CHAPTER 6

IRON STATUS

INTRODUCTION

Anaemia is the most common nutritional disorder globally, affecting over one billion individuals, approximately a quarter of the world's population. Women of reproductive age, infants and preschool children are particularly affected, but children of school going age and working men can also be adversely affected. It is estimated that about 10% of children aged less than 5 years in developed countries are anaemic compared with 41% of children in developing countries and 56% in Africa, the majority being due to iron deficiency[1,2].

Data on iron status of South African children are scarce. Nevertheless, available data indicate that iron deficiency anaemia occurs in approximately 10-50% of infants and young children[3-6]. A study on newborns showed a prevalence of anaemia of 7%, on the basis of a haemoglobin (Hb) concentration of < 11 g/dL at birth, which increased to 41% at 3 months of age[5]. Another study, found a 17% prevalence of anaemia (Hb < 11 g/dL) in infants younger than 12 months of age. In the latter study, 15% of the study group had serum ferritin levels less than 12 æg/L[4]. In school children, decreased Hb levels of 4-36% have been reported. Higher rates were found in children and those from urban areas[6]. In preschool children, the prevalence of iron deficiency anaemia is reported to vary from 10-56%, the higher prevalence being common in underprivileged communities[7-9]. In a more recent study 10, 9% and 23% of infants attending a "Well-Baby-Clinic" in Johannesburg had a Hb level below 11 g/dL and ferritin concentration below 12 æg/L, respectively; the two parameters correlated strongly. In the same study, the prevalence of low Hb and ferritin concentrations, among children attending preschool centres in Soweto, was 28% and 55% respectively; however, there was no correlation between these two parameters, indicating that anaemia due to other causes was common in this group.
Iron stores at birth vary in direct proportion to the weight of the baby, independent of the iron status of the mother. The iron stores are normally adequate for the first 4 months of life; in premature infants, total body iron status is lower, and, as a consequence of rapid postnatal growth, the depletion of iron stores is faster. From the age of four months to four years, iron intake is often inadequate, because of the rapid growth rate, the insufficient iron content of breast milk and the impaired absorption of iron from staple cereals. Studies from Central America and other countries indicate that by 9 months 25% of children are iron deficient and by 3 years this figure increases to approximately 50%[11,12].

Current evidence indicates that there is an interaction between vitamin A and iron metabolism[13,14]. It would appear that iron deficiency anaemia may be a consequence of inadequate intake of vitamin A, and that vitamin A supplementation may improve iron balance[15,16]. Although the mechanism for this interaction remains to be defined, it is known that vitamin A deficiency may be associated with mild anaemia which is characterised by low serum iron and elevated levels of this element in storage depots, particularly the liver. Vitamin A, therefore, may be involved in the regulation of iron release

from hepatic stores, thus making iron stores unavailable for haemopoiesis. In view of this interrelationship, the assessment of iron status was incorporated in this study.

METHODOLOGY

Full Blood Count (FBC) and Serum Ferritin

Blood (5mL; the total volume of blood drawn for the survey was 5mL) was drawn by a paediatric sister or a doctor from the antecubital fossa and transferred into EDTA-containing vacuum tubes. The latter were labelled and placed in the cool boxes containing ice-pack(s). The samples were protected from light at all times using sheets of black plastic. They were transported to the predetermined laboratory for a specific area within a maximum of 24 hours (usually within 8-12 hours) where a FBC was done using a Coulter counter. The South African Institute for Medical Research was responsible for all FBCs countrywide except in the Western Cape where the FBCs were done by the Department of Haematology at Tygerberg Hospital, University of Stellenbosch, and in KwaZulu/Natal by the Department of Haematology, King Edward Hospital, University of Natal. Once the FBCs were completed, plasma was separated from the remaining blood sample and stored at -20oC until the samples were shipped (frozen) to the central laboratory in the Department of Human Nutrition at Tygerberg Hospital, University of Stellenbosch, for analysis. The samples, once received in the latter laboratory, were stored at -80oC. In children from whom a blood sample was drawn, the appropriate section of the child's questionnaire was completed with regard to illness, diarrhoea, cough and fever; the latter was determined using temperature strips.

Serum ferritin was determined by radioimmunoassay[17]. The coefficients of variation for the internal standards used in the analysis for low (28,6 æg/L), medium (56,2 æg/L) and high (283,5 æg/L) serum ferritin concentration were 7,6%, 5,2% and 4,7%, respectively.

Diagnostic Criteria Used

The criteria[18-21] used (Table 6.1) were not adjusted for altitude, in the case of Hb, but were adjusted for age for the Mean Corpuscular volume (MCV). The findings are presented using univariate (Hb), bivariate (Hb and ferritin) and trivariate (Hb, ferritin and MCV) analysis.

Table 6.1. Criteria used for assesment of Iron status

	Haemoglobin (g/dL)	Ferritin (*u*g/dL)	MCV (fL)
"Iron depleted"*	>= 11	<12	-
Iron deficiency aneamia	< 11	<12	< 73 for 0-2 years < 75 for 3-4 years <76 for 5 years
Iron repleted	>= 11	<12	-
Further classification of the iron deficiency aneamia group			
Mild aneamia	10-11	<12	As above
Moderate aneamia	7-<10	<10	As above
Severre aneamia	<7	<10	As above

* Serum Iron, total iron binding capacity and percentage saturation were not determined in this study. A clear distinction between iron deficiency and iron depletion cannot therefore be made.

RESULTS

The mean Hb concentration for the population studied (n = 4494) was 12 g/dL without any difference between rural and urban children (Table 6.2); KwaZulu/Natal and Gauteng had the highest mean concentrations. The overall prevalence of anaemia (Hb <11 g/dL) was 21%, with the lowest prevalence in KwaZulu/Natal (10%) and the highest in the Northern Province (34%) (Table 6.2; Fig. 6.1). The prevalence of moderate anaemia (Hb 7-<10 g/dL) was present in 7% of the population [highest in the Northern Province (14%)], whereas severe anaemia was not common (0,2%). A similar prevalence was found in rural and urban children. No difference was found in the prevalence of anaemia between males [22,1%; confidence interval (CI) 19,7; 24,5] and females [19,9%; CI 17,5; 22,3).

Table 6.2. Haemoglobin concentration by area of residence

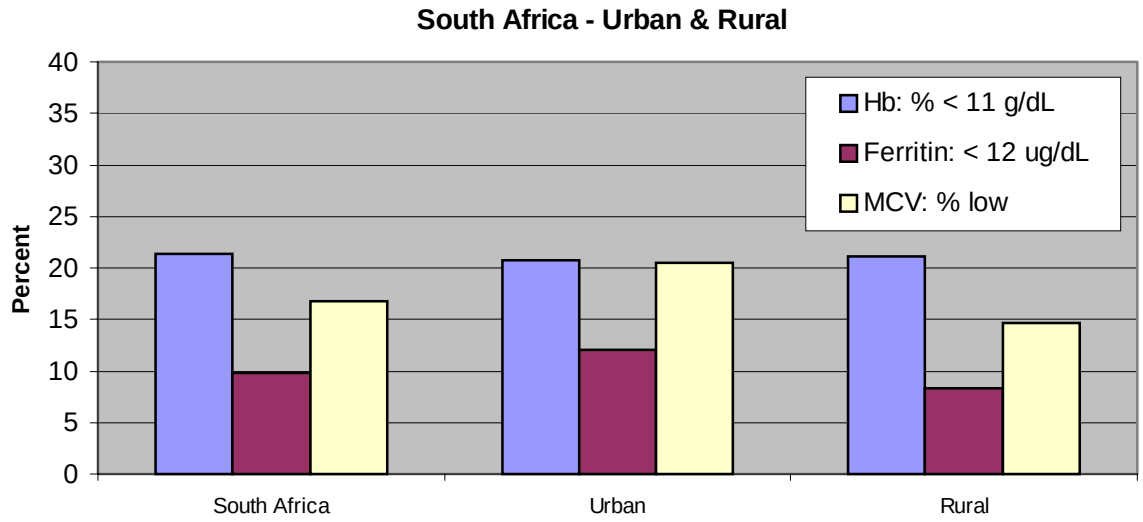
Haemoglobin concentration in children aged 6 to 71 months, South Africa, 1994

	Northern Cape	Western Cape	Eastern Cape	KwaZulu Natal	Eastern Transvaal	Northern Province	Gauteng	North West	Free State	South Africa	Rural	Urban
Heamoglobin (g/dL)												
No. of Children	486	395	498	500	500	562	390	553	610	4494	2251	2169
Mean	11.7	11.4	11.7	12.3	11.6	11.3	12.1	11.5	11.9	11.8	11.8	11.8
95% confidence interval	11.5;11.9	11.2;11.5	11.6;11.9	12.2;12.5	11.3;11.9	11.2;11.5	11.8;12.3	11.3;12.3	11.3;11.7	11.7;12.1	11.7;11.9	11.7;11.9
Percent 0,0-6,9 g/dL	0.6	0.0	0.0	0.2	0.7	0.0	0.8	0.4	0.0	0.2	0.1	0.4
7,0-9,9 g/dL	5.5	6.9	4.0	3.5	9.5	14.4	5.0	7.2	5.5	6.8	6.9	6.2
10,0-10,9 g/dL	15.4	21.7	16.6	6.7	17.5	19.8	10.5	16.9	11.6	14.4	14.4	14.1
>11,0 g/dL	78.5	71.4	79.5	89.6	72.3	65.8	83.7	75.5	82.9	78.6	78.9	79.3
% < 11 g/dL	21.5	28.6	20.6	10.4	27.7	34.2	16.3	24.5	17.1	21.4	21.1	20.7
95% confidence interval	15.6;27.3	21.5;35.8	15.2;26.0	7.1;13.6	20.6;34.9	28.4;40.1	10.6;21.8	19.5;28.4	12.6;21.6	19.4;23.4	18.3;23.9	18.0;23.3

Note: The figures for each province and South Africa are based on all available haemoglobin results, including unmatched records. The rural and urban figures are based on matched records plus one North West urban cluster, for which blood tests were done but for which no questionnaires were received.

The mean serum ferritin concentration was 35 æg/L and was similar across provinces, but significantly ($p < 0,01$) lower in urban children (Table 6.3). Depleted iron stores (ferritin < 12 æg/L) were found in 10% of children throughout the country; the lowest prevalence was found in the Eastern Cape (5%) and the highest in the Western Cape (16%) (Fig. 6.1). Six percent of children had ferritin values of less than 10 æg/L, indicating severe iron depletion, the highest percentage being in the Western Cape (Table 6.3). A higher prevalence of iron depletion was found in urban (12%) than rural areas (8%) (Fig. 6.1). No difference was found in the prevalence of iron depletion between males (10,4%; CI 8,5; 12,3) and females (9,1%; CI 7,4; 10,7).

Figure 6.1. Iron status area of residence



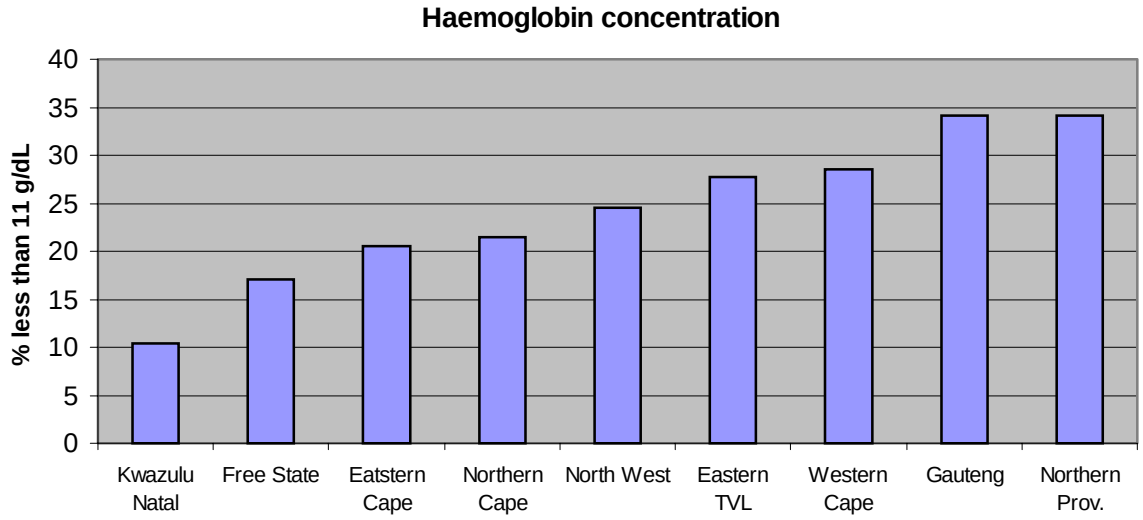


Figure 6.1. Iron status area of residence (continued)

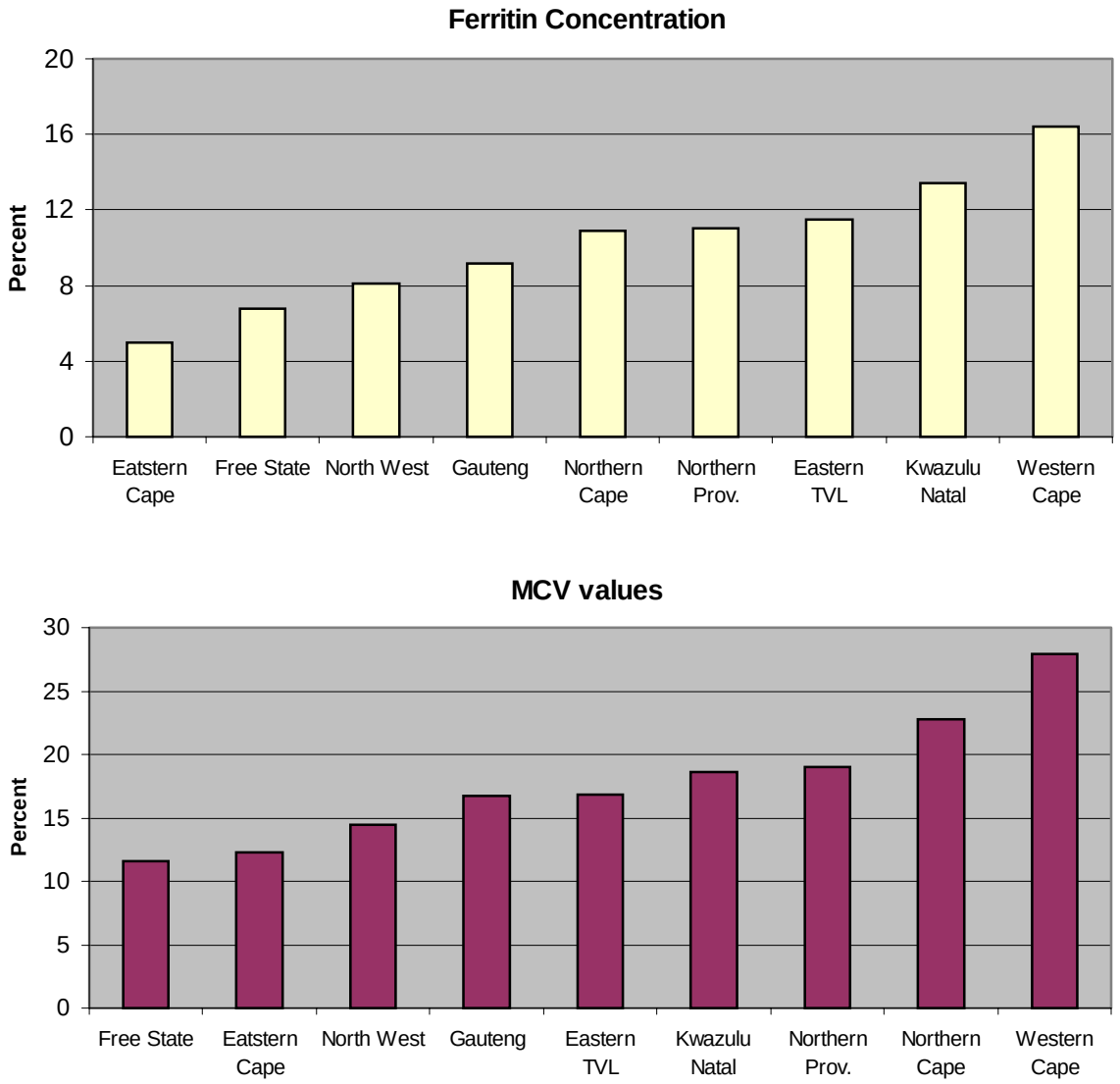


Table 6.3. Ferritin concentration by area of residence

Ferritin concentration in children aged 6 to 71 months, South Africa, 1994

	Northern Cape	Western Cape	Eastern Cape	KwaZulu Natal	Eastern Transvaal	Northern Province	Gauteng	North West	Free State	South Africa	Rural	Urban
Ferritin(*u*g/dL)												
No. of Children	513	413	477	516	476	578	335	500	646	4454	2264	2115
Mean	37.3	29.6	38.1	33.6	33.7	33.2	33.8	35.0	36.0	34.6	36.1	32.2
95% confidence interval	32.5;42.1	27.1;32.2	35.0;41.3	29.6;37.7	29.7;37.7	30.3;36.0	30.7;36.9	31.7;38.3	33.5;38.4	33.3;36.0	34.3;37.9	30.3;34.0
Percent 0,0-9,9 *u*g/dL	6.5	9.7	2.6	8.2	7.4	6.2	6.9	3.9	3.2	5.8	4.5	7.7
10,0-11,9 *u*g/dL	4.4	6.7	2.4	5.2	4.1	4.8	2.3	4.2	3.6	4.0	3.8	4.4
>12,0 *u*g/dL	89.1	83.6	95.0	86.6	88.5	89.0	90.8	91.9	93.2	90.2	91.7	87.9
% < 12 *u*g/dL	10.9	16.4	5.0	13.4	11.5	11.0	9.2	8.1	6.8	9.8	8.3	12.1
95% confidence interval	7.2;14.6	12.2;20.6	2.9;7.0	8.6;18.3	7.4;15.6	8.1;12.8	5.5;12.8	5.9;10.3	14.7;8.9	8.5;11.2	6.6;10.0	9.8;14.4

Note: The figures for each province and South Africa are based on all available ferritin results, including unmatched records. The rural and urban figures are based on matched records plus one North West urban cluster, for which blood tests were done but for which no questionnaires were received.

Table 6.4. Mean corpuscular volume (MCV) values by area of residence

MCV values in children aged 6 to 71 months, South Africa, 1994

	Northern Cape	Western Cape	Eastern Cape	KwaZulu Natal	Eastern Transvaal	Northern Province	Gauteng	North West	Free State	South Africa	Rural	Urban
MCV (fL)												
No. of Children	486	395	498	500	500	561	390	553	610	4493	2250	2169
Mean	78.9	76.5	80.0	78.8	79.7	78.6	79.3	78.8	80.9	79.1	79.6	78.4
95% confidence interval	76.1;77.7	76.5;77.5	79.2;80.9	77.5;79.7	78.8;80.6	77.8;79.4	78.1;79.5	78.1;79.5	80.2;81.7	78.8;79.5	79.1;80.0	77.9;79.0
Percent low i.e.												
<73 fL for 0-2 years <75 fL for 3-4 years <76 fL for 5 years	22.8	27.9	12.3	18.6	16.8	19.0	18.7	14.5	11.6	16.8	14.7	20.5
95% confidence interval	17.3;28.2	22.3;33.6	8.6;16.0	13.3;23.9	13.1;20.4	13.8;24.2	14.0;23.4	11.2;17.9	9.0;14.3	15.0;18.5	12.5;16.8	17.7;23.3

Note: The figures for each province and South Africa are based on all available MCV results, including unmatched records. The rural and urban figures are based on matched records plus one North West urban cluster, for which blood tests were done but for which no questionnaires were received.

Table 6.5. Iron status based on haemoglobin and ferritin concentrations and MCV values by area of residence

Percentage of children aged 6 to 71 months with MCV values, haemoglobin and ferritin concentrations above and below selected cut off values in South Africa, 1994

	Northern Cape	Western Cape	Eastern Cape	KwaZulu Natal	Eastern Transvaal	Northern Province	Gauteng	North West	Free State	South Africa	Rural	Urban
Heamoglobin (g/dL) and Ferritin (*u*g/dL)												
No. of Children with both tests done	475	392	457	474	461	552	332	462	601	4206	2107	2032
% Hb >= 11 and Ferritin >=12	74.0	63.1	78.2	79.0	69.0	64.4	80.5	72.3	80.2	74.2	75.4	73.6
% Hb < 11 and Ferritin >=12	15.1	20.5	17.5	6.8	19.3	25.0	10.5	18.4	13.0	16.0	16.2	14.5
% Hb >= 11 and Ferritin <12	4.4	8.2	2.0	10.7	4.7	1.5	5.2	3.3	2.9	4.8	3.8	6.5
% Hb < 11 and Ferritin <12	6.5	8.2	2.4	3.5	7.0	9.1	3.8	5.0	3.9	5.0	4.6	5.4
95% confidence interval	3.6;9.4	5.0;11.4	1.1;3.8	1.4;5.6	4.2;9.8	6.4;11.8	1.6;6.0	2.9;7.1	2.2;5.6	4.1;5.8	3.5;5.7	4.1;6.7
Heamoglobin (g/dL) and Ferritin (*u*g/dL) and MCV (fl)												
No. of Children with all 3 tests done	475	392	457	474	461	551	332	462	604	4206	2106	2032
% Hb < 11 , Ferritin <12 and MCV low	5.4	5.8	1.3	3.1	4.7	5.6	3.2	2.8	2.8	3.4	3.0	4.2
95% confidence interval	2.7;8.1	3.2;8.4	0.4;2.3	1.1;5.2	2.5;7.0	3.6;7.7	1.0;5.4	0.9;4.7	1.4;4.4	2.7;4.2	2.1;3.8	2.9;5.4

Note: The figures for each province and South Africa are based on all available results, including unmatched records. The rural and urban figures are based on matched records plus one North West urban cluster, for which blood tests were done but for which no questionnaires were received.

Table 6.6. Haemoglobin concentration by age group

Heamoglobin concentration of children aged 6 to 71, South Africa, 1994

	6-11 months	12-23 months	24-35 months	36-47 months	49-59 months	60-71 months
Heamoglobin (g/dL)						
No. of Children	215	634	796	964	988	807
Mean	11.0	11.3	11.5	12.1	12.2	
95% confidence interval	10.8;11.2	11.2;11.4	11.3;11.6	11.7;11.9	12.0;12.2	12.1;12.3
Percent 0,0-6,9 g/dL	0.0	0.3	0.6	0.1	0.1	0.2
7,0-9,9 g/dL	17.9	14.9	9.0	5.2	2.4	2.0
10,0-10,9 g/dL	30.3	21.3	19.1	13.6	9.8	5.8
>11,0 g/dL	51.8	63.5	71.3	81.1	87.7	92.0
% < 11 g/dL	48.2	36.5	28.7	18.9	12.3	8.0
95% confidence interval	39.6;56.7	31.4;41.5	23.9;33.5	15.6;21.9	9.8;14.8	5.7;10.3

Table 6.7. Ferritin concentration by age group

Ferritin concentration of children aged 6 to 71, South Africa, 1994

	6-11 months	12-23 months	24-35 months	36-47 months	49-59 months	60-71 months
Ferritin(*u*g/dL)						
No. of Children	212	648	793	947	963	804
Mean	32.3	28.0	30.3	34.2	38.2	40.3
95% confidence interval	27.5;37.1	25.7;30.3	28.2;32.5	32.0;36.5	35.3;41.1	37.6;42.9
Percent 0,0-9,9 *u*g/dL	10.0	11.3	6.1	5.1	4.7	2.0
10,0-11,9 *u*g/dL	4.8	6.6	7.2	3.5	2.3	1.6
>12,0 *u*g/dL	85.2	82.1	86.7	91.4	93.0	96.4
% < 12 *u*g/dL	14.8	17.9	13.3	8.6	7.0	3.6
95% confidence interval	9.1;20.5	14.3;21.5	10.1;16.5	6.3;10.9	4.6;9.4	1.9;5.3

Note: The figures are based on all available results on matched records only.

Table 6.8. Iron status based on haemoglobin and ferritin concentrations and MCV values by age group

Percentage of children aged 6 to 71 months with MCV values, haemoglobin and ferritin concentrations above and below selected cut off values in South Africa, 1994

	6-11 months	12-23 months	24-35 months	36-47 months	49-59 months	60-71 months
Heamoglobin (g/dL) and Ferritin (*u*g/dL)						
No. of Children with both tests done	202	603	738	896	926	762
% Hb >= 11 and Ferritin >=12	44.9	57.9	65.5	76.8	83.4	90.2
% Hb < 11 and Ferritin >=12	40.0	23.5	21.1	14.7	10.0	6.0
% Hb >= 11 and Ferritin <12	5.8	5.7	5.9	4.6	5.5	2.7
% Hb < 11 and Ferritin <12	9.3	12.9	7.5	3.9	1.1	1.1
95% confidence interval	4.9;13.7	9.9;16.0	5.0;10.1	2.2;5.5	0.3;1.8	0.3;1.9
Heamoglobin (g/dL) and Ferritin (*u*g/dL) and MCV (fl)						
No. of Children with all 3 tests done	202	603	738	895	926	762
% Hb < 11 , Ferritin <12 and MCV low	8.8	9.6	4.1	2.7	0.7	1.0
95% confidence interval	4.5;13.1	6.8;12.4	2.5;5.7	1.3;4.1	0.0;1.3	0.2;1.7

Figure 6.3. Iron status by age group

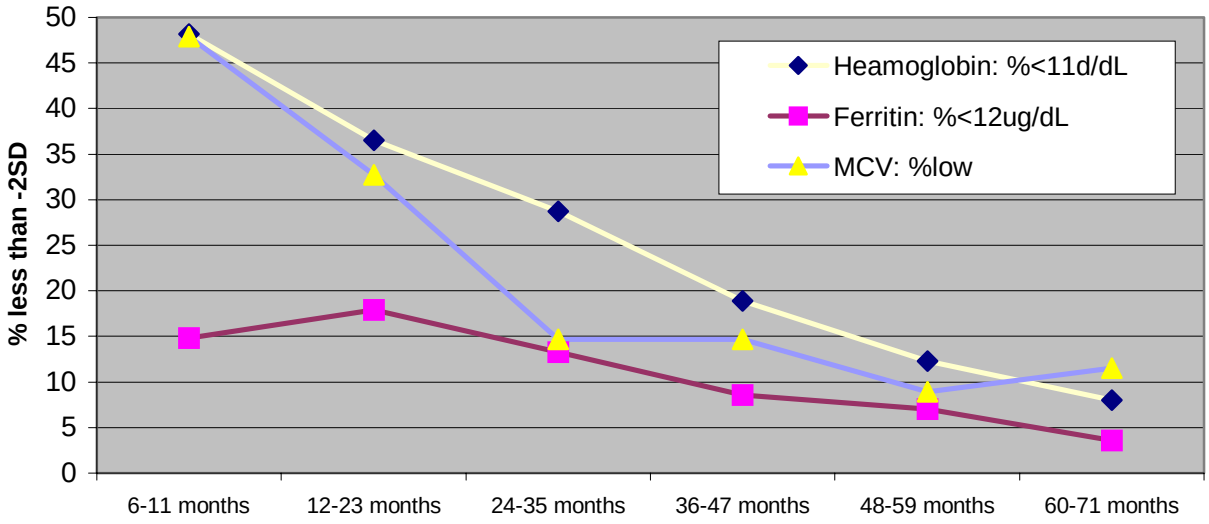


Table 6.9. Mean corpuscular (MCV) values by age group

MCV values of children aged 6 to 71, South Africa, 1994

	6-11 months	12-23 months	24-35 months	36-47 months	49-59 months	60-71 months
MCV (fL)						
No. of Children	215	634	796	963	998	807
Mean	73.0	75.2	78.2	80.1	80.8	81.4
95% confidence interval	71.9;74.1	74.5;75.9	77.7;78.8	79.5;80.6	80.3;81.2	80.9;81.9
Percent low i.e.						
<73 fL for 0-2 years <75 fL for 3-4 years <76 fL for 5 years	47.9	32.2	14.7	14.7	8.9	11.5
95% confidence interval	39.4;56.4	28.2;37.2	11.7;17.8	11.8;17.6	6.7;11.0	8.7;14.3

Note: The figures are based on all available results on matched records only.

Table 6.10. Haemoglobin concentration by socioeconomic factors

Heamoglobin concentration of children aged 6 to 71, South Africa, 1994

	Type of housing			Highest education attained by mother				
	Formal	Traditional	Informal	< Standard 5	Standard 5	Standard 8	Standard 10	Tertiary Education
Heamoglobin (g/dL)								
No. of Children	2943	851	526	1640	1124	887	482	150
Mean	11.8	11.9	11.6	11.8	11.7	11.8	12.0	12.0
95% confidence interval	11.7;11.9	11.7;12.1	115.;11.8	11.7;11.9	11.6;11.8	11.7;11.9	11.8;12.1	11.8;12.2
Percent 0,0-6,9 g/dL	0.3	0.0	0.5	0.1	0.3	0.4	0.2	0.0
7,0-9,9 g/dL	6.9	6.1	6.3	7.1	6.1	6.8	6.4	1.6
10,0-10,9 g/dL	14.5	12.3	15.9	14.0	16.1	13.6	10.9	15.2
>11,0 g/dL	78.3	81.6	77.3	78.8	77.5	79.2	82.5	83.2
% < 11 g/dL	21.7	18.4	22.7	21.2	22.5	20.8	17.5	16.8
95% confidence interval	19.3;24.0	14.5;22.4	17.7;27.7	18.3;24.2	19.6;25.4	17.4;24.2	13.1;21.9	8.8;24.8

Note: The figures are based on all available results on matched records only.

Figure 6.3. Iron status by maternal education

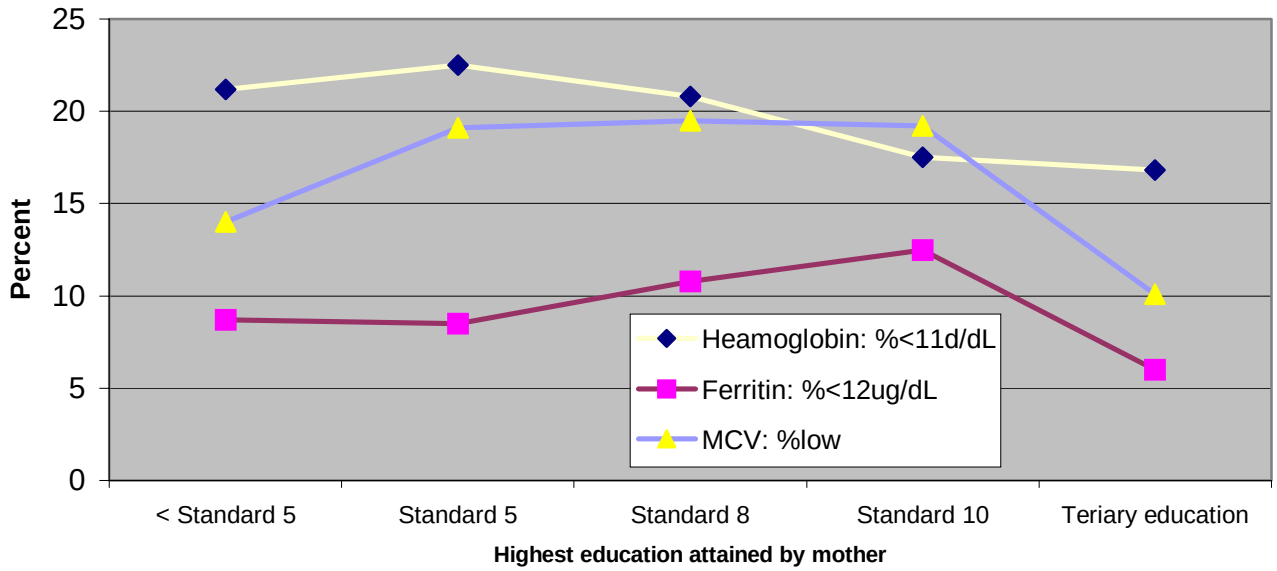


Table 6.11. Ferritin concentration by socioeconomic factors

Ferritin concentration of children aged 6 to 71, South Africa, 1994

	Type of housing			Highest education attained by mother				
	Formal	**Traditional**	**Informal**	**< Standard 5**	**Standard 5**	**Standard 8**	**Standard 10**	**Tertiary Education**
Ferritin(*u*g/dL)								
No. of Children	2920	847	524	1646	1124	872	467	139
Mean	33.1	38.1	34.7	37.1	33.9	31.3	32.9	36.2
95% confidence interval	31.7;34.5	35.2;41.0	31.0;38.3	34.8;39.4	32.1;35.8	29.3;33.2	29.9;35.8	31.2;41.1
Percent 0,0-9,9 *u*g/dL	6.3	4.4	5.4	5.0	5.1	6.7	8.4	2.3
10,0-11,9 *u*g/dL	4.2	3.9	3.2	3.7	4.4	4.1	4.1	3.7
>12,0 *u*g/dL	89.5	91.7	91.4	91.3	90.5	89.2	87.5	94.0
% < 12 *u*g/dL	10.5	8.3	8.6	8.7	9.5	10.8	12.5	6.0
95% confidence interval	8.8;12.2	5.5;11.1	5.8;11.4	6.7;10.7	7.1;11.9	7.1;11.9	8.3;13.3	8.9;16.0

Note: The figures are based on all available results on matched records only.

Table 6.12. Iron status based on haemoglobin and ferritin concentrations and MCV values by socioeconomic factors

Percentage of children aged 6 to 71 months with MCV values, haemoglobin and ferritin concentrations above and below selected cut off values in South Africa, 1994

	Type of housing			Highest education attained by mother				
	Formal	**Traditional**	**Informal**	**< Standard 5**	**Standard 5**	**Standard 8**	**Standard 10**	**Tertiary Education**
Heamoglobin (g/dL) and Ferritin (*u*g/dL)								
No. of Children with both tests done	2746	806	500	1547	1057	825	448	137
% Hb >= 11 and Ferritin >=12	7307	77.2	74.1	74.4	74.7	73.7	76.1	81.7
% Hb < 11 and Ferritin >=12	15.7	14.4	17.6	17.1	15.4	15.6	11.4	12.2
% Hb >= 11 and Ferritin <12	5.2	4.4	3.9	4.3	4.0	5.1	7.4	2.3
% Hb < 11 and Ferritin <12	5.4	4.0	4.4	4.2	5.9	5.6	5.1	3.8
95% confidence interval	4.3;6.6	2.4;5.6	2.4;6.3	3.1;5.3	4.2;7.7	3.7;7.5	3.7;7.5	0.2;7.5
Heamoglobin (g/dL) and Ferritin (*u*g/dL) and MCV (fl)								
No. of Children with all 3 tests done	2745	806	500	1547	1057	824	448	137
% Hb < 11 , Ferritin <12 and MCV low	4.1	2.3	2.7	2.8	4.4	4.4	2.8	1.9
95% confidence interval	3.1;5.1	1.1;3.4	1.0;4.4	1.8;3.8	2.9;5.9	2.7;6.1	1.0;4.6	0.0;4.5

Note: The figures are based on all available results on matched records only.

Table 6.13. Mean corpuscular (MCV) values by socioeconomic factors

MCV values of children aged 6 to 71, South Africa, 1994

	Type of housing			Highest education attained by mother				
	Formal	Traditional	Informal	< Standard 5	Standard 5	Standard 8	Standard 10	Tertiary Education
MCV (fL)								
No. of Children	2942	851	526	1640	1124	886	482	150
Mean	78.8	80.1	78.7	79.8	78.6	78.8	78.7	79.8
95% confidence interval	78.4;79.2	79.3;80.8	77.9;79.4	79.3;80.2	78.1;79.1	78.1;79.4	77.9;79.6	78.5;81.0
Percent low i.e.								
<73 fL for 0-2 years <75 fL for 3-4 years <76 fL for 5 years	19.2	12.1	17.4	14.0	19.1	19.5	19.2	10.1
95% confidence interval	16.9;21.5	9.0;15.1	13.2;21.6	11.8;16.2	16.3;21.8	15.7;21.8	14.4;24.0	3.3;17.0

Note: The figures are based on all available results on matched records only.

The mean MCV was 79 fL and was similar across provinces and urban and rural areas. On a national basis, when MCV was used as a criterion of iron deficiency anaemia, 17% of children were classified as anaemic (Table 6.4); the highest prevalence was seen in the Western Cape (28%; in this province, the prevalence of thalassaemia in some populations should be born in mind) and the Northern Cape (23%) (Fig. 6.1). A significantly higher percentage of urban children were affected (Fig. 6.1).

By bivariate analysis (Hb ò 11 g/dL and ferritin <12 æg/L) (Table 6.5), 5% of the population were iron depleted or deficient, with Western Cape and KwaZulu/Natal having the highest prevalence, and Northern Cape, Eastern Transvaal and Gauteng having a higher prevalence than the remaining provinces. A similar prevalence (5%) for iron deficiency anaemia (Hb <11 g/dL and ferritin <12 æg/L) was found, which was the highest in the Northern Province (9%), followed by the Western Cape (8%), Eastern Transvaal (7%) and Northern Cape (6%). It is of interest that on a national basis 16% of children would appear to have an underlying infection/inflammation, or alternatively they may have underlying folate or vitamin B12 deficiency (Hb < 11 g/dL and ferritin ò 12 æg/L) (Table 6.5); the highest prevalence was seen in the Western Cape and Northern Province. In this regard, it is also of interest that there was a weak correlation (r = 0,12) between serum ferritin and Hb concentration (Fig. 6.2). By trivariate analysis (Hb <11 g/dL, ferritin <12 æg/L and low MCV) (Table 6.5), 3% of the population had iron deficiency anaemia; Western Cape, Northern Cape, Eastern Transvaal and Northern Province had a higher prevalence than the other provinces. In both bivariate and trivariate analysis, a higher percentage of urban children were affected for most of the parameters used.

The prevalence of anaemia decreased significantly (Chi square for linear trend = 335; p < 0,001) with increasing age (Table 6.6; Fig 6.3), with only 8% of children in the 60-71 month age group being anaemic. The same pattern was found for the prevalence of iron

depletion (Table 6.7), iron depletion with or without iron deficiency anaemia (Table 6.8), which peaked for the 12-23 month old age group, and for iron deficiency anaemia (Tables 6.8, 6.9; Fig. 6.3). In general, a lower percentage of children of mothers with tertiary education tended to be anaemic (Table 6.10; Fig.6.4); these children, together with those living in informal/traditional types of housing, also tended to have a lower prevalence of iron depletion or deficiency (Tables 6.11, 6.12) and iron deficiency anaemia (Tables 6.12, 6.13; Fig. 6.4).

As a group, children with marginal vitamin A status (serum vitamin A concentration <20 æg/dL) were at a significantly higher risk of also being anaemic [Risk Ratio (RR) 1,64; CI 1,46; 1.84] and of having iron deficiency anaemia (RR 1,48; CI 1,14; 1,91); children with vitamin A deficiency (serum vitamin A concentration <10 æg/dL) were even at higher risk of being anaemic (RR 2,13; CI 1,73; 2.62).

DISCUSSION

This national survey has shown that the prevalence of anaemia is 21% in the population; however, the prevalence of moderate (7%) and severe (0,2%) anaemia is much lower. Iron depletion or deficiency was present in 10%, and iron deficiency anaemia in 5% of children. These findings indicate that iron deficiency anaemia per se is not a serious problem in South Africa except in the 6-23 month old age group.

The consequences of iron deficiency anaemia include congestive cardiac failure, increased susceptibility to infections, poor physical growth, increased fatigability, reduced work and mental performance, retardation of psychomotor development and reduced learning capacity[22]. Some of these associations, especially mental performance, impaired psychomotor development and reduced learning capacity in infants and children, remain the subject of controversy[23-25]; the latter stems primarily from study design limitations which include the diagnostic criteria used, the severity and chronicity of iron deficiency, the specificity and sensitivity of the assessment tests employed to measure mental and motor development as well as confounding environmental influences. Nevertheless, the most recent study[26], which overcomes most of the said limitations, is strongly indicative of significant developmental delays occurring in the presence of iron deficiency anaemia (Hb <10,5 g/dL; serum ferritin < 12 æg/L), but not of iron deficiency, in 12-18 month old infants. In addition, the study provides strong evidence that the developmental delays are reversible, at least in the short-term, when the anaemia is treated; the reversal of developmental delays in the longer-term[27,28] is still the subject of debate[29].

The causes of iron deficiency are multifactorial and include increased needs during periods of rapid growth, low intake of iron-rich foods, decreased absorption of iron from cereal staples, parasitic gastrointestinal infections, which result in blood loss from the gastrointestinal tract, malaria and recurrent infections[30]. With regard to the latter, the presence of the acute phase response is known to depress serum iron and Hb concentration[31]. One of the surprising findings of this study was the low rate of anaemia (Hb < 11 g/dL) found in KwaZulu/Natal. The rate was significantly less than all the other provinces, with the exception of Gauteng. The reasons for this are unclear. One would have expected that anaemia would be a significant problem in this area, given the reported high prevalence, particularly in the north of the province, of hookworm infestation and malaria, both known to impact adversely on haematological status[32,33].

In terms of prevention of iron deficiency, the placental transfusion the newborn receives if the cord is allowed to pulsate before being clamped (may account for one-fourth to one-third of the total fetal blood volume at birth)[34], the promotion of breastfeeding[35] and, later in life, the consumption of iron-rich foods together with the prevention of infection and intestinal parasitic infestation[36] are all important preventive measures. Other approaches to increasing the dietary intake of iron include mainly the fortification of weaning foods as well as food staples, and the daily administration of pharmaceutical iron supplements. Recently, major achievements in the fortification of foods have been accomplished[37,38]; however, this approach would appear inappropriate for South Africa, because of the prevalence of iron overload[39] which is reported to be high, especially in adult males[40] (31-35%). In this regard, one wonders whether the consistently lower prevalence of iron deficiency in the rural areas found in this study is not related to the traditional iron cooking utensils used[39]. The provision of pharmaceutical iron supplements for the prevention and

treatment of iron deficiency is often hampered by operational (supply and logistics), infrastructural (access to health care services) and technological (assessment of iron status, the form, dosage and duration of iron supplements, compliance and monitoring) problems. Recent advances[34,41,42] hold the great promise of replacing the need for the current daily administration of iron supplements with a weekly dosage regimen, thus improving compliance, decreasing side-effects and making such an intervention considerably cheaper. It should, however, be borne in mind that, although iron supplementation is effective in correcting iron deficiency, it is not free of adverse effects on morbidity[43-46]. Of considerable concern, is the recent finding that iron supplements in non-iron deficient young children leads to a significant retardation in weight gain[47]; until these new findings are confirmed or disproved, great care should be exercised with the administration of iron supplements.

RECOMMENDATIONS

One in five children in the country is anaemic, one in fifteen is moderately anaemic and one in five hundred is severely anaemic. In terms of iron status, one in ten children is iron depleted or deficient, one in twenty is severely iron depleted or deficient, and one in twenty has iron deficiency anaemia. Anaemia and poor iron status are more prevalent in urban areas. Children in the 6-23 month age group are the most severely affected.

SAVACG offers its assistance in the implementation of those recommendations for which it has the relevant expertise and infrastructure. In terms of the recommendations made in this chapter, SAVACG can assist with recommendations 6.1.7, 6.1.8, 6.1.9, 6.1.10, 6.1.11, 6.1.12, 6.2.1, 6.2.2 and 6.2.3.

6.1 Short-term

6.1.1 An iron sulphate syrup supplement distribution programme should be instituted for three years primarily for all children in the 6-23 month age group.

6.1.2 For children 24-71 months of age, a screening system, using Hb concentration, should be introduced and iron supplements administered as necessary.

6.1.3 Iron supplements should also be dispensed to children who have been ill, but only during the period of convalescence.

6.1.4 The form of iron supplements should be ferrous sulphate due to its low cost and reasonable bioavailability. For children 6-23 months of age, the daily dosage schedule should be 1 mg/Kg of elemental iron given orally twice a week. For older children, 30 mg of elemental iron should be administered orally twice a week for a month; the need for longer supplementation periods should then be re-evaluated.

6.1.5 The iron supplement should be distributed through primary health care clinics (fixed or mobile) or by community health workers. A record of the dispensing of the supplements should be kept in the Road to Health card.

6.1.6 Breastfeeding should be promoted according to the recommendations made in Chapter 3.

6.1.7 The feasibility of fortifying baby and toddler foods with iron should be investigated by the Department of Health with a view to implementation.

6.1.8 Health care personnel and community health workers should be trained with regard to the importance of iron in child development, and the dosage, administration and documentation of the supplements.

6.1.9 All children should be treated for intestinal parasitic infestations. The feasibility of this programme should be established by the Department of Health. An environmental health programme on the prevention of re-infestation should also be introduced.

6.1.10 Effective management is crucial to the success of these recommendations and should include training for and monitoring and evaluation of the iron supplementation programme recommended.

6.1.11 As part of the recommended monitoring and evaluation programme, the efficacy of the recommended twice weekly dosage schedule as well as the reported retardation of weight gain in children with normal iron status who receive iron supplements should be further investigated. It is also recommended that, in conjunction with the recommendations for a vitamin A intervention programme, the suitability, in terms of the type and composition, of the currently available vitamin and mineral supplements dispensed at primary health care clinics is assessed and appropriately adapted. Further, the causes for the differences in the prevalence of poor iron status between urban and rural areas should be investigated.

6.1.12 Maternal education as well as education of the public at large regarding the role of iron in child development should also be undertaken.

6.2 Medium-term

6.2.1 At the end of three years of iron supplementation, a repeat survey should be conducted for the evaluation of the programme and the confirmation of the findings of the on-going monitoring and evaluation recommended in section 6.1.9.

6.2.2 Nutrition education at the household level regarding food diversification and the improvement of dietary quality to increase the dietary intake of iron should be undertaken. This can be achieved by promoting child-to-child education programmes and improving knowledge regarding iron-rich foods, especially in the urban areas.

6.2.3 Universal food fortification is not recommended in view of the reported high prevalence of iron overload in large segments of the adult population.

6.3 Long-term

6.3.1 The long-term improvement of iron status of children should be addressed within the proposed framework of the Nutrition Committee48 regarding an integrated nutrition strategy for South Africa which must be compatible with the ethos and principles of the government's Reconstruction and Development Programme for socioeconomic upliftment.

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