BLOOD RESULTS

Table 7-15 shows that there are some correlations between anthropometric measurements for all children and haemoglobin concentrations. Haemoglobin was correlated with Height, r= 0.380 p<0.01, weight, r= 0.436 p<0.005, head circumference, r= 0.299 p<0.05 and chest circumference, r= 0.523 p<0.001.

There was no overall correlation of MCV or serum ferritin with any anthropometric data. However, MCV was correlated with head circumference in the second age group r= 0.430 p<0.05, triceps skinfold was correlated with Hb in that age group r= 0.585 p<0.01, and chest circumference was correlated with serum ferritin in the third age group r= 0.567 p<0.05.

SOCIAL FACTORS AND BLOOD RESULTS

Some social factors were significantly related to the haematological parameters. MCV was correlated with the educational level of the mother r= 0.310 p<0.05, the mothers' age had an association with the concentration of Hb r= 0.286 p<0.05. Children of non-white mothers had a lower serum ferritin r= 0.618 p<0.005 whereas children had a higher MCV concentration when their mothers cooked special food for them r= 0.302 p<0.05.

Only 4 mothers were continuing breast feeding when the study was carried out. 64% of the mothers breast fed for any time even just a few days (4 mothers, 10% from those breast fed). 5, 10 and 15% of those mothers breast fed for 1, 2 and 3 months respectively. The survival curve in figure 7-11 shows the extent of breast feedings and its' duration.

Figure 7-12 shows the mothers' practices in feeding their babies. The mean child's age in months when the mother stopped breast milk was 4 months. Infant formulas were started at 3 months and stopped on average at only sixth months of

Table 7-15. Correlations between blood results and anthropometric measurements
for children in Edinburgh study

Correlations	Haemoglobin n=37			MCV n=37			Serum Ferritin n=28		
	r	p	Sig	r	p	Sig	r	p	Sig
Height (cm)	0.380	0.010	*	0.259	0.061		-0.051	0.398	
Weight (kg)	0.436	0.004	**	0.225	0.090		0.018	0.464	
Head Circumference (cm)	0.299	0.036	*	0.237	0.079		0.008	0.483	
Chest Circumference (cm)	0.523	0.000	**	0.260	0.060		0.028	0.443	
Triceps Skinfold (mm)	0.255	0.064		0.106	0.267		0.196	0.159	
Subscapular Skinfold (mm)	0.113	0.253		-0.033	0.423		0.164	0.202	

* Correlation is significant at the 0.05 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).

age. Follow-up formulas were started at the age of 6 months and stopped at the age of 13 months. Introducing fresh milk was on average at the age of 13 months and the family food was introduced at the age of 10 months. 6 months was considered the right age to introduce food fortified with iron in the opinion of the mothers.

Table 7-16 shows the reasons for stopping breast milk for those who were breast fed at any stage. 11.3% said that the reason was there was no enough milk for breast feeding. The same percentage said the child was no longer interested in the breast milk. 9.7% thought the time of breast feeding provided was sufficient. Study or work made 8% stop breast feeding of their babies.
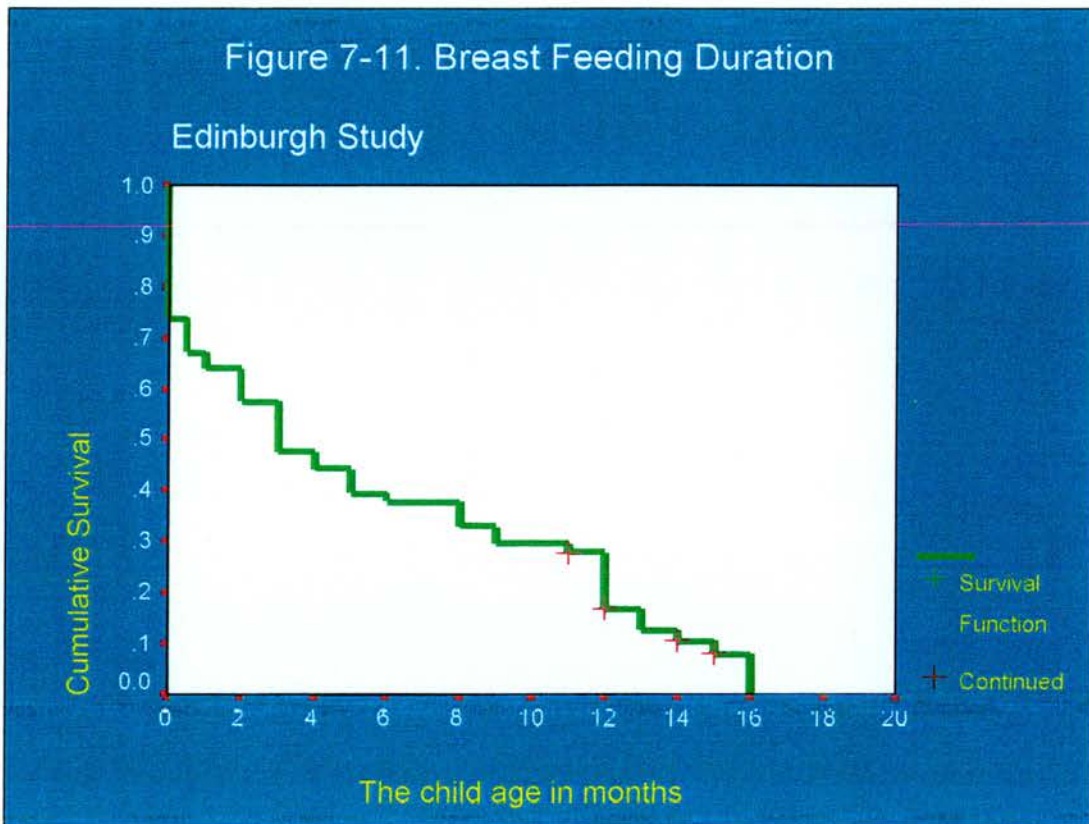

Figure 7-11. Breast Feeding Duration

Figure 7-12. Mothers' Practices Regarding Their Babies Feeding
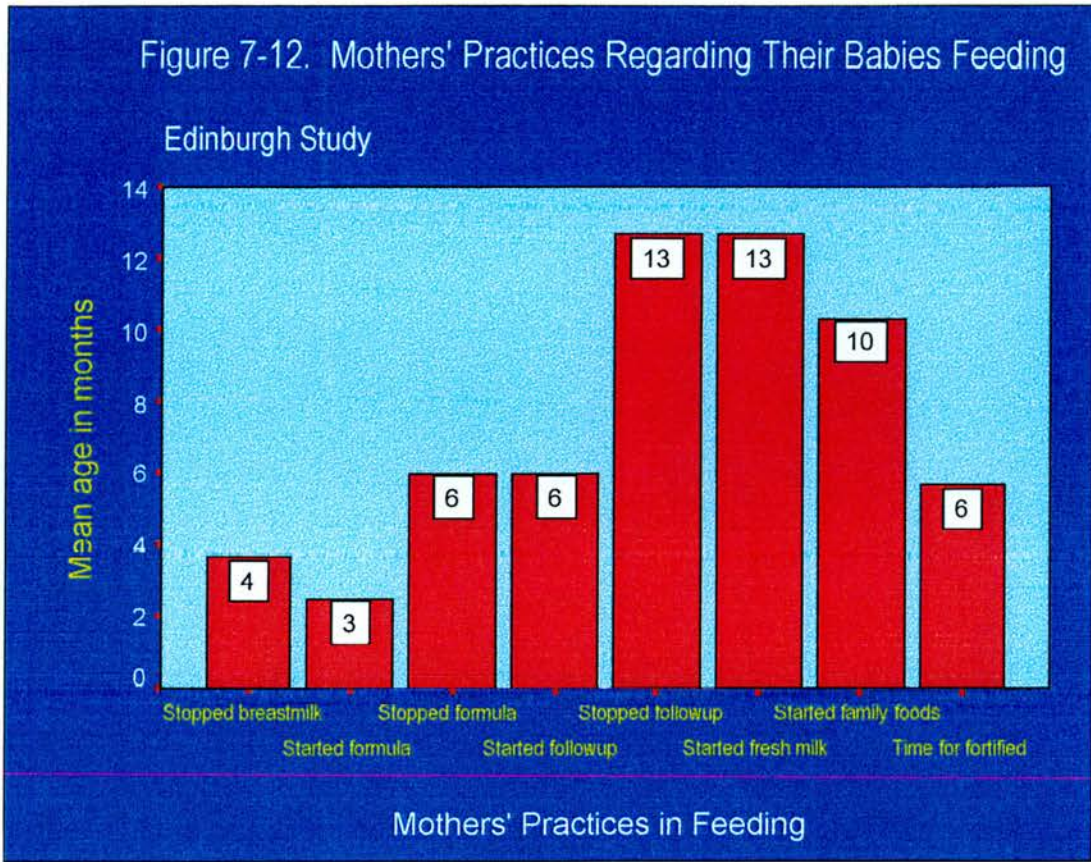
Table 7-16. Reasons for Stopping Breast-feeding are:

	Frequency	Percent	Percent of those breast fed
Not enough milk	7	11.3	18.4
Child no longer interested	7	11.3	18.4
Sufficient feeding achieved	6	9.7	15.8
Study or work	5	8.1	13.2
Mothers' health problem	4	6.5	10.5
Feeding problems	2	3.2	5.3
Other	1	1.6	2.6
Total	38	61.3	100.0

CHAPTER

RESULTS OF THE ROYAL HOSPITAL FOR THE SICK CHILDREN STUDY

8
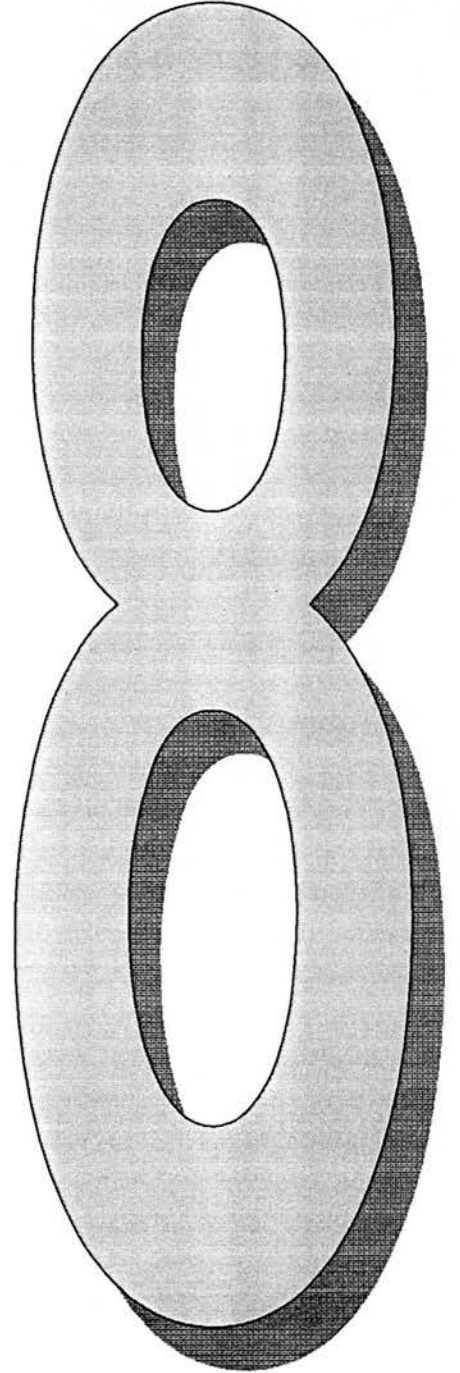
RESULTS OF THE ROYAL HOSPITAL FOR THE SICK CHILDREN STUDY

Results of 2320 blood samples analysed in the Haematology Department in the 2 months of the study were available. Of these, 1146 were excluded because of known presenting conditions which could influence the haematological data. 981 results were normal. 193 were abnormal, having either low Hb or low MCV or both Hb and MCV low.

Of the abnormal children, 44 were less than 8 months of age, 82 were between 8 months and 3 years and 67 were older than 3 years.

The prevalence of anaemia was 82 out of 289 or 28.3% in children aged between 8 months and 3 years and 67 out of 716 or 9.4% in children older than 3 years. 44 out of 151 or 29.1% of the infants aged less than 8 months were anaemic. However a number of this latter group were either neonates or infants under 3 months of age who were in-patients at the Simpson Memorial Maternity Pavilion who although not excluded because of their recorded diagnosis may nevertheless have had known causes for their anaemia.

116 children of age less than 3 years were studied in detail. These included 32 normals who were selected at random as a comparison group from the 207 normals in this age group.

Comparisons were made between haematological parameters and food intake (calculated from the FFQ's) on the 59 children, 45 abnormals and 14 normal controls, whose parents returned the FFQ's.

THE HAEMATOLOGICAL RESULTS

Figure 8-1 shows the distribution of haemoglobin concentration for the normals and abnormals children aged up to 3 years. The red curve and dots represent the normals and the blue curve and dots represent the abnormal children.

Not all abnormal children in this figure had a low Hb, as they were defined as abnormals because of the abnormality of MCV or serum ferritin. 63 children (81.8%

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form children having Hb results) had low Hb, the percentage of boys having low haemoglobin concentration more than that in girls.

The regression curve in the abnormals was lowest in the early age then started increasing with age and at the end of the second year of life dropped down. In the normal children, the regression curve took the opposite direction, it was highest then dropped and after the end of the second year of life increased.

Figure 8-1. Haemoglobin Concentrations For Children Aged up to 3 Years
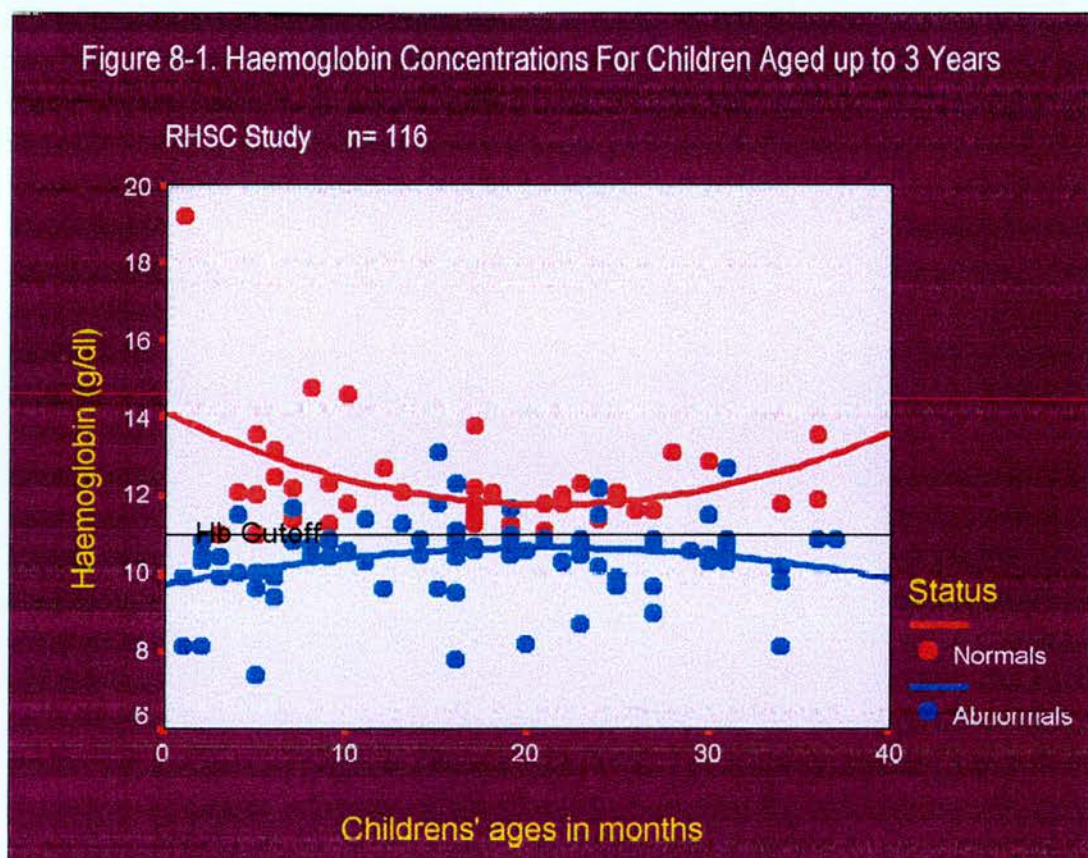
MCV regression curves in figure 8-2 for normals and abnormals showed almost the same tendency; they were highest in the early age then dropped down to be lowest at almost the end of the second year of life the increased. The percentage of children with low MCV were less (46.8% form the total children having MCV results) than those with low Hb, the percentage of girls with low MCV was higher than that in boys.

Figure 8-2. MCV Concentrations For Children Aged up to 3 Years
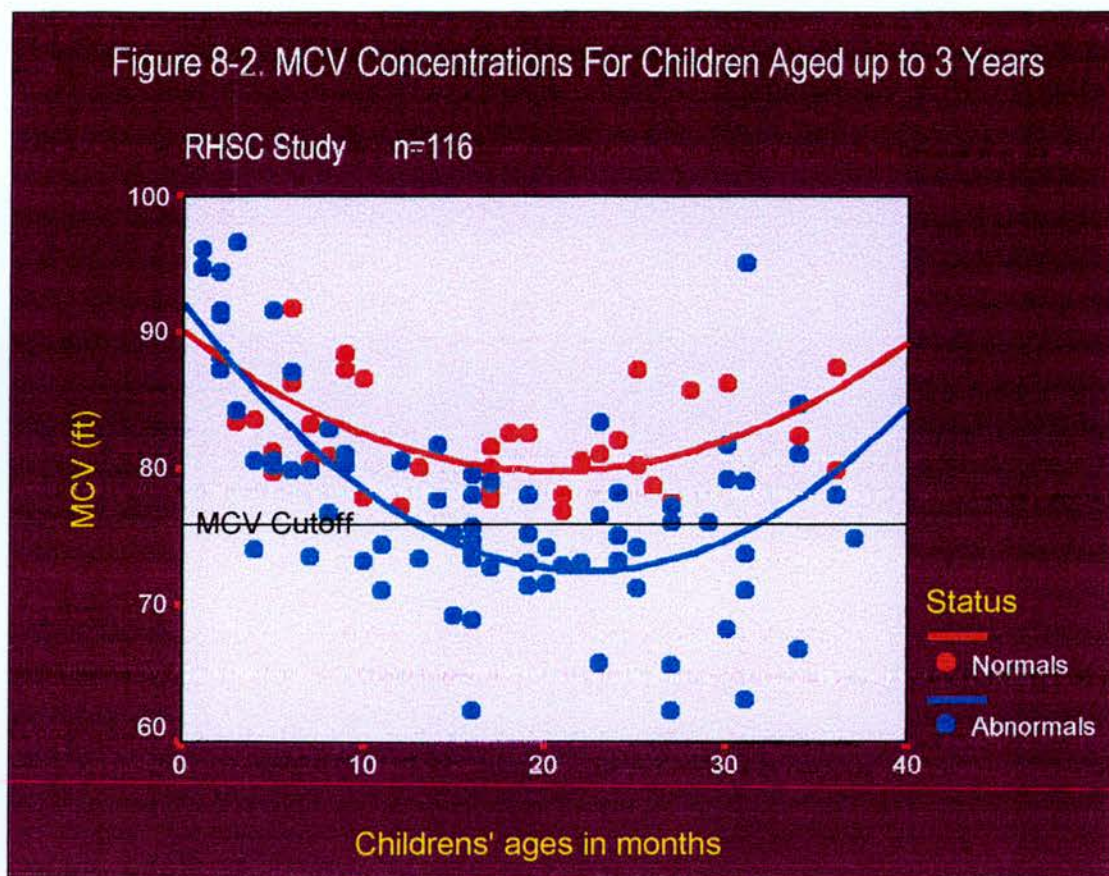
Unfortunately, only one normal child had a serum ferritin test, which does not give sufficient idea about the tendency of the regression curve for normal children. For abnormal children, the regression curve decreased with age and started increasing at the end of the second year of life, girls in this group were higher than boys (figure 8-3).

CORRELATIONS BETWEEN BLOOD RESULTS AND FOODS INTAKE

Table 8-1 shows the correlations between blood parameters and specific foods from the FFQs. Only honey was negatively correlated with Hb concentration $r = -0.271$ $p < 0.05$.

MCV had correlations with many food intake. Breast milk was correlated positively with MCV $r = 0.354$ $p < 0.005$. Cow & Gate infant formula was also correlated positively with MCV $r = 0.198$ $p < 0.05$. MCV was negatively correlated with milk drinks such as whole fresh cows' milk $r = -0.316$ $p < 0.01$, chocolate

Figure 8-3. Serum Ferritin Concentrations For Children Aged upto 3 Years
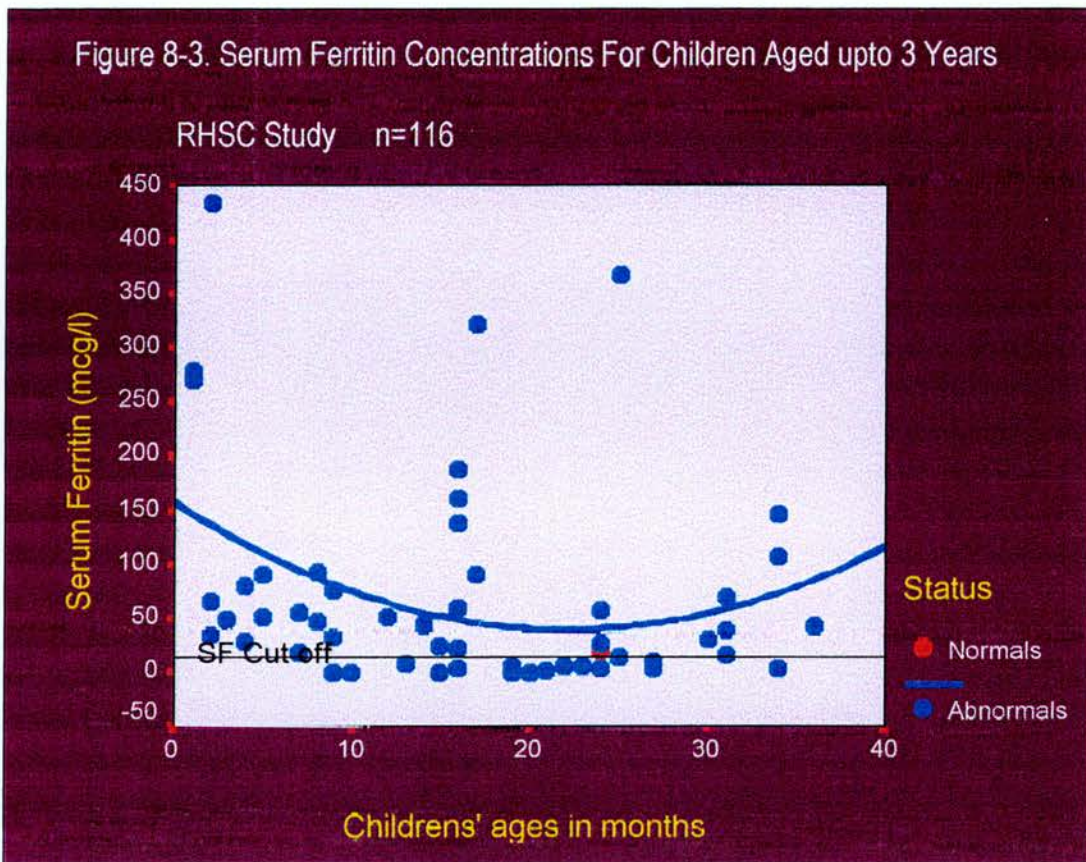
flavoured milk r= -0.455 p<0.001 and banana flavoured milk r= -0.487 p<0.001. Some breakfast cereals had negative correlations, rice krispies r= -0.281 p<0.05 and cornflakes r= -0.377 p<0.005. Both fried eggs and scrambled eggs had negative correlations with MCV, r= -0.335 p<0.005 and r= -0.276 p<0.05. Lentils, scones and pancakes, ice cream and milk pudding had the following negatively correlations r= -0.221 p<0.05, r= -0.266 p<0.05, r= -0.249, p<0.05, r= -0.263 p<0.05 and r= -0.336 p<0.005 respectively. Cheese also had a negative correlation r= -0.228 p<0.05.

Only Cow & Gate infant formula was strongly correlated with serum ferritin, r= 0.689 p<0.001.

Food groups which had correlations with blood parameters are listed in table 8-2. None of the food groups had any correlations with haemoglobin concentration. MCV

Table 8-1. Correlations between blood results and average food intakes of specific foods in RHSC study (from FFQ data)

Correlations	Haemoglobin n=59			MCV n=59			Serum Ferritin n=27		
	r	p	Sig	r	p	Sig	r	p	Sig
Breast milk	0.164	0.107		0.354	0.003	**	0.109	0.295	
Cow & Gate	-0.038	0.388		0.198	0.066	*	0.689	0.000	***
Whole fresh cows' milk	0.076	0.285		-0.316	0.007	**	-0.243	0.111	
Chocolate flavoured milk	0.029	0.415		-0.455	0.000	***	-0.080	0.345	
Banana flavoured milk	0.039	0.385		-0.487	0.000	***	-0.077	0.352	
Rice Krispies	-0.075	0.286		-0.281	0.016	*	-0.130	0.259	
Cornflakes	-0.174	0.094		-0.377	0.002	**	-0.104	0.303	
Honey	-0.271	0.019	*	0.014	0.459		-0.057	0.390	
Fried eggs	0.138	0.148		-0.335	0.005	**	-0.071	0.362	
Scrambled eggs	0.113	0.197		-0.276	0.017	*	-0.159	0.214	
Lentils	-0.056	0.337		-0.221	0.046	*	-0.121	0.274	
Crisps	-0.020	0.441		-0.266	0.021	*	-0.167	0.203	
Scones and pancakes	-0.021	0.436		-0.249	0.029	*	-0.104	0.303	
Ice cream	-0.211	0.055		-0.263	0.022	*	-0.208	0.149	
Milk pudding	0.013	0.462		-0.336	0.005	**	-0.101	0.307	
Cheese	-0.006	0.483		-0.228	0.041	*	-0.272	0.085	

*** Correlation is significant at the 0.001 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

Table 8-2. Correlations between blood results and the intake foods by food groups in the RHSC study

(Data from FFQ)

Correlations	Haemoglobin n=59			MCV n=59			Serum Ferritin n=27		
	r	p	Sig	r	p	Sig	r	p	Sig
Infant Formulas	0.015	0.455		0.280	0.016	*	0.542	0.002	**
Cows' milk	0.042	0.376		-0.491	0.000	***	-0.266	0.090	
Breakfast cereals	-0.131	0.161		-0.281	0.016	*	-0.402	0.019	*
Milk products	0.045	0.367		-0.249	0.029	*	-0.262	0.093	
Milk and milk products	0.051	0.352		-0.414	0.001	**	-0.304	0.062	
Eggs	-0.011	0.467		-0.362	0.002	**	-0.178	0.187	
Cereals	0.064	0.314		-0.221	0.046	*	-0.324	0.050	*
Chocolates	-0.018	0.447		-0.274	0.018	*	-0.149	0.229	

*** Correlation is significant at the 0.001 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

* Correlation is significant at the 0.05 level (1-tailed).

was positively correlated with infant formulas r= 0.280 p<0.05. Cows' milk was negatively correlated with MCV r= -0.491 p<0.001. Breakfast cereals group were also negatively correlated with MCV r= -0.281 p<0.05. Both milk products and the combination of milk and milk products were correlated negatively with MCV r= -0.414 p<0.005 and r= -0.362 p<0.005 respectively. Eggs, cereals and chocolate groups had the following negative correlations r= -0.362 p<0.005, r= -0.221 p<0.05 and r= -0.274 p<0.05 respectively.

Infant formulas as a group had the only positive correlation with serum ferritin concentration r= 0.542 p<0.005. Breakfast cereals and cereals had negative correlations r= -0.402 p<0.05 and r= -0.324 p<0.05 respectively.

ANTHROPOMETRIC MEASUREMENTS AND BLOOD RESULTS

Haemoglobin concentration was correlated positively with MCV r= 0.270 p<0.05, haematocrit r= 0.858 p<0.001, MCH r= 0.328 p<0.01 and MCHC r= 0.286 p<0.05 in this study. Triceps skinfold and subscapular skinfold had negative correlations with Hb, r= -0.980 p<0.01 and r= -0.977 p<0.05 respectively.

MCV was correlated with serum ferritin r= 0.334 p<0.05, MCH r= 0.960 p<0.001 and MCHC r= 0.413 p<0.001. Weight was negatively correlated with MCV r= -0.465 p<0.001. Triceps skinfold and subscapular skinfold were correlated with MCV r= 0.931 p<0.05 and r= 0.970 p<0.05 respectively. More details are shown in table 8-3.

Serum ferritin concentration was correlated with MCH r= 0.323 p<0.05. Weight had a negative correlation r= -0.329 p<0.05 and subscapular skinfolds had a positive correlation r =0.906 p<0.05.

SOCIAL FACTORS AND BLOOD RESULTS

The mothers' occupation was negatively correlated with Hb concentration r= -0.317 p<0.01 as can be seen in table 8-4. In the children whose mothers cook special food for the child in addition to the family food, the haemoglobin concentration increases r= 0.322 p<0.01.

Table 8-3. Correlations between blood results and anthropometric measurements in RHSC study

Correlations	Haemoglobin n=59			MCV n=59			Serum Ferritin n=27		
	r	p	Sig	r	p	Sig	r	p	Sig
Haemoglobin (g/dl)									
MCV (fl)	0.270	0.019	*						
Serum Ferritin (mcg/l)	-0.084	0.339		0.334	0.045	*			
Hct %	0.858	0.000	***	0.116	0.191		-0.148	0.230	
MCH (pg)	0.328	0.006	**	0.960	0.000	***	0.323	0.050	*
MCHC (g/dl)	0.286	0.014	*	0.413	0.001	***	0.184	0.179	
Height (cm)	0.196	0.119		-0.424	0.004	**	-0.353	0.083	
Weight (kg)	-0.163	0.113		-0.465	0.000	***	-0.329	0.047	*
Triceps Skinfold (mm)	-0.980	0.010	**	0.931	0.034	*	0.753	0.124	
Subscapular Skinfold (mm)	-0.977	0.011	*	0.970	0.015	*	0.906	0.047	*

*** Correlation is significant at the 0.001 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
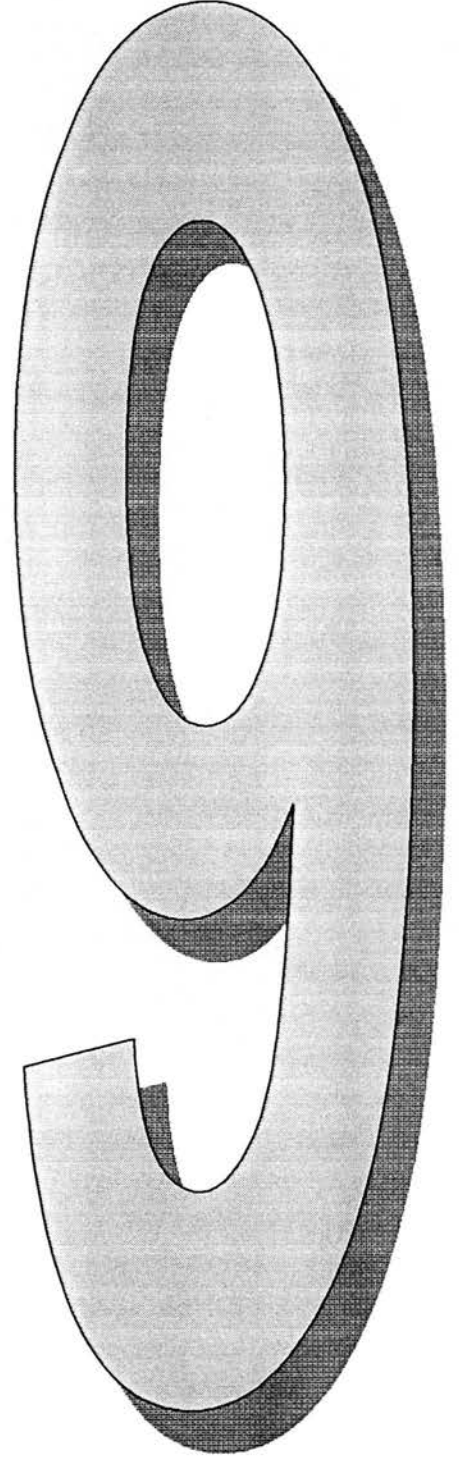* Correlation is significant at the 0.05 level (1-tailed).

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Table 8-4. Correlations between blood results and some social parameters in RHSC study

Correlations	Haemoglobin n=59			MCV n=59			Serum Ferritin n=27		
	r	p	Sig	r	p	Sig	r	p	Sig
Mothers' occupation	-0.317	0.008	**	-0.197	0.069		0.081	0.347	
Mothers' educational level	-0.226	0.052		-0.352	0.005	**	0.216	0.150	
Fathers' educational level	-0.219	0.057		-0.343	0.006	**	0.211	0.156	
Period of giving infant formula	-0.021	0.438		0.305	0.012	*	0.416	0.019	*
Time of starting giving family food	-0.091	0.273		-0.364	0.006	**	-0.404	0.039	*
Whether cooking special food for the child	0.322	0.008	**	-0.311	0.010	*	-0.621	0.000	***

*** Correlation is significant at the 0.001 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

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Both mothers' and fathers' educational level had negative correlations with MCV $r= -0.352$ $p<0.005$ and $r= -0.343$ $p<0.01$ respectively. The longer infant formula fed, the higher is the MCV concentration $r= 0.305$ $p<0.05$. However introducing family food to the baby late correlates with lower MCV concentrations $r= -0.364$ $p<0.01$ but cook special food for the child decreased MCV concentrations $r= -0.311$ $p<0.05$.
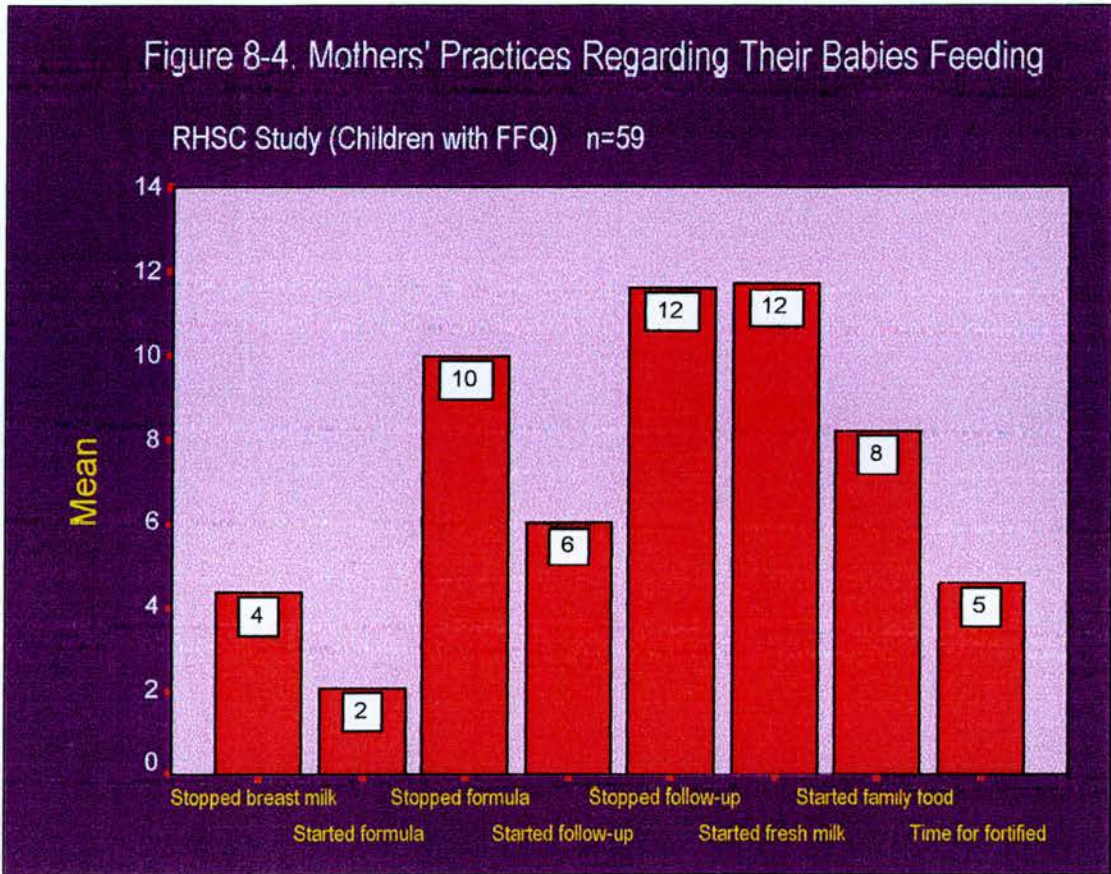
The longer infant formula was fed, the higher the serum ferritin concentrations $r= 0.416$ $p<0.05$. Introducing the family food late decreased the concentration of serum ferritin $r= -0.404$ $p<0.05$. As with MCV, cooking a special food for the child did not increase the concentration of serum ferritin but reduced it $r= -0.621$ $p<0.005$.

Figure 8-4 shows the mean values for the introduction and stopping of infant formulas and family food. 4 months was the mean age of the infant when his/her mother stopped breast feeding, with a range from a few days to 12 months. The mothers started giving infant formulas when their children about the age of 2 months on average, range from birth to 10 months, then they stopped infant formulas at the mean age of 10 months, range 3 and 24 months. However, the mean for starting infant formula will include both those who start it at birth and those who start it after breast feeding.

CHAPTER

DISCUSSION

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Figure 8-4. Mothers' Practices Regarding Their Babies Feeding

RHSC Study (Children with FFQ)   n=59

Follow-up formulas were started on average at the age of 6 months, range between 2 and 12 months and stopped at a mean age of 10 months range between 9 and 18 months.

Fresh cows' milk was introduced on average when the child became 1 year old, range 4 to 24 months. Family foods were introduced at the age of 8 months, range 2 and 24 months.

The mothers thought that the suitable time for introducing fortified food with iron was 5 months, but opinions on this ranged from a few days to 7 months.

DISCUSSION

Four studies have been performed in Riyadh, Saudi Arabia and Edinburgh, UK. Table 9-1 summarises the investigations performed in the four studies.

Because of the universal commonness of iron deficiency, it would be expected that there would be ample data, past and updated, in both developed and developing populations, which would portray accurately not only the epidemiology of iron deficiency anaemia, but the intensity of its stigmata, its sequelae, the interventions undertaken and the precise benefits to health accruing, both currently and in the future.

Despite the potential high incidence of iron deficiency anaemia in children in Saudi Arabia, there are no studies about iron intake and its relationship with iron deficiency anaemia in children, not in only Saudi Arabia, but in all countries in the Middle East. Furthermore, there are no studies about the incidence of iron deficiency anaemia in normal children. The few studies available on iron deficiency anaemia among children were hospitals based studies and did not study iron intake for the subjects.

In the UK, the situation is much better in terms of information available about the prevalence in some cities (tables 4-2 and 4-6) which have shown relatively lower prevalence of iron deficiency anaemia among children than in many countries. However, the crucial problem which still exists is, how food intake can affect the status or pathogenesis of iron deficiency anaemia, and how this relationship can be improved to prevent the its occurrence.

For these reasons, carrying out studies in both countries, Saudi Arabia and UK, it was hoped would highlight the situation of the relationship existing between food intake in general and iron intake in particular with the haematological parameters of the individual. In addition, it was planned to clarify the influence of social aspects on these aspects.

Table 9-1 Number of children having haematology tests, weighed food intakes and food frequency questionnaires

Study	Number of sample	Age in months	Haematology tests	Weighed food intake	FFQ
Riyadh, Community	189	<16	68	73	74
		16-22	71	71	72
		>22	40	38	40
Riyadh, Hospitals	24	<16	11	-	11
		16-22	7	-	7
		>22	6	-	6
Edinburgh, Community	62	<16	7	13	13
		16-22	16	24	24
		>22	14	25	25
Edinburgh, RHSC	116	<16	50	-	23
		16-22	29	-	11
		>22	37	-	25

HAEMATOLOGICAL RESULTS

Haemoglobin concentrations increased with the increasing of age then dropped down at the end of the second year of life. This finding is the same in both the Edinburgh and the Saudi studies (figures 6-1 and 7-1). MCV and serum ferritin moved in the opposite direction; they were higher in the first year of life then dropped to the lower level at the end of the second year of life. In general, in the beginning of the second year of life, all blood parameters were decreased. This explains the reduction of iron stores of between the age of 10 to 20 months (figures 6-2, 6-3, 7-2 and 7-3).

From the longitudinal study of the Saudi children, Hb in the second age group was dependent on Hb and serum ferritin concentrations in the first age group and MCV was dependent on Hb in the first group. Hb in the older children depended on its' concentration when the child was younger (<16 months), and was affected more by Hb concentration in the second age group, in addition to MCV and serum ferritin of the second age group. MCV in older children was also affected by both Hb and MCV of the second age group. Serum ferritin in the older children was affected only by MCV in the youngest age group.

These data show the influence of the precursor concentrations of blood parameters on the concentrations of the current age. For instant, the Hb concentration in the second age group can be determined by the iron stores as indicated by the very strong positive correlation with serum ferritin in the youngest age group. This situation did not change with Hb and MCV in the oldest age group; they were determined by Hb, MCV and serum ferritin at the previous age. All these suggests that early markers of iron status have a profound influence on later parameters and thus on susceptibility to iron deficiency anaemia.

Although, the main aim of the study was not to assess the incidence of iron deficiency anaemia, the number of the subjects studied in Riyadh was sufficient to obtain an indication of the incidence of the iron deficiency anaemia. The prevalence of iron deficiency anaemia in the Riyadh study was 36.3%, which was similar to the range of many studies which have previously carried out in the city. The percentage of low haemoglobin concentration for all children in the Saudi study was 21.2% which is less than the prevalence in recent published studies, 36% in children aged

up to 2 years in the study by Al-Fawaz (1993) and 65% in infants in the study by Al-Hifzi et al.(1996).

No Saudi studies on iron intake using weighed intake have been performed, but available data from FFQs shows that iron intakes are much lower than the RDA.

IRON INTAKE

The mean iron intake in the Edinburgh part of this study (table 7-2, p 141) was 5.10 mg/d, 5.22 for boys and 4.93 for girls. These values are similar to the study carried out by Harbottle and Duggan in Asian children aged 1-3 years in Sheffield in 1992, where the mean was 5.3 mg/d, and Gregory et al.(1995) whose mean was 5.5 mg/d and median 5.3 mg/d in children aged 1½-4½, but slightly lower than the values in a study by Payne and Belton (1992), in children living in Edinburgh which were 5.6 mg for boys and 5.1 mg for girls aged 2 years . Iron intake in this study also lower than the findings by Harris et al. (1983) whose mean was 9.6 mg/d for children aged 0.5 years falling to 7.0 for children aged 3 years whilst Mills and Tyler (1992) found mean intakes of 9.6 mg/d for infants for children aged 0.5 years and 6.4 mg/d at 1 year in their survey of infant feeding in 1990.

The mean iron intake in the Saudi study, (table 6-3 p 91), was 5.38 mg/d, 6.40 mg/100 kcal or 0.53 mg/kg which slightly higher than the Edinburgh study. Iron intake in the first age group was higher (6.50 mg/d) than the second and the third age groups. This intake was dropped down in the second age group (4.38 mg/d), but then increased in the third age group (5.14 mg/d) (table 6-4). Intakes of infant formula contributed greatly to the high intake iron intake and consequently to the higher blood parameters in the first age group. Probably the type of iron (haem or non-haem) is more important than the amount of iron intake as a whole. Meat and fish provided 12.2% of the total iron for children not taking infant formula in Edinburgh study. In the Saudi study, meat and fish provided between 4.41 to 8.64% of iron intake for the three age groups.

On the another hand breakfast cereals which are likely to be fortified with iron provided 0.20 to 2.48% of the total iron intake for the three age groups in the Saudi study versus 26.34% in Edinburgh study. Eggs which provided 3.63 -11.64% of iron intake, also contain phosphoprotein and albumin which inhibit iron absorption. It is

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iron intake and haemoglobin (tables 6-14 and 6-12). This percentage is much higher than the percentage of iron intake provided by eggs in Edinburgh study.

These data put the childrens' feeding patterns and the quality of their foods in term of iron availability in the Saudi population in perspective.

In both studies, Riyadh and Edinburgh, only about 20% of the children have iron intakes above the RNI. 23% of the Saudi children and 21% in Edinburgh did not achieve 50% of the RNI. Even more, 21% of the Saudi group and 20% from Edinburgh study did not achieve the LRNI, and thus had inadequate intakes.

The haematological parameters were correlated with the current iron intakes rather than the precursor haematological parameters. In table 6-5, iron intake in the first age group was correlated with serum ferritin for that age group. In the second age group, iron intake correlated with only blood results in that age group. In the older children group, iron intake was correlated more strongly with the blood test in the same age group. Probably improvement of iron intake will improve the haematological parameters in the short term but not necessarily in the long term.

Regression curves for the associations between blood parameters and iron intakes were similar in both the Saudi and Edinburgh studies. The regression curves showed positive correlation between Hb and iron intake in both studies. MCV curves showed increasing tendency then values fall when the children became older. Serum ferritin regression curves showed increases especially among older children.

From table 6-6, the proportions of children having low Hb concentration who achieved RNI to those did not were higher in the youngest children; 4% versus 20% (20%) in infants and 8% versus 23% (35%) in children. Only 8% of children in the

second age group who had low Hb concentration had sufficient iron intake. In the third age group none of the children had a sufficient iron intake when they had a low Hb concentration. This was similar for MCV and serum ferritin. This probably means that infant formulas provided iron but it was not in a sufficient amount. As the children became older, they did not take infant formula or baby food any more, which led to less children with sufficient iron intake in the second age group and even none in the third age group.

HAEM AND NON-HAEM IRON

Mira et al., 1996 in the report of the their Australian study indicated that they had not been able to find any published studies which had directly measured the intake of haem iron in children in the 12-36 months age group. In this study, data on haem iron intake has been provided for two different communities.

In the Edinburgh study haem iron intake was 0.31 mg/d for all children, or 0.02 mg/kg body weight per day. These values are comparable to but slightly above those found in the UK study by Gregory et. al (1995), who found an average haem iron intake of 0.2 mg/d by children aged between 1-3 years or 0.02 mg/kg body weight per day. However Mira et al. (1996) in the Australian study of children aged between 12-36 months found a mean haem iron intake of 0.42 mg/d in iron replete children and 0.28 mg/d in iron depleted children.

Haem iron intake in the Saudi study was 0.32 mg/d for all children. This is similar to haem iron intake for the children in Edinburgh study.

The positive affects of haem iron can clearly be seen to have a much greater effects than their actual amounts as iron per se by the data from the FFQ studies.

The main meat dishes in children of the ages studied were chicken then lamb in the Saudi study. Chicken was correlated positively with Hb in table 6-12 and Hb and MCV in tables 6-12 and 6-20, it was more common in the first and the second age groups and lamb only correlated with Hb and MCV in the third age group in the third age group (table 6-16). In Edinburgh study, there were different meat dishes such as beef, pork, bacon, sausages and ham sandwiches. These varieties of food containing haem iron gave the children in Edinburgh study more choice, by which to provide the required amount of iron required daily.

Meat and fish in Edinburgh study provided 12.2% of the total iron intake for children not taking infant formulas and from 4.4 to 9.3% for the three age groups in the Saudi study.

Haem iron, meat and meat and fish products such as chicken, poultry and lamb in the Saudi study (tables 6-12, 6-14, 6-16 and 6-18) and beef, pork, bacon in Edinburgh study (table 7-10) showed good correlations with the haematological parameters, Hb, MCV and serum ferritin.

All this suggests that small amounts of haem iron have a considerable effect on iron status and thus on the prevalence of iron deficiency anaemia.

BREAST FEEDING, INFANT FORMULAS AND COWS' MILK

64% of the mothers in the Edinburgh study breast fed their children for some time, which is higher than the prevalence of breast feeding in the UK (Wharton, 1997; Williams, 1998). The reasons for this high prevalence are that those who agreed to participate in this study did so because as a group they were more concerned to improve their childrens' health than the mothers in general. This high percentage probably also reflects a bias toward higher social class in those agreeing to participate in the study. Initially this study did not design to study the mothers practice in breast feeding; its target was to study the childs' food intakes.

Although, these reasons can be said to be true in the Saudi study, which also showed a high prevalence of breast feeding, the overall pattern is different. 100% of the Saudi mothers breast fed for varying times with a mean 10 months. The majority of them were continuing breast feeding when the study was being carried out (figure 6-11). This may well also be the reason why some results differ between the Edinburgh and Saudi studies.

The duration of breast feeding in the Saudi study of 10 months (figure 6-10) is similar to the finding by other authors (Lawson, 1981; Al-Shehri et al., 1995; Al-Nozha et al., 1997)

In this Saudi study however, giving infant formulas was common and many gave infant formula in the first month (30% of those giving infant formulas). Follow-up formulas also were introduced between the age 5 to 15 month by many mothers. The linking of this data gives the likely reasons for having high incidence of iron deficiency anaemia in the Saudi children. It was obvious that the Saudi mothers in general provided long term breast feeding, but 26% of them never gave infant formulas and 12% never gave both infant of follow-up formulas. It is a good practice for mothers to breast fed, but it should be combined with a sufficient amount of iron intake after the 4 months of age, preferably, with a high bioavailability. Infant formulas as detailed in tables 6-12, 6-15 and 7-10 have been shown in these studies to have positive correlations with iron intake.

Introducing cows' milk was another potential effect in increasing the occurrence of iron deficiency anaemia. In this study, 35% and 24% of the Saudi infants were taking liquid and powdered cows' milk respectively before the end of the first year of life. This data is lower than found by Al-Shehri et al., (1995). However 46% of Edinburgh children were taking cows' milk before the age of 1 year. This figure in the Edinburgh study was not necessarily higher than the figures in the Saudi study as some of the Saudi children were taking both liquid and powdered cows' milk.

Products such as dried milk (table 6-18), cheese (table 6-12), full cream milk (table 6-12), cream have correlated negatively with the haematological parameters and iron intake indicating their effect on the pathogenesis of iron deficiency anaemia. For instance, milk had a negative correlation with Hb as shown in table 6-14 and with iron intake (table 6-12).

BLOOD RESULTS AND FOOD INTAKES

Many of the positive correlations of nutrients with Hb, MCV, serum ferritin and negative correlations with iron deficiency may simply indicate that those children with a good appetite and good food intake are more likely to achieve good haematological parameters and are less likely to become iron deficient.

Dietary fibre had a positive correlation with Hb in Edinburgh study, which comes against some thought that fibre decreases iron absorption. Dietary fibre per se does not influence iron absorption (Hurrell, 1998), but the phytic acid component of some dietary fibre inhibits iron absorption, rather than the fibre itself (Cook, 1998a). When the dietary fibre adjusted to energy intake, this correlation became weaker, and cornflakes correlated negatively with Hb and MCV in Edinburgh study, but sugar coated cereals correlated positively with Hb in the same group of children (table 7-10) So probably, breakfast cereals which are rich in fibre but not necessarily rich in phytate, could be these fortified with iron, and also the positive effects of supplements iron may outweigh by negative effects of the fibre or phytate.

Baby food had strong positive correlations with iron intake, for example rusks in tables 6-14 and 6-18, and Cerelac with wheat in tables 6-12 and 6-18. These baby foods contain iron and thus can also be used to enhance iron intake.

Vitamin C is known to have positive effects by promoting iron absorption.

In the Saudi study, some fruits containing vitamin C had positive correlations with some blood results. Mango and apples had strong positive correlations with MCV and serum ferritin and fresh orange juice with Hb in table 6-12, oranges had a strong positive correlation with Hb in table 6-14 and apples in table 6-18 had a strong positive correlation with serum ferritin. Fresh apple juice correlated positively with Hb in the Edinburgh study (table 7-10).

From the weighed food intake, it has been seen that the Saudi children whose fathers were studying in Edinburgh were consuming some of their traditional food. One child had low Hb, two had low MCV and one had low serum ferritin. Mean iron intake for this group was 4.68 mg/d which is lower than both the iron intake in the Saudi and Edinburgh studies.

RHSC STUDY

The prevalence of anaemia in the RHSC study, 28.3% in children aged between 8 months and 3 years may appear higher than expected for a UK population. Gregory, et al. (1995) found only 12% in the UK study of children aged 1-4 years. However the RHSC children are all either out-patients or in-patients attending the hospital and as such are not a random sample of the whole Edinburgh population. Nevertheless, the prevalence results do seem to indicate continuing and underlying anaemia, much of which may be related to iron deficiency as shown by the results of the Edinburgh study.

There is less correlation of diet with the haematological results, but this data is in general from children with relatively poor iron status and the fact that many of these children are not healthy may also be because they do not have a very good diet. The inclusion of a group of normals of the same age should have helped to give a better overall group with a wide range of food (and iron) intakes and haematological parameters. It is thus disappointing that the group did not show more in the way of positive correlations between diet and the blood parameters, which reflect iron status.

THE ANAEMIC GROUP IN THE SAUDI STUDY

It is surprising to find negative correlations between Hb and MCV and some foods when it would be expected to have positive correlations between such as Hb and MCV with kan'ad fish, and MCV with chicken as in table 6-27. The reason is probably that, those children were not taking enough according to their mothers, either due to lack of appetite (70% of all children) or some type of malnutrition, as was often noted in their medical reports.

Introducing either powdered milk (59% before one year) or liquid milk (31% before one year) may also be one of the causes of iron deficiency anaemia in this group.

50% of the mothers and 29% of the fathers were illiterate, this is possibly an additional reason for these children having iron deficiency anaemia.

Summary

It has to be said that results from the data-sets in this study are not always consistent. Some foods are positively correlated with iron status in some cases but negatively in others. The reasons for this are not completely clear but with the large number of statistical tests performed, this is not altogether surprising. However a number of consistent relationships have emerged and definite conclusions can be made.

CHAPTER

CONCLUSION,

RECOMMENDATIONS

AND

FUTURE RESEARCH
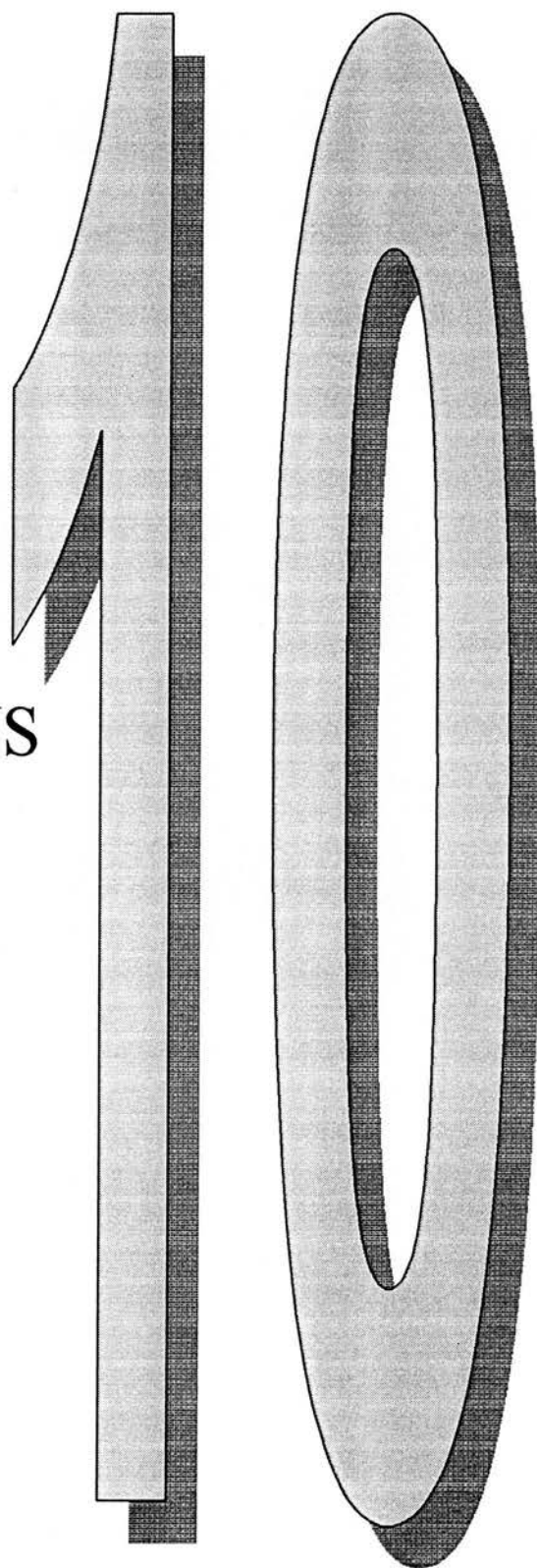
CONCLUSIONS

1- The combination of weighed intake data and FFQ data can create, as in this study, a unique opportunity to analyse the relationship between nutrients, foods and the parameters of iron deficiency. Thus conclusions can be drawn from both nutrient intakes and food group intakes provided by the weighed intakes, but also one can relate the frequency of food intake to factors indicative of iron deficiency anaemia.

2- About 80% of the children studied in both Riyadh and Edinburgh did not achieve the RNI for iron. 23% of the Riyadh children and 20% of the Edinburgh children did not achieve the LRNI for iron.

3- Iron intakes in Riyadh and Edinburgh are similar whether expressed as mg/day, mg/kg body weight or mg/1000 kcal. However, it is concluded that factors other than iron intake make significant contributions to iron deficiency.

4- Despite the low amount of haem iron intake, less than 5% of the total iron intake, it has been clearly shown to be strongly correlated with serum ferritin concentrations or iron stores. Thus, haem iron has a very important role in improving iron status among children and so reducing iron deficiency.

5- Chicken and lamb were good sources of iron in the Riyadh studies and beef, pork and bacon in the Edinburgh studies.

6- In this study, some breakfast cereals, such as sugar coated cereals, were positively associated with haemoglobin and serum ferritin.

7- Infant formulas were positively associated with good iron status as reflected by serum ferritin. Without infant formulas, it was difficult for the majority of children in the age groups studied to achieve the RNI for iron.

8- Some baby foods had strong positive correlations with iron intake, probably because they are fortified with iron.

9- Some vegetables and fruits have been shown to be positively associated with serum ferritin.

RECOMMENDATIONS

1- Haem iron has been shown in this study and in the literature to enhance iron status. Animal protein has also been shown in the literature to improve iron absorption.

   Foods such as lamb, chicken, beef, pork and bacon should be encouraged in the diets of the children as long as they are acceptable on religious and ethical groups.

2- Breakfast cereals are, in general, a good source of iron, especially fortified breakfast cereals and wheat-based cereals in particular. These foods should be encouraged in each community.

3- Introducing adequate amounts and sources of vitamin C to children should be emphasised.

4- Exclusive breast-feeding in Saudi Arabia should be combined with the provision of iron rich foods, either commercial or homemade.

5- As it was difficult for the majority of children in the age groups studied to achieve the RNI for iron, are the current recommended nutrient intakes realistic or should they be reviewed?

6- The amounts of infant and follow-up formulas given were not sufficient for the Saudi children; the duration of their use was too short. The use of the follow-up formulas for a longer period is recommended.

7- Cows' milk, dry or liquid, should be avoided before the end of the first year of life. Fortified milk with iron would help older children to achieve greater iron intake.

8- There is a need to improve the weaning and post weaning diet to be suitable for the child in terms of acceptance and nutritional value.

9- Home made iron rich foods for children should be encouraged, especially for older children.

10- Producing snack types of foods rich in high bioavailable iron would help to reduce the prevalence of iron deficiency anaemia in the population.

11- Supplementation of some foods with iron should considered for non-meat eaters (vegetarians) and for those having religious reasons for not eating specific foods.

12- Increase awareness about iron deficiency anaemia is required for health workers, parents, and those in authority with respect to health policy.

13- A comprehensive nutritional education programme targeting all the population including health workers and mothers using a suitable approach for each group in the country should be designed and supported by the authorities (Childs et al,. 1997; Yip, 1997). Health workers in primary health care should understand iron nutrition and iron deficiency in young children.

14- Media communication especially television programmes, short courses in school, small attractively coloured publications, and suitable and direct education interventions are needed for all age groups.

15- A suitable nutritional data base system for dietary studies in children is urgently needed.

FUTURE RESEARCH

To continue the attempt to find suitable approachs to improve iron status in children, there are many suggested measures which should be carried out.

1. More investigations on haem iron intake in different ages and populations.

2. Defining the best iron rich foods or dishes in each community and promoting them to parents.

3. Studying the availability of iron from the traditional foods, especially children foods.

4. Establishing portion sizes for different age groups for each community to enable a semi-quantitative food frequency questionnaire to be produced.

5. Defining the effects of the social aspects on nutrition in children.

6. Improving the taste and palatability of those childrens' foods which are high in bioavailable iron.

7. Defining appropriate laboratory criteria for iron deficiency anaemia in children in each community.

8. Finding the best method for diagnosing iron deficiency at an early stage, and following-up the children affected.

9. Studying the awareness of iron deficiency anaemia in different populations and different social levels.

10. Evaluation of the knowledge of health visitors, well baby clinic workers and health professionals especially those working in the health centres.

11. Reviewing the recommended nutrient intake for iron for each population and for different age groups and genders.

12. Identifying suitable food vehicles for fortification with iron

APPENDICES

APPENDIX I

بسم الله الرحمن الرحيم

المملكة العربية السعودية
جامعة الملك سعود
كلية العلوم الطبية التطبيقية

الأخ الفاضل والد الطفل
الأخت الفاضلة والدة الطفل
السلام عليكم ورحمة الله وبركاته   وبعد

نظرا لارتفاع نسبة مرض فقر الدم الناشئ عن نقص الحديد لدى الأطفال في المملكة، حيث وجد أنه يمثل حوالي 43% في مدينة الرياض، وهذه النسبة عالية جدا على الرغم من توفر سبل العيش الرغيد والرعاية الصحية والله الحمد.

لهذا فقد رأينا إجراء مسح في بعض المراكز الصحية في مدينة الرياض لمحاولة التعرف على مسببات المرض وبالتالي إيجاد الوسائل لعلاجه.

لذا أدعوكم للمشاركة في هذا المشروع الخير الذي يسعى أولا للتأكد من أن طفلكم ليس من المصابين بهذا المرض إذا أخذنا في الاعتبار أن الأعراض الأولية له تكون غير واضحة إلا إذا أجريت التحاليل المناسبة. وكذلك علاجه قبل استفحاله إن كان لديه نقص في الحديد مع تقديم المشورة المناسبة لكم للحفاظ على صحة طفلكم، ثم إن هذا المسح سيفيد الأطفال الآخرين بعد معرفة مسبباته في المملكة.
ويتطلب المسح:

1- أخذ عينة صغيرة من دم الطفل(1 ملل).

2- أخذ قياسات الطول والوزن ومحيط الرأس والصدر.   (ويتم ذلك في المركز الصحي)

3- وزن الغذاء الذي سيتناوله الطفل لمدة أربعة أيام متتالية او عدد الملاعق من الطعام. (ويتم ذلك في المنزل) وسيتم تأمين وسائل الوزن (أطباق، أكواب، ميزان حساس) لعائلة الطفل حسب الحاجة الى ذلك.
كما سيتم إمدادكم بشرح مفصل عن طريقة الوزن وتسجيل الأوزان، مع إمكانية القيام بزيارة العائلة في المنزل
المرجو من العائلة الكريمة عدم التردد في الاتصال بالباحث أو بالمركز الصحي عند وجود أي سؤال، أو عندما تكون إحدى النقاط غير واضحة.
شاكرين لكم كريم تعاونكم للحفاظ على سلامة أبنائنا، حفظ الله أبناءكم من كل سوء، والله يرعاكم،
والسلام عليكم ورحمة الله وبركاته

الباحث

عبدالعزيز بن محمد العثمان

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بسم الله الرحمن الرحيم

اسم الطفل:

المركز الصحي:

رقم الهاتف:

رقم الملف الصحي:

الجنس: ذكر انثى

رقم المجموعة :

إسم ولي أمر الطفل:

رقم الهاتف:

العنوان :

موافق :   غير موافق :

الموعد:

ملاحظات:

تاريخ الميلاد: / / 141هـ

رقم المركز: تاريخ الدراسة: / /1415هـ

رقم الدرج:

الأخ المسئول عن الملفات الصحية: الرجاء تحويل الطفل لأخذ المقاييس الجسمية، ثم الى المختبر

Head Circumference		Skinfold thicknesses	
Chest Circumference		Subscapular skinfold	
Height			
Weight			

الأخ المسئول عن المختبر: الرجاء أخذ عينة من الدم، وتقدير الآتي:

Hb		MCV	
Haematocrit		Serum Ferritin	
RBCs			

بسم الله الرحمن الرحيم

عنوان الدراسة : أغذية الفطام وعلاقتها بعوز الحديد لدى الأطفال من سن 9 أشهر إلى 24 شهراً

مقدمة :-

أولاً: نشكر لكم كريم تعاونكم معنا لإجراء هذه الدراسة، مما يعكس مدى وعيكم بأهمية مثل هذه الدراسات، والتى نأمل أن تكون سبباً في معرفة مسببات هذا المرض ومن ثم علاجه.

ثانياً: نؤكد على ضرورة الدقة المتناهية في أخذ أوزان الغذاء الذي يتناوله الطفل ونوعه، وكذلك المتبقي بعد الأكل، وذلك خلال الأربعة أيام القادمة، وكتابة ذلك بدقة في كراسة تسجيل البيانات.

ثالثاً: نرجو أن يعطى الطفل غذاءه المعتاد دون زيادة أو نقصان وكذلك عدم إضافة أغذية جديدة لم يسبق للطفل تناولها من قبل،حيث يمكننا ذلك من إجراء الدراسة بشكل سليم، كما ييسر لنا إعطاءكم وجهة نظرنا في تغذية طفلكم بعد إجراء التحليلات اللازمة، وتقديم المشورة المناسبة لصحة طفلكم.

1– لتسهيل الدراسة أمامكم فقد تم طباعة المعلومات على أوراق ملونة:

فاللون الأزرق للمعلومات العامة

واللون الزهري لشرح طريقة استخدام الميزان

واللون الأبيض لتسجيل البيانات

2– لتسجيل البيانات في الأوراق البيضاء يتم تخصيص ورقة لكل يوم على حدة .

3– جميع ما يتناوله الطفل في المنزل أو في خارجه سواء كان الطعام سائلاً أو صلباً فيجب تسجيله .

4– إن تسجيل البيانات كاملة مهم جداً ويمكن الاحتفاظ بعلبة الغذاء إن كان معلباً ليمكننا التعرف على محتويـات الغذاء .

5– جميع المعلومات سرية ولن يطلع عليها سوى الباحث والمشرف على البحث فقط .

6– في حالة وجود أي مشكلة ولو كانت صغيرة فلا تترددوا في الاتصال بنا على الـهاتف 4682534 أو المركـز الصحي على الهاتف (   )

7– يرجى كذلك تعبئة استبانه تكرار الغذاء بكتابة نوع المادة الغذائية في العمر المناسب لعدد مرات اسـتهلاكها سواءً يومياً أو أسبوعيا مع كتابة الوزن أو الحجم التقريبي لها بين القوسين [الوزن بالجرام - والحجم بالمللتر] .

8– بالنسبة للرضاعة الطبيعية لا يكتب الحجم بل تكتب مدة الرضاعة الفعلية بالدقائق مثـلاً 10 دقـائق تكتـب بيـن القوسين.

9– نأمل إعادة الميزان إلى علبته وإعادته إلى المختبر في المركز الصحي بعد الانتهاء مع الأوراق التـى تـم استلامها وذلك يوم:

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وصف الغذاء أو الشراب :-

إن وصف الغذاء والشراب وكتابة أسمه ونوعه أو اسم الشركة المصنعة بل نفضل الاحتفاظ بالعلبة إن كـان الغذاء مصنعاً، إن ذلك كله لهو في غاية الأهمية ويتم تسجيل البيانات في جدول التسجيل اليومي في خانة(وصفها) كما يلي:

1) الأغذية المصنعة أو المعلبة مثل الحليب ومشتقاته [لبن – زبادي – قشطة –جبـن – لبنـة –.....الـخ] والخـبز والبسكويت والحلويات والشوكولاته والبطاطس المجففة وعصير الفواكه والأغذية المعلبة للأطفال .

مثلاً الحليب هل هو كامل الدسم أو نصف الدسم أو قليل الدسم أو منزوع الدسم

الجبن يكتب نوعه كذلك مثلاً كيري أو البقرة الضاحكة

الخبز هل هو خبز أبيض أو كامل (بر) أيضا هل هو شرائح أم صامولي أم عادي.

الحلويات والشوكولاته يكتب اسم النوع مثلاً مارس أصابع أو باونتي ..... إلخ

وهذه أمثلة لتسجيل الوصف :-

ليس هكذا	وإنما هكذا
عصير فواكه	– عصير فواكه مشكله برتقال + مشمش+موز +تفاح مضافاً إليه سكر
	– عصير مشكل الواحة وتكتب الأصناف
شوكولاته	– كادبوري أصابع 30 جم أو– بسكويت بالشوكولاته (3 أقراص) ماركة كذا
البطاطس المجففة	– بطاطس مجففة ماركة كذا مع الكاتشب وزن 100 جم.
شوربة	– شوربة عدس مع الطماطم أو شوربة كويكر مع الطماطم.

2) الأغذية المطبوخة :- يكتب نوع الطبخ مثلاً مسلوق – مطبوخ – مشوي – مقلي ..... إلخ.

كما تكتب المواد المضافة إليه مثلاً ملح – بهارات – طماطم –بصل – ثوم.

أما الوجبات المشهورة مثل الرز أو الكبسة أو الجريش أو القرصان فلا حاجة لكتابة المواد المضافة .

3) أ– اللحوم نوع اللحم (لحم غنم – دجاج – كبدة – كلاوى .... إلخ)

ب– يفضل أن يفصل العظم قبل الوزن _إن كان يوزن_ أي قبل أن يتناوله الطفل .

ج– تكتب المواد المضافة عند طبخه.

د– إذا اعطي الطفل مرقة اللحم فيحدد ذلك مع بيان نوعية اللحم .

4) الأسماك :- ا– يكتب نوع السمك   ب– هل هو طازج أو معلب   ج– طريقة الطبخ.

5) الخضار والفواكه .أ– هل تعطى للطفل طازجة أو مطبوخة

ب–تحدد أصناف الخضار المطبوخة مثلاً بامية +جزر +بطاطس +لوبيا .... إلخ

كذلك الحال عند تقديمها طازجة كالسلطة يكتب وزن كل منها .

ج– يحدد إن كانت قدمت بالقشرة أو بدونها سواء كانت خضار أو فواكه مثل التفاح – الكمثرى –الخوخ ...الخ.

د– الفواكه المشكلة مثل سلطة الفواكه تكتب جميع الأصناف وهل مضافاً إليها سكر أم لا

هـ–المعلبات يكتب اسم المنتج والأصناف ويمكن الاحتفاظ بالعلبة .

طريقة الوزن واستخدم الميزان

حاولي التدرب على وزن أغذية معينة بعضها صلبة وبعضها سائلة وتقديمها للطفل ثم وزن المتبقي من كل صنف وذلك قبل بـدء البرنامج .

وللوزن يرجى اتباع الآتي:

1-يوضع الميزان في مكان بعيداً عن متناول الأطفال وفي مكان ثابت قريب من فيش كهربائي كما يكون بعيداً عن الفرن أو الماء .

2-يشغل الميزان بلمس الزر (ON/ ZERO) حتى يظهر الصفر (0) مع عدم لمس الأزرار الأخرى.

3- يوضع الطبق البلاستيكي المعطى لكم ولا يتم تغييره بآخر حيث أننا نعرف وزن ذلك الطبق، ثم توضع فيه المــادة الغذائيــة (نقصد مادة غذائية واحدة فقط كالرز أو أغذية الأطفال مثل سيريلاك مع القمح ويكتب وزنه في الورقة المخصصة لذلك (الأوراق البيضاء) بعد كتابة اليوم والتاريخ في أعلاها .

مثال	الطبق +جزر	98جم
	الطبق +جزر + طماطم	112جم
	الطبق +جزر + طماطم +خس	119جم

ويوزن المتبقي بنفس الطريقة ويسجل الوزن في خانة المتبقي.

مثال:	الطبق + جزر +طماطم +خس	92 جم
	الطبق + جزر +طماطم	69 جم

4- بالنسبة للمشروبات :

أ) المواد المعلبة يكتب وزنها أو حجمها إذا تم شربها كاملة أما إذا تبقى جزء منها فيوزن المتبقي في علبته .

مثال عصير برتقال	ماركة الواحة	200مل
المتبقي		60مل

أو تستخدم الكأس المعطاة لتقديم المشروب للطفل، ويكتب في خانة الحجم ربع كأس أو ثلثها أو نصفها أو كأس كاملة.

ب) بالنسبة للمواد الغير المعلبة فيتبع الآتي :-

أ- يشغل الميزان حتى يظهر الصفر.

ب-تعبأ المادة الغذائية في الكأس بعيداً عن الميزان ثم يتم التأكد من ظهور الصفر على الميزان ثم توضع الكأس على المــيزان ويسجل وزنها.   مثال:

كأس +حليب طازج نصف دسم	112جم
المتبقي	43 جم

أو تستخدم الكأس المعطاة لتقديم المشروب للطفل، ويكتب في خانة الحجم ربع كأس أو ثلثها أو نصفها أو كأس كاملة.

5- بالنسبة للحلويات والبسكويتات يكتب وزنها كما يلي:

بسكويت ديمة بالتمر	3 أقراص أو يكتب وزنها
بسكويت بالكريمة نوع كذا	2 قرص أو يكتب وزنها

الحلويات توزن دون غلاف

6- بعد الانتهاء من أي وزن يرجى لمس الزر (ON/ZERO) وذلك للتأكد من أن الميزان على وضع الصفر.

7- بعد الانتهاء من أي وزن يرجى لمس الزر (OFF) ليتم إطفاء الميزان.

المملكة العربية السعودية

جامعة الملك سعود

كلية العلوم الطبية التطبيقية

استبانة

إسم الطفل:

□□   □
□□   □

رقم الإستبانة

رقم المجموعة :

١- عدد الأولاد   بنين □   بنات □

ب- ترتيب الطفل بين الأولاد   □

٢- الأم   تعمل □   لا تعمل □

الوظيفة   □

٣- الأب   يعمل □   لا يعمل □   الوظيفة □

٤- المستوى التعليمي   الأب □

الأم □

٥- السن   الأب □

الأم □

٦- الجنسية   الأب □

الأم □

٧- الغذاء الممنوع تناوله لأسباب صحية :

الأب ....

الأم ....

الطفل ....

٨- متى بُدأ إعطاء الطفل ما يلي:

حليب مجفف للأطفال   عند عمر   لا   ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩ ١٠ أشهر □

حليب مجفف عادي(نيدو، العلالي، وادي فاطمة....)   عند عمر   لا   ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩ ١٠ أشهر □

حليب طازج   عند عمر   لا   ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩ ١٠ أشهر □

أغذية الأطفال نوعها(   )   عند عمر   لا   ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩ ١٠ أشهر □

من غذاء الأسرة   عند عمر   لا   ١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩ ١٠ أشهر □

٩- متى ترون ضرورة إعطاء الطفل حليب معزز بالحديد؟   عند عمر   لا اعرف١ ٢ ٣ ٤ ٥ ٦ ٧ ٨ ٩ ١٠ أشهر □

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10- (ا) هل يتم عادةً تناول الغذاء مع جميع أفراد العائلة

الإفطار ☐ الغداء ☐ العشاء ☐ ☐

(ب) وفي نهاية الأسبوع(الخميس والجمعة)

الإفطار ☐ الغداء ☐ العشاء ☐ ☐

(ج) الوجبة التي يتناولها طفلك وهو يشاهد التلفزيون هي:

الإفطار ☐ وجبة خفيفة الغداء ☐ وجبة خفيفة العشاء ☐

لا يوجد تلفزيون ☐ ليس لديه هذه العادة ☐ ☐

11- هل يأكل الطفل باستخدام

الملعقة ☐ ☐

الشوكة والسكين ☐ ☐

اليد ☐ ☐

أخرى ☐ ☐

12- إذا لم يأكل الطفل الطعام المقدم له هل:

(أ) يعطى طعاماً بديلاً ☐ ☐

(ب) يحاول معه حتى يأكل ولو جزء من نفس الطعام ☐ ☐

(ج) تطعمه الأم بنفسها ☐ ☐

(د) يجبر على أكل ولو جزء منه ☐ ☐

(هـ) يترك حتى يجوع فيطلب الأكل ☐ ☐

13- هل يتم إعداد طعام خاص للطفل ☐ ☐

أم يشارك الأسرة في طعامها ☐ ☐

14- لدى طفلك:

ا- شهية جيدة للطعام ☐ ☐

ب-شهية ضعيفة للطعام ☐ ☐

ج- يرفض كثيراً من الأطعمة ☐ مثل................. ☐

د- يحب بعض الأطعمة ☐ مثل................. ☐

15-يتم إعطاء الطفل المشروب عادة في:

-الرضاعة ☐ ☐

- كأس مع ماصة بلاستيكية ☐ ☐

- كأس الأطفال ذات الميزاب ☐ ☐

- كأس عادية ☐ ☐

- من عبوة المشروب ☐ ☐

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العادات

16- هل يذهب الطفل الى فراشه للنوم في أوقات منتظمة

إن كان الجواب نعم، فمتى ؟

- ومتى يصحو في الغالب أثناء أيام الأسبوع

- ومتى يصحو في الغالب أثناء أيام نهاية الأسبوع

17- هل يعاني الطفل من مشاكل النوم

إن كان الجواب نعم،فما هي ؟.................................

17- هل يعاني الطفل من مشاكل الاسنان

إن كان الجواب نعم،فما هي ؟.................................

18- هل يستخدم الطفل الحفاظة ؟

19- الجواب نعم [ن]   لا [لا]   أحياناً [أ]

طفلي كثير الحركة ولا يجلس أكثر من دقائق

صعب المزاج

متقلب المزاج

يحب أن يلعب لوحده

يحب مشاركة الآخرين

20- ما هي الأوصاف التي تناسب طفلك ؟

هادئ وسهل القياد

نشيط لكنه سهل القياد

نشيط لكنه غير مجامل

قد يعتدي على الأطفال الآخرين

أخرى.......................

21-سؤال للأب، عندما تذهب لشراء الأغذية فإن الآتي يؤثر على اختيارك:

-تكلفة الغذاء

- توفر الغذاء في المحل

إذا لم تجد صنفاً معيناً في هذا المحل، هل تشتري بديلاً عنه ؟

أم تبحث عنه في محل آخر

- سهولة إعداده أو تقديمه للطفل

- الإعلانات التجارية

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استبانة تكرار الغذاء

رقم الإستبانة

إسم الطفل: العمر

الرجاء رسم دائرة حول الرقم المناسب لعدد مرات استهلاك الطعام أو الشراب يومياً أو أسبوعياً، مع ملاحظة أن (ن) تعني: نادراً، (س) تعني: مرة كل أسبوعين، (لا) تعني: لا يعطى الطفل من هذا الغذاء.

الرسم للاستخدام	الوزن بالجرام	أسبوعياً	يومياً	الغذاء
				اللحوم ☐ لا
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	غنم
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بقر
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	دجاج
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	أرانب
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	أخرى
				الأسماك ☐ لا
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	كنعد ( )
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	رنجه ( )
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	تونة ( )
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	أصابع ( )
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	أصابع مع ( )
				أغذية الأطفال ☐ لا
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	سيريلاك مع الرز
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	سيريلاك مع القمح
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	سيريلاك مع القمح والعسل
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	ميلوبا
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	سيميلاك
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بسكويت ( )

للاستخدام الرسمي	الوزن بالجرام	أسبوعيا	يوميا	الغذاء
☐			☐ لا	الحبوب
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	قمح(قرصان، مرقوق، ....)
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	أرز
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	ذرة
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	كورن فليكس بالقمح
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	كورن فليكس بالذرة
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	معكرونة( )
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	سلق
☐			☐ لا	الخبز
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بر
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	صامولي
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	عادي
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	مفرود
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	شرائح
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	تميس
☐			☐ لا	الخضروات
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	الخضراء
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3 (	البطاطس( )
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3 (	الجزر( )
☐			☐ لا	البقول
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	الفول
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	العدس
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	الحمص

للاستخد الرسمي	الوزن بالجرام	أسبوعيا	يوميا	الغذاء
☐				**منتجات الألبان** ☐ لا
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	زبدة
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	قشطة
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	جبن مثلثات
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	جبن كيري
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	جبنة بيضاء
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	جبنة سائلة
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	جبن أصفر
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	زبادي
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	لبنة
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	عسل
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	مربى
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	تمر
☐				**الفواكه** ☐ لا
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	برتقال
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	تفاح
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	موز
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	كمثرى
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	أخرى( )
☐				**البيض** ☐ لا
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	مسلوق
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	مقلي
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	شكشوكة
☐				**الحلويات** ☐ لا
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	كيك
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	كيك بالكريمة
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	ايس كريم بالحليب
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	ايس كريم بالكريمة
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	ايس كريم بالشوكولاته
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	ايس كريم عادي
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	كاكاو
☐	☐	6 5 4 3 2 1 لا ن س	3 2 1	حلوى

للاستخدام الرسمي	الوزن بالجرام	أسبوعيا	يوميا	الغذاء
☐			☐ لا	البيتزا
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بيتزا باللحم
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بيتزا بالخضار
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بيتزا بالتونه
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بييتزا بالجبن
☐			☐ لا	الساندوتشات
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	نوعها
☐			☐ لا	الأغذية المعلبة
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بطاطس
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	فش فاش
☐	☐	لا ن س 1 2 3 4 5 6	1 2 3	بوب كورن

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المشروبات

للاستخدام الرسمي	الحجم بالمليلتر	أسبوعيا	يوميا	الشراب
			☐ لا	حليب الأم
☐		6 5 4 3 لان 7 6 5 4 3 2		مرات الإرضاع
☐				حليب الأطفال
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	( )
☐			☐ لا	حليب الأبقار
☐			☐ لا	طازج
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	قليل الدسم
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	نصف دسم
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	منزوع الدسم
☐			☐ لا	مجفف
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	قليل الدسم
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	نصف دسم
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	منزوع الدسم
☐			☐ لا	حليب معلب
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	قليل الدسم
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	نصف دسم
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	منزوع الدسم
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	بالشوكولاته
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	بالموز
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	بالفراولة
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	اخرى( )
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	يضاف السكر
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	مركز
☐			☐ لا	عصيرات
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	طازجة
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	معلبة
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	برتقال
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	ليمون
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	( )
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	بيبسي كولا
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	شاي قهوة
☐		6 5 4 3 2 1 لان س	5 4 3 2 1	اخرى( )

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APPENDIX II

DEPARTMENT *of* CHILD LIFE *and* HEALTH

The University of Edinburgh
20 Sylvan Place
Edinburgh EH9 1UW

Telex 727442 (UNIVED G)

Fax 0131 536 0821

Email   @ed.ac.uk

Telephone 0131 536 0690

or direct dial 0131 536 0804/0825

Dear Parent/Guardian of

　　We are writing to invite you and your son to take part in a study on nutrition in young children and its relationship to iron deficiency anaemia (1st of September - 19th of December 1997). Iron deficiency anaemia is relatively high (up to 25%) among young children.

Your son's name has been chosen at random from the Health Board list.

If you are willing to take part in the survey, we will ask you to record all the food your son eats during four days. We will provide you with scales, plastic measuring cups and dishes for this. All instructions will be provided.

We will also record his measurements such as weight, height, head and chest circumference.

The results of this study will help to understand why do children become anaemic and then how we can prevent it.

We will arrange to visit you at home to answer your questions.

At the end of the study, you will be invited to come to the Haematology Department, Royal Hospital for Sick Children, so that a blood sample can be taken from your son to test for iron deficiency. However you may participate in the food survey without any obligation to then have the blood sample taken.
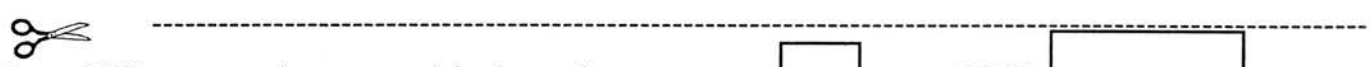
All information that we collect will be considered confidential.

Please fill the slip below and return it to me in the stamped addressed envelope.

Thank you for your consideration of participating in this study.
Your sincerely

Dr. N. R. Belton Ph.D, FRCPCH
Mr. A. M. Al-Othman. B.Sc. M.Sc.

I would like you to phone to explain the study .　　☐　　CODE: ☐

I do not want to take part in the study.　　☐

I agree to take part in the study and it would be most convenient for you to telephone between:

　　9.30 - 11.00 am ☐　　11.00 -12.00 am ☐

　　1.00 - 3.00 pm ☐　　3.00 - 5.00 pm ☐　　5.00 - 8.00 pm ☐

Child's Name: ....*(Please correct if different)*
Address: ....*(Please correct if different)*
Edinburgh　....................................　D.O.B. ....

Tel. No. [   ]　　Sign .... Mother/ Father

Please note that we will phone you to confirm a suitable appointment for you

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DEPARTMENT *of* CHILD LIFE *and* HEALTH

The University of Edinburgh
20 Sylvan Place
Edinburgh EH9 1UW

Telex 727442 (UNIVED G)
Fax 0131 536 0821
Email   @ed.ac.uk
Telephone 0131 536 0690

or direct dial 0131 536

Dear parents of

When your child   was at the Royal Hospital for Sick Children, Edinburgh, a blood sample was taken and as a result of that your child was included in the investigation which is described in the letter enclosed. As we couldn't contact you at the Hospital to ask for your help in answering the questions, we are writing to you to ask if you would fill in the questionnaire which is enclosed and return it to us in the envelope provided.

It is important that all the information you give is as accurate as possible. Please be as specific as you can about the type of food or drink eaten by your child. You can write any information about that type in the brackets on the form.

If possible please write the volume or amount given. This is particularly important for drinks such as milk. To help you to do this, the following information may be helpful:-

---

1. A cup holds 200ml and mug holds 300ml for all drinks, i.e. milk, juice, tea, etc. You could just put cupful or half-a-cup for the amount you usually give if that is easier.

2. Use spoonfuls (teaspoon, desert spoon or tablespoonfuls) as a measure for applicable food i.e. vegetables, rice, jam, honey etc. If you just say spoonful, we will assume you mean level (flat not heaped) teaspoonfuls.

3. For cereals, commercial baby foods or infants formulas, you can record the dry weight by spoonful or by manufacturers scoop (for baby formulas).

4. Biscuits: How many eaten each time?

5. Breads: Indicate amount e.g. number of slices and the size, (thin, medium or thick).

6. Fruit and eggs: Indicate whether all or half or a quarter are eaten each time. e.g. half an orange, or all of a small or normal sized banana.

Please Mr/Mrs   remember that information you will proved may not help your child alone, but will help all children any where.

Please don't hesitate to write or phone any of us for any inquiry.

Thank you very much for your help and spending of your time

Dr NR Belton, Dr AE Thomas and Mr Al-Othman

QUESTIONNAIRE

Questionnaire's Number : ☐

Group Number: ☐

Date of today: / /1997

Child's Name...

Date of birth: / / 199

Address:.. EH

Tel. : ☐

Sex: Male ☐   Female ☐

Height		Triceps Skinfold	
Weight		Subscapular Skinfold	
Head Circumference			
Chest Circumference			

Hb	
MCV	
Serum Ferritin	

Name:

1-(A) Number of children in family   Males [　　　]   [　　　]   Females [　　　]

(B) Position of child in family e.g 1st, 2nd ...child

(For questions 2-7) IF "SINGLE PARENT" PLEASE WRITE "SP" IN THE APPLICABLE SPACE

2- Mother is   Not working [　]   working [　]   Occupation [＿＿＿＿＿＿＿＿＿＿＿＿]
3- Father is   Not working [　]   working [　]   Occupation

4- Educational level   Father 1- University or above   2- Left school at 18   3- Left school at 16   4- Not educated
                        Mother 1- University or above   2- Left school at 18   3- Left school at 16   4- Not educated

5- Age   Father [＿＿＿＿＿]   Mother [＿＿＿＿＿]
6- Ethnic group   Father [＿＿＿]   Mother

7-Do you have food allergy or intolerance?

		No	Yes	
Father		[　]	[　]	What Type ....
Mother		[　]	[　]	What Type ....
Child		[　]	[　]	What Type ....

8- At what age (months in number) of the child did you start / stop giving the following items?(N for Never)
(why) if you stopped breastfeeding early).   Started   Stopped

	Started	Stopped	
A- Breast feeding		[　　]	Months (why)..................
B- Infant formula, type( )	[　　]	[　　]	Months
C- Dried cow's milk	[　　]	[　　]	Months
D- Fresh milk.................................	[　　]	[　　]	Months
E- Follow up formula, type ( )	[　　]	[　　]	Months
F- Family food................................	[　　]	[　　]	Months

9- At what age (in months) you should give your child formula with iron? [＿＿＿] months   Don't know [　]

10- (A) Does your child often eat with family during weekdays?

1- Breakfast [＿＿]   2-Lunch [＿＿]   3- Dinner [＿＿]   4- Snacks [＿＿]

(B) During weekends

1- Breakfast [＿＿]   2-Lunch [＿＿]   3- Dinner [＿＿]   4- Snacks [＿＿]

11-Is your child able to eat with a:

1-Spoon [＿＿＿]   4-Hand [＿＿＿]
2-Fork [＿＿＿]   5-Other [＿＿＿]
3-Knife and fork [＿＿＿]

12-If your child did not eat the meal, would you usually:

1- Give him/her some thing else. [＿＿]   4- Leave it until he become hungry . [＿＿]
2- Spend time coaxing him/her to eat [＿＿]   5- Force him/her to eat .
3- Give him/her the meal your self. [＿＿]

13- Do you prepare a special meal for him/her ? [＿＿]
Or share the family in their food ? [＿＿]
Both [＿＿]

14- Your child :

1- Has a good appetite. [＿＿＿]   2- Has a poor appetite. [＿＿]
3- Is a fussy eater (refuses some foods) [＿＿]   i.e................................
4- Likes some foods [＿＿]   i.e................................
5- Eats any non-food materials [＿＿]   Specify............................

15- Which of the following is your child able to drink from:

1- Bottle. [＿＿]   4- Adult cup. [＿＿]
2- Feeding cup with spout. [＿＿]   5- All [＿＿]
3- Cup with straw. [＿＿]

16- From where did you get the information to make up infant formula?

1-Tin   2- Hospital Classes   3-Health visitor   4-Your doctor   5- Friends or relatives   6- Other(   )

17- Your child is/has: Yes(Y),   No (N),   or Sometimes (S)

	Y	N	S
a- Irritable	Y	N	S
b-Very restless, cannot sit still for more than a few minutes.	Y	N	S
c-Quiet and well-behaved.	Y	N	S
d- Sleep problems.	Y	N	S

18- Give your child a grade between 0 (quiet all the time) and 10 (very active),by indicating putting a cross (X) on this line.

0 1 2 3 4 5 6 7 8 9 10

FOOD FREQUENCY QUESTIONNAIRE

Questionnaire' Number:
Child's Name:... *Age:* *or date of birth: / /199*

The following questions are about the foods your child USUALLY eats.
Please indicate the number of times per days or weeks that he/she eats item on
average. Ring the answer as these examples:
If he/she eats this food every day, ring 1 under number of times a day
If he/she eats this food three times a day, ring 3 under number of times a day
If he/she eats this food 5 times a week, ring 5 under number of times a week
If he/she eats this food once a fortnight, ring F under number of times a week
If he/she rarely or never eats this food , ring N under number of times a week

PLEASE ANSWER ALL QUESTIONS

DRINKS/FOOD	PER DAY	PER WEEK	Volume (ml)/ Weight(gm)
BREAST MILK (Times a day)	2 3 4 5 6	F N 1 2 3 4 5 6	
INFANT FORMULA - type:			
Cow & Gate	1 2 3 4 5	F N 1 2 3 4 5 6	
SMA (White)	1 2 3 4 5	F N 1 2 3 4 5 6	
SMA (Gold)	1 2 3 4 5	F N 1 2 3 4 5 6	
Farley's type (	)1 2 3 4 5	F N 1 2 3 4 5 6	
Milupa type (	)1 2 3 4 5	F N 1 2 3 4 5 6	
Other ( )	1 2 3 4 5	F N 1 2 3 4 5 6	
COW'S MILK			
Fresh			
Skimmed	1 2 3 4	F N 1 2 3 4 5 6	
Semi-skimmed	1 2 3 4	F N 1 2 3 4 5 6	
Whole	1 2 3 4	F N 1 2 3 4 5 6	
Flavoured Milk			
Chocolate	1 2 3 4	F N 1 2 3 4 5 6	
Banana	1 2 3 4	F N 1 2 3 4 5 6	
Strawberry	1 2 3 4	F N 1 2 3 4 5 6	
Other(	)1 2 3 4	F N 1 2 3 4 5 6	
Other( )	1 2 3 4	F N 1 2 3 4 5 6	
With sugar added	1 2 3 4	F N 1 2 3 4 5 6	
INFANT FOLLOW UP FORMULAS			
Cow & Gate type ( )	1 2 3 4	F N 1 2 3 4 5 6	
SMA type ( )	1 2 3 4	F N 1 2 3 4 5 6	
Farley's type ( )	1 2 3 4	F N 1 2 3 4 5 6	
Milupa type ( )	1 2 3 4	F N 1 2 3 4 5 6	
Other ( )	1 2 3 4	F N 1 2 3 4 5 6	

DRINKS/ FOOD	PER DAY	PER WEEK	Volume (ml)/ Weight(gm)

COMMERCIAL WEANING FOOD

Containing Meat (	)1 2 3 4	F N 1 2 3 4 5 6
Jars (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6
Dry (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6
Other (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6
and (	) 1 2 3 4	F N 1 2 3 4 5 6

CEREALS

Weetabix	1 2 3 4	F N 1 2 3 4 5 6
Rice krispies	1 2 3 4	F N 1 2 3 4 5 6
Cornflakes	1 2 3 4	F N 1 2 3 4 5 6
Porridge	1 2 3 4	F N 1 2 3 4 5 6
Sugar coated cereals	1 2 3 4	F N 1 2 3 4 5 6
Oat based cereals	1 2 3 4	F N 1 2 3 4 5 6
Ready-brek	1 2 3 4	F N 1 2 3 4 5 6
Baby Cereals (	)1 2 3 4	F N 1 2 3 4 5 6
and (	)1 2 3 4	F N 1 2 3 4 5 6
and (	)1 2 3 4	F N 1 2 3 4 5 6
Other(	) 1 2 3 4	F N 1 2 3 4 5 6

JUICE

Fresh

Orange	1 2 3 4	F N 1 2 3 4 5 6
Apple	1 2 3 4	F N 1 2 3 4 5 6
lemon	1 2 3 4	F N 1 2 3 4 5 6
Other( )	1 2 3 4	F N 1 2 3 4 5 6
With sugar	1 2 3 4	F N 1 2 3 4 5 6

Squash (In bottles)

Orange	1 2 3 4	F N 1 2 3 4 5 6
Apple	1 2 3 4	F N 1 2 3 4 5 6
Other ( )	1 2 3 4	F N 1 2 3 4 5 6

Canned

Ribena (	)1 2 3 4	F N 1 2 3 4 5 6
Five Alive (	)1 2 3 4	F N 1 2 3 4 5 6
Other (	)1 2 3 4	F N 1 2 3 4 5 6
Cola	1 2 3 4	F N 1 2 3 4 5 6
Tea	1 2 3 4	F N 1 2 3 4 5 6
Coffee	1 2 3 4	F N 1 2 3 4 5 6
Chocolate (drink)	1 2 3 4	F N 1 2 3 4 5 6

FOOD	PER DAY	PER WEEK	Weight(gm)
MEAT			
Beef	1 2 3 4	F N 1 2 3 4 5 6	
Lamb	1 2 3 4	F N 1 2 3 4 5 6	
Pork	1 2 3 4	F N 1 2 3 4 5 6	
Bacon	1 2 3 4	F N 1 2 3 4 5 6	
Ham	1 2 3 4	F N 1 2 3 4 5 6	
Chicken or other poultry	1 2 3 4	F N 1 2 3 4 5 6	
Sausage	1 2 3 4	F N 1 2 3 4 5 6	
Liver/kidney/heart	1 2 3 4	F N 1 2 3 4 5 6	
Canned Meat ( )	1 2 3 4	F N 1 2 3 4 5 6	
FISH			
White fish(cod/haddock/ fish fingers)	1 2 3 4	F N 1 2 3 4 5 6	
kipper/herring	1 2 3 4	F N 1 2 3 4 5 6	
sardines/salmon	1 2 3 4	F N 1 2 3 4 5 6	
MILK PRODUCTS			
Butter/ Margarine	1 2 3 4	F N 1 2 3 4 5 6	
Cheese type ( )	1 2 3 4	F N 1 2 3 4 5 6	
and ( )	1 2 3 4	F N 1 2 3 4 5 6	
Cream	1 2 3 4	F N 1 2 3 4 5 6	
Low Fat Yogurt	1 2 3 4	F N 1 2 3 4 5 6	
Full cream Yogurt	1 2 3 4	F N 1 2 3 4 5 6	
Fruit or Flavored yogurt	1 2 3 4	F N 1 2 3 4 5 6	
Other ( )	1 2 3 4	F N 1 2 3 4 5 6	
JAM	1 2 3 4	F N 1 2 3 4 5 6	
MARMALADE	1 2 3 4	F N 1 2 3 4 5 6	
HONEY	1 2 3 4	F N 1 2 3 4 5 6	
PEANUT BUTTER	1 2 3 4	F N 1 2 3 4 5 6	
LEMON CURD	1 2 3 4	F N 1 2 3 4 5 6	
FRUIT			
Oranges	1 2 3 4	F N 1 2 3 4 5 6	
Apple	1 2 3 4	F N 1 2 3 4 5 6	
Banana	1 2 3 4	F N 1 2 3 4 5 6	
Pears	1 2 3 4	F N 1 2 3 4 5 6	
Peaches	1 2 3 4	F N 1 2 3 4 5 6	
Grapes	1 2 3 4	F N 1 2 3 4 5 6	
Tomatoes	1 2 3 4	F N 1 2 3 4 5 6	
Other( )	1 2 3 4	F N 1 2 3 4 5 6	
EGGS			
Boiled	1 2 3 4	F N 1 2 3 4 5 6	
Fried	1 2 3 4	F N 1 2 3 4 5 6	
Scrambled	1 2 3 4	F N 1 2 3 4 5 6	

FOOD	PER DAY	PER WEEK	Weight(gm)

VEGETABLES

Potatoes

Boiled/Mashed	1 2 3 4	F N 1 2 3 4 5 6	
Baked	1 2 3 4	F N 1 2 3 4 5 6	
Chips	1 2 3 4	F N 1 2 3 4 5 6	
Peas	1 2 3 4	F N 1 2 3 4 5 6	
Green beans	1 2 3 4	F N 1 2 3 4 5 6	
Baked beans	1 2 3 4	F N 1 2 3 4 5 6	
Carrots	1 2 3 4	F N 1 2 3 4 5 6	
Lentils	1 2 3 4	F N 1 2 3 4 5 6	
Cucumber	1 2 3 4	F N 1 2 3 4 5 6	
Cauliflower	1 2 3 4	F N 1 2 3 4 5 6	
Sweetcorn	1 2 3 4	F N 1 2 3 4 5 6	
Mushrooms	1 2 3 4	F N 1 2 3 4 5 6	
Broccoli	1 2 3 4	F N 1 2 3 4 5 6	
Cabbage	1 2 3 4	F N 1 2 3 4 5 6	
Spinach	1 2 3 4	F N 1 2 3 4 5 6	
Brussel Sprouts	1 2 3 4	F N 1 2 3 4 5 6	
Other ( )	1 2 3 4	F N 1 2 3 4 5 6	

BISCUITS, CAKES AND PUDDINGS

Biscuits, type ( )	1 2 3 4	F N 1 2 3 4 5 6	
Crisps, type ( )	1 2 3 4	F N 1 2 3 4 5 6	
Corn Snacks	1 2 3 4	F N 1 2 3 4 5 6	
Sponge cake	1 2 3 4	F N 1 2 3 4 5 6	
Scones and pancakes	1 2 3 4	F N 1 2 3 4 5 6	
Ice cream ( )	1 2 3 4	F N 1 2 3 4 5 6	
Chocolate ( )	1 2 3 4	F N 1 2 3 4 5 6	
Milk Pudding	1 2 3 4	F N 1 2 3 4 5 6	

PIZZA	1 2 3 4	F N 1 2 3 4 5 6	
RICE	1 2 3 4	F N 1 2 3 4 5 6	
MACARONI / Spaghetti	1 2 3 4	F N 1 2 3 4 5 6	
WHEAT(wholemeal)	1 2 3 4	F N 1 2 3 4 5 6	

BREADS AND SANDWICHES

White bread	1 2 3 4	F N 1 2 3 4 5 6	
Wholemeal	1 2 3 4	F N 1 2 3 4 5 6	
Softgrain / Brown Breads	1 2 3 4	F N 1 2 3 4 5 6	
Sandwiches with cheese	1 2 3 4	F N 1 2 3 4 5 6	
ham	1 2 3 4	F N 1 2 3 4 5 6	
tuna	1 2 3 4	F N 1 2 3 4 5 6	
chicken roll	1 2 3 4	F N 1 2 3 4 5 6	
peanut butter	1 2 3 4	F N 1 2 3 4 5 6	
marmite	1 2 3 4	F N 1 2 3 4 5 6	
tinned meat	1 2 3 4	F N 1 2 3 4 5 6	
Butter/ Margarine	1 2 3 4	F N 1 2 3 4 5 6	
Hamburger	1 2 3 4	F N 1 2 3 4 5 6	
Other( )	1 2 3 4	F N 1 2 3 4 5 6	

INSTRUCTIONS
PLEASE READ THESE CAREFULLY

1- The instructions you need are printed on the coloured pages, the yellow for general instructions and the green for using the scales.
2- Record your child's food intake on the white pages, starting a new page each day.
3- Your child should eat <u>EXACTLY</u> as he does normally.
4- Food and drinks taken over a period of FOUR FULL DAYS must be recorded.
5- Full instructions for using the scales are giving on page 3.
6- The following equipment has been provided:
   An electronic scale   Measuring Cups
   Plastic bowls
7- IT IS IMPORTANT THAT ALL THE INFORMATION YOU GIVE IS AS ACCURATELY AS POSSIBLE.
   All the information received in this survey is confidential.

WHEN YOU FINISH FOUR DAYS OR IF YOU HAVE ANY DOUBTS OR DIFFICULTIES DO NOT HESITATE TO PHONE ME ANY TIME.
My phones numbers are:

Abdulaziz Al-Othman   536 0825   (467 0340 Home)   (Mobile 0410 792 766)

DESCRIBING FOOD AND DRINKS:

A GOOD DESCRIPTION OF ALL FOODS AND DRINKS IS VERY IMPORTANT.
BE SPECIFIC ABOUT THE TYPE OF FOOD OR DRINK EATEN.

1- BREAST MILK:
How long? i.e. 10 minutes, 15 minutes, etc.

2- INFANT'S MILK and FOOD:
WRITE THE TYPE, BRAND'S NAME MANUFACTURER AND HOW MANY SPOONS (DRY) YOU USE, (OR WEIGHT THE FORMULA) AND HOW MUCH WATER YOU ADD.

NOT THIS WAY	BUT THIS WAY
Milk formula	Sma, White cap, three spoons dried milk + 120 ml water.
Cereals	Milupa, Seven Cereals, 40 gm + 140 ml water.
Heinz	Heinz, red label savoury, Cheesy Pasta & Vegetables, half jar or 100 gm.

2- COOKED FOOD:
State how the food was cooked, i.e. Boiled, fried, grilled etc.
If a food is fried, STATE WHAT TYPE OF FAT OR OIL WAS USED.
Again state if SALT has been added. i.e. write SALT ADDED.

3- MEAT; FISH AND POULTRY :
It is important to write:
a- Type ?
b- How is it cooked? Is it salted?
c- Have other ingredients been added, e.g. Vegetables?
d- Is it lean or fatty?
e- Does weight include a bone?

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USING THE SCALE

1- To switch ON: Press the ON/ZERO button. Wait for few seconds until a single 0 appears.
2- To switch OFF: FIRMLY press the OFF button.
3- Before weighing the next item, touch the ON/ZERO button to set the scale to 0.
4- A CIRCLE (O) WILL APPEAR ON THE UPPER LEFT-HAND CORNER WHEN THE SCALE HAS STEADIED, IF IT IS NOT STEADIED, (-) WILL APPEAR UNDER THE CIRCLE.

INSTALLATION:
1- Place the scales in a stable, vibration-free location.
2- Remove anything on the pan
3- Press ON/ZERO key, zero will appear on the display.
4- Place the dish or the cup on the pan and start weighing, and write the reading.
PLEASE DO NOT PUT VERY HOT ITEMS DIRECTLY ON TO THE SCALES.

WEIGHING MEALS:
PRACTICE WEIGHING MEALS SEVERAL TIMES BEFORE YOU BEGIN THE SURVEY.

1- Press ON/ZERO button, and wait until 0 appear.
BE SURE YOU ARE USING kg MODE AS DEFAULT, NOT lb. MODE, WHICH WILL APPEAR ON THE DISPLAY.
2- Put the item of food in the given plastic bowl, then put them on the scale, and write down the reading on the provided table (NEW TABLE EACH DAY). If the item require milk or water to be added with it, i.e. cereals (Milupa, Cow & Gate etc..), you should weigh the dry item, and write the weight, then take the bowl with the dry item away from the scale, and add the liquid required, then weigh them together, and write again the weight.

e.g. Milupa, 7 cereal   33g
      Dish + Milupa + Fresh milk, semi-skimmed,   112g
Take the bowl away from the scale.

PRESS ON/ZERO BUTTON TO BE SURE THAT THE SCALE ON ZERO.
3- Put the next item of food (if any) as the first one, (step 2), etc.....
e.g. Boiled potatoes   47g
Take the bowl away from the scale. Then press ON/ZERO button.
4- Weight the left-over even the bowl is empty, and write the reading in the left-over column.

PLEASE REMEMBER:
All parts of the meal MUST be weighed separately, without any sauces.

WEIGHING LEFT-OVERS:
When the meal is finished place the left-over food on the bowl and weigh the bowl and food together.
1- Set scale to (0). Sit bowl either empty or with left-over food on scale. Read weight.
2- Write the total weight in the "left-overs" column.

WEIGHING SNACK FOODS:
This includes biscuits, cake, fruit, sweets.
1- Switch on scale. Wait until (0) appears.
2- Put the item in the plastic bowl then place them on scale, read weight and write it.
3- Fruit should be weighed without skin.
4- Some items have standard weight, e.g. Certain sweets and biscuits. You do not need to weigh these
    providing, you record the size on the wrapper. But weighing them is better.
e.g. 1 standard Mars Bar, size 62.5 g.
       1 milk Bounty (2 pieces), size 58 g.

DRINKS:
All drinks should be measured by using the measuring cups, excluding water.

To record the volume:
1- Pour the drink into the provided measuring cup.
2- Write the reading in /ml/, and describe the item.
3- Pour the drink in a normal cup to feed the child.
4- Do the same with next items.
5- If any drink is left over, pour the drink left in the measuring cup again and record the volume of it in
    the "left-over" column.
6- If you adding sugar to drinks, please weight it before, or use teaspoon to measure the amount.

e.g. Orange squash   130 ml
      water   50 ml
      sugar   4 gm

WRITE BRAND'S NAME, AND IT'S CONTENTS.
e.g. Ribena, orange juice   250 ml
Left-over (in its' column)   78 ml (By pouring the drink left in the measuring
   cup)

or, Tropical FIVE ALIVE (orange, apricot, guava, mango and passion-fruit. 250 ml.
Left-over (in its' column)   43 ml (By pouring the drink left in the measuring
   cup)

ANY FOOD EATEN AWAY FROM HOME SHOULD BE RECORDED AND DESCRIBED AS FAR AS POSSIBLE.

Please do not forget to take food table sheet with you, and the measuring some plastic cups with you.

HOW TO RECORD YOUR RECIPES:

At the back of this folder you will find some blank sheets for writing some of your recipes.
It is important to give the weight and a description of each ingredient, including any sauce that is
    added. Also, give a brief outline of the cooking method used.
Usually give the weight of the food after cooking, without additives, e.g. Meat without bone or fat.

Child's Name............................ Day.................... Date /   / 199

Time	Food	Description	Grams		office use	
			weight	left-over		

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PUBLICATIONS

THE IMPORTANCE OF WEANING PRACTICES IN THE PATHOGENESIS OF IRON DEFICIENCY ANAEMIA IN SAUDI ARABIA

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In order to find the prevalence of iron deficiency anaemia (IDA) among young children in Riyadh (Saudi Arabia) , and its relevance to weaning diet, 183 healthy children randomly chosen from eight different health centres have been studied longitudinally at 9, 16, and 24 months. Twenty six iron deficient children from three hospitals were also studied. Haemoglobin (Hb), mean corpuscular volume (MCV), serum ferritin (SF), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and haematocrit were estimated, and anthropometric measurements taken. A food frequency questionnaire (also estimating weights and volumes) and a social questionnaire were filled by the investigator (AA) by interviewing mothers. A 4 days weighed intake was also performed. Compeat-4 was used to calculate food intake and statistical packages SPSS and Excel for data analysis. Children with Hb<11 g/dl, MCV< 70 fl and SF<10 μg/l have seen considered iron deficient. Results indicate that IDA among these children is high despite the availability of appropriate food. This indicates poor attitudes to and perception of healthy foods and of when and how weaning should be carried out.

Iron intake and iron status in young children in Edinburgh. By ABDULAZIZ M. AL-OTHMAN[1], NEVILLE R. BELTON[1] and TERRY R KIRK[2], [1]*Department of Child Life and Health, University of Edinburgh, EH9 1UW, and* [2]*Centre for Nutrition and Food Research, Department of Dietetics and Nutrition, Queen Margaret College, Edinburgh, EH12 8TS.*

Fe-deficiency anaemia is recognized as a common problem in young children in the UK (Department of Health, 1994). The present study has sought to measure iron intake in young children (9-36 months old), to identify nutritional factors that may affect Fe intake and Fe status and to ascertain whether a food-frequency questionnaire can identify those at risk due to their diet.

Sixty-one healthy children aged between 9 and 36 months old were studied. They were those whose parents agreed to participate from a larger number chosen randomly from children registered at three health centres in Edinburgh using the Lothian Health Board list. A 4 d weighed food inventory, a semi-quantitative food-frequency and social questionnaire (FFQ) and anthropometric measurements were completed for all children. Haemoglobin (Hb), mean corpuscular volume (MCV), serum ferritin (SF), mean corpuscular Hb (MCH), mean corpuscular Hb concentration (MCHC) and packed cell volume were estimated in blood samples taken from thirty-seven of the children at the end of their food intake studies. Compeat-5 (Carlson Bengston Consultants Ltd, London) was used to calculate nutrient intakes and SPSS and Excel were used for data analysis.

Fe intake showed a mean of 5.14 mg with a range from 1.56-11.6mg/d. The mean for Hb was 123g/l (range 103-148g/l) and the median value for SF was 16.0 μg/l (range 2.0-53.0μg/l). SF correlated positively with Fe (r 0.40, $p<$ 0.05). Although the mean Fe intake represented 73% of the Recommended Nutrient Intake (RNI) (Department of Health, 1991), only twelve children (19.7 %) achieved the RNI. In contrast, sixteen children (26.2 %) did not reach the lower recommended nutrient intake (LRNI) for Fe.

Haem iron intake averaged 0.31 mg/d for all the children in this study or 0.02 mg/kg body weight per day in those children not taking any infant formula. These values are comparable to those found in the UK study by Gregory (1995) who found an average haem iron intake of 0.2 mg/d by children aged between 1-3 years or 0.02 mg/kg body weight per day. However Mira et al. (1996) in a study of children aged between 12-36 months in Sydney, Australia, found a mean haem iron intake of 0.42 mg/d in iron replete children and 0.28 mg/d in iron depleted children.

Breakfast cereals were good sources of Fe for most the children. On the FFQ, sugar-coated cereals correlated with Hb (r = 0.51, $p<0.001$) whereas corn flakes were inversely correlated with Hb (r = −0.37, p = 0.011) and with MCV (r = −0.36, p = 0.015). Similarly on the FFQ, Hb was correlated with pork (r = 0.37, p = 0.013), bacon (r = 0.28, p = 0.044) and sausages (r = 0.29, p = 0.04) whereas beef was correlated with MCV (r = 0.43, p = 0.004).

We have shown that Fe intakes less than both the RNI and LRNI are common in children between the ages of 9 months and 3 years. Our conclusion is that breakfast cereals and meat are important dietary factors which positively influence Fe intake and Fe status in this age group who are vulnerable to Fe-deficiency anaemia. We consider these foods should be strongly recommended to parents for inclusion in the post-weaning diet of children of this age.

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Gregory JR, Collins DL, Davies PSW, Hughes JM, Clarke PC (1995). National Diet and Nutrition Survey: children aged 1½-4½ years. London: HMSO.

Iron intake in young children in relation to body weight and energy intake. By ABDULAZIZ M. AL-OTHMAN[1], NEVILLE R. BELTON[1] and TERRY R KIRK[2], [1]*Department of Child Life and Health, University of Edinburgh, and [2]Centre for Nutrition and Food Research, Department of Dietetics and Nutrition, Queen Margaret College, Edinburgh, Scotland, UK*

The report, Weaning and the Weaning Diet (Department of Health, 1994) recommended that more information on patterns of nutrition and diet during the first 2 years of life should be available and that the natural history of iron deficiency in infants in this country should be determined.

The Reference Nutrient Intake (RNI) for iron is 7.8 mg up to the age of 1 year and 6.9 mg for children aged 1 to 3 years (Department of Health, 1991). Despite this apparently lower requirement, iron deficiency is more common in the second year of life than the first.

We have measured the intake of iron and related it to energy intake and body weight by performing four day weighed intakes in 189 children in Riyadh, Saudi Arabia and 61 children in Edinburgh, all between 8 months and 3 years of age. The results are:

Daily Iron Intake	Boys					Girls				
	Mea	Med	SD	Min	Max	Me	Med	SD	Min	Max
Riyadh										
8-14 months *n* 74 (M 37, F 37)										
mg	6.55	6.61	2.92	0.95	11.57	6.46	6.24	2.96	1.70	13.28
mg/1000	8.62	8.70	3.48	2.61	14.87	9.05	8.05	4.56	2.87	18.95
mg/kg body	0.71	0.69	0.34	0.11	1.40	0.74	0.63	0.41	0.17	1.98
15-22 months *n* 75 (M 37, F 38)										
mg	4.50	4.07	2.09	1.32	9.51	4.25	4.00	1.61	1.29	8.89
mg/1000	4.84	4.53	1.40	2.52	7.88	5.05	4.66	1.55	2.44	9.72
mg/kg body	0.41	0.35	0.18	0.11	0.83	0.39	0.37	0.15	0.14	0.87
23-36 months *n* 40 (M 23, F 17)										
mg	4.96	4.74	1.27	2.88	7.51	5.39	5.40	1.57	2.71	8.56
mg/1000	4.52	4.15	1.16	2.97	7.95	4.52	4.18	1.31	3.40	8.51
mg/kg body	0.39	0.39	0.10	0.26	0.63	0.45	0.42	0.17	0.19	0.81
Edinburgh										
8-14 months *n* 13 (M 7, F 6)										
mg	7.12	6.86	3.24	1.93	11.62	5.64	5.01	2.61	3.00	10.63
mg/1000	7.82	8.52	2.92	2.87	12.24	7.28	6.84	3.31	3.28	13.22
mg/kg body	0.68	0.70	0.30	0.19	1.14	0.58	0.50	0.25	0.35	1.07
15-22 months *n* 23 (M 15, F 8)										
mg	4.71	4.03	2.51	1.56	9.16	4.50	4.80	1.73	1.65	6.26
mg/1000	5.39	5.27	2.31	1.88	10.81	4.54	5.04	1.58	1.94	6.41
Mg/kg body	0.40	0.32	0.22	0.12	0.84	0.41	0.45	0.16	0.15	0.59
23-36 months *n* 25 (M 15, F 10)										
mg	5.00	4.47	1.84	2.88	8.75	4.84	4.33	2.43	1.63	11.02
mg/1000	4.91	4.60	1.49	3.14	8.04	5.32	4.66	1.93	3.18	9.53
mg/kg body	0.34	0.30	0.11	0.22	0.58	0.36	0.35	0.15	0.12	0.72

Although iron deficiency anaemia is more common in Saudi Arabia than in the UK, 24% in the Riyadh population studied compared with 12% of 1½-2½ years olds in the UK study of 1992/3 (Gregory et al. 1995), these results indicate that iron intake in Riyadh is not very different from that in Edinburgh even when expressed per 1000 kcal or per kg body weight. The iron intake values are higher in the age group 8-14 months in both Riyadh and Edinburgh but in the two older groups are similar to iron intakes of the 1½-2½ year olds in the UK study (Gregory et al. 1995).

These results confirm that factors other than the total amounts of iron in the diet are of importance in determining the prevalence of iron deficiency anaemia. From our preliminary analysis, the amount of haem iron may be a significant factor.

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USE OF LABORATORY DATA TO INDICATE IDEAL FOOD CHOICE FOR THE PREVENTION OF IRON DEFICIENCY IN YOUNG CHILDREN

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Studies on 189 children in Riyadh, Saudi Arabia and 61 in Edinburgh, Scotland have been used to establish the correlation between haematological parameters indicative of iron deficiency and diet in children between 8 months and 3 years of age. Measurements of blood haemoglobin (Hb), haematocrit (Hct), MCV, MCH, MCHC and serum ferritin have been compared with nutrient and food intake data, collected by both weighed intakes and food frequency questionnaires (FFQ), to identify the foods which relate best to the haematological indicators of iron status.

Intakes of meat and fish had a significant positive correlation with Hb in both the Saudi and Edinburgh children. Specifically lamb, fish and chicken in Saudi Arabia and pork in Edinburgh were positively correlated with haematological results such as Hb and Hct. Significant positive correlations of fruit, fruit juices and vegetable consumption with haematological parameters were found in both communities although no correlation with vitamin C intakes was shown. Iron intakes were positively correlated with serum ferritin.

These results emphasise the importance of dietary haem iron in the prevention of iron deficiency anaemia in young children.