ANAEMIA IN WOMEN AND CHILDREN ON WAR-TIME DIETS*

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(With 2 Figures in the Text)

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Introduction

The work reported in this paper was an inquiry to ascertain whether

(1) Anaemia was prevalent among women and children at the time of the investigation;

(2) There was any evidence of an increased incidence of anaemia;

(3) The aetiology of the anaemia could be indicated from the evidence available to us.

The presence and degree of anaemia were determined by a haemoglobin estimation. Detailed study of individual cases and aetiological factors, which would entail long periods of investigation, was not within the scope of the present inquiry.

The material studied was in no way a cross-section of society. Groups of women and children similar to groups investigated before the war were examined, so that comparisons could be drawn between the figures obtained in the present inquiry and pre-war figures. The number of persons examined was 1074.

Technique

Haldane's method was used throughout and the values were expressed in percentages, 100% on this scale being equivalent to 13·8 g. haemoglobin per 100 c.c. The same standard tube was used for all estimations. The instrument was one that had been checked against Price-Jones's (1931) standard. It was rechecked by the oxygen capacity method and found to be correct within an error of 1%. Estimations were carried out by all the authors: constant cross checks were made and readings were found to agree closely. Only freely flowing blood was used. At the beginning of the present investigation children under 3 years old were pricked in the heel with a cutting needle (Drucker, 1923), and those over 3 years old in the ear; but since estimations from ear pricks in children proved unreliable, all these results were subsequently discarded. As a horny heel would not bleed freely, a prick from the ball of the great toe was substituted for older children. A cold foot was warmed before pricking. Estimations on twenty-four children at one residential nursery were made with a Sahli instrument, which was checked against our Haldane standard. For these estimations we are indebted to the medical officers in charge of the nursery.

Examination of women

Standard

The usually accepted haemoglobin standard for British women is that of Price-Jones (1931), determined on a group of 100 women, nurses and a few students, on duty at a London hospital, whose average age was 24 years. Price-Jones's figures agree well with those of Jenkins & Don (1933) (Table 1) for representative English women in different parts of the country, and also with American figures. As a standard for comparison, therefore, a mean haemoglobin value of 98·3% (Haldane scale) or 13·56 g. %, with a range of 90–110%, will be taken as an average pre-war figure for supposedly healthy adult British women (Price-Jones, 1931).

Clinical material

The women studied fell into three groups, nurses and students, factory workers, and housewives. The haemoglobin values were determined during November and December 1941, and these tests were repeated 6 or more weeks later on those women who received iron therapy. The women were all performing their various duties and were presumed to be in average health.

Group 1. *Nurses and students.*

This group consisted of 353 nurses and women students at a London hospital and its base hospital in the country. They ranged in age from 18 to 60 years, but 65% were under 26 years of age, and 94% were under 40 years of age. No significant difference was found between the haemoglobin values of different age groups: age was, therefore, ignored in the analysis of the figures.

The students and nurses formed two homogeneous groups if we except the members of the auxiliary nursing service working at the base hospital. A considerable proportion of the latter, mostly from the North, had been doing factory or domestic work before joining the service, and their previous income level had probably been lower than that of the majority of the other nurses. With this exception, both nurses and students were attached to the main hospital in London: chance decided who was posted to the base, the London and country groups being strictly comparable.

The classification into town and country subgroups was made on a residential basis: a nurse or student had to have been 2 or more months in, or away from, London to qualify for either group. The majority of the women, however, had been at one or other hospital for 6 or more months.

The habits and mode of life of the nurses and students were studied in some detail. All the nurses lived in. The sleeping and working conditions in both hospitals were considered satisfactory. In the country the nurses had more opportunities for fresh air and exercise than their colleagues in London, but less for seeing their friends and getting meals and additional food in their off-duty times. Each nurse was questioned as to her health, and any with a history of recent illness were excluded: remarkably few of the women suffered from any menstrual trouble. A detailed estimation of the diets eaten was made through the co-operation of the catering authorities at both hospitals.

A comparison of the mode of life and diet of the students living in and out of London was more difficult. In London the majority of the students were resident in hospital, and those that were not had their midday meal in the hospital refectory. The students living out of London were billeted, and there were no canteens where a meat meal could be obtained.

Group 2. *Factory workers*

This group consisted of 159 women working in a paper factory, converted for war purposes, in a small town near London. The women's ages ranged from 18 to 58 years, 58% being under 26 years of age. They were said to be a representative cross-section of the employees. Mostly local women, a large proportion had come into the factory on leaving school and had worked there ever since. No wage figures were available but the women appeared on the whole to be comfortably off. Welfare conditions in the factory seemed good and there was a canteen, but only a few of the women we tested availed themselves of it.

Group 3. *Housewives*

This group was formed of 32 women, aged 18 to 43 years, the mothers of children attending the Queen's Hospital for Children in the East End of London. Little was known about these women beyond the fact that their children were attending the out-patient department.

Results of the examinations

Before considering in detail the results obtained in the different groups studied, it should be noted that all the mean haemoglobin values in the present series are significantly lower than the pre-war standard of 98·3% (Table 1). The mean figure for all the groups combined is 89·5%: the lowest mean of any one sub-group is 82·6% and the highest 94·0%. Such figures suggest a very real increase in anaemia among women at the present time.

Group 1. *Nurses and students*

The most striking finding in this group is the marked difference between the mean haemoglobin values of those resident in town and country respectively. Both means are significantly lower than the pre-war standard, but the women in the country, nurses and students alike, were significantly more anaemic than their fellows in London (Table 1).

Table 1. *Haemoglobin values in women*

	No. of cases	Mean Hb g. %	Mean Hb Haldane %	Standard deviation	Coefficient of variation	Maximum value	Minimum value	Percentage of cases with Hb below 90%	Percentage of cases with Hb below 80%
Price-Jones's series (1931)	100	13·6	98·3	4·40	4·5	110	90	0	0
Jenkins & Don's series (1933)	116	13·9	100·5	8·14	8·1	123	77	9	1
Present series									
All cases	544	12·3	89·5	9·16	10·2	120	56	54	10
Nurses and students									
London									
Combined nurses and students	170	12·5	90·6	7·80	8·6	106	56	43	5
Nurses	97	12·5	90·5	8·23	9·1	105	56	39	7
Students	73	12·5	90·8	6·39	7·0	106	79	44	3
Country									
Combined nurses and students	183	11·6	84·1	6·20	7·4	98	60	84	17
All nurses	132	11·4	82·9	6·53	7·7	98	60	83	20
Professional	52	11·5	83·7	7·03	8·4	98	60	81	17
Auxiliary	80	11·3	82·6	6·15	7·5	94	63	85	21
Students	51	11·7	84·6	4·22	4·9	92	72	86	12
Factory workers	159	13·0	94·0	10·18	10·8	120	64	30	7
London housewives	32	12·4	89·6	9·16	10·3	112	75	53	9

The mean haemoglobin values of the nurses and students were 90·5 and 90·8% respectively in the town, and 82·9 and 84·6% in the country. Thus there was a close agreement between the figures for nurses and for students in each of the two localities. In London 43% of the women had a haemoglobin of under 90% and 5% under 80%. In the country the corresponding rates were 84 and 17% respectively (Table 1).

It was suggested that the figures for the country nurses were lower than those for the London nurses because of the inclusion of the members of the auxiliary nursing service in this group. The figures show that this was not the cause, since the mean figure for the professional nurses when in the country was 83·7% and for the auxiliary nurses 82·5%.

An inquiry was made into the sickness rates among the nurses, other than the auxiliary nurses, at the two hospitals. During the 6 months before the inquiry the percentage of nurses off duty was higher in the country than in London, but the difference was not quite significant, though the percentage number of working days lost was just significantly higher in the country group (Table 2). It was difficult to assess the value of these figures

as the numbers were small and the risks at the two hospitals not necessarily the same in such a short period.

The results of the dietetic surveys at the two hospitals are set out in Tables 3 and 4. The diets were those eaten over the 3 months preceding the haemoglobin estimation. The amounts are calculated per week and per day. The diet per nurse was calculated from the total amount of each food sent to the kitchen per week, divided by the number of individuals for whom the food was ordered. No correction for days off was made. There were differences in the form in which certain foods were supplied at the two hospitals and allowance has been made for this in the calculations. For example, the meat ration at the town hospital was 16 oz. weekly, estimated free of bone and fat, whereas at the country hospital it was also 16 oz. but was weighed with bone and fat. Also, at the town hospital the whole meat ration was allowed, regardless of the week's supply of unrationed animal protein, whereas in the country the meat ration was cut when alternative supplies of unrationed animal protein were available. The values given in the table for calories, protein, etc. are taken from McCance & Widdowson's tables (1940). In the case of meat, greens and other foods, average figures for several different kinds have been used.

The diets provided at the two places differed considerably in calorie yield, in protein content and in their variety. The London diet yielded approximately 1865 calories a day,

Table 2. *Sickness rates among nurses for* 6 *months ended* 31. xii. 41

	No. of nurses	No. off duty	Percentage off duty	Possible days on duty	Days lost	Percentage days lost	Days lost per nurse
In London	80	26	32·5	14,720	512	3·5	6·4
In the country	53	27	51·0	9,752	504	5·2	9·5

disregarding any extras such as cake, biscuits and chocolate, which were fairly easily obtainable in London at the time of the survey. The daily calorie yield of the country diet was only 1662, which was more unsatisfactory than the difference between it and the town diet would suggest, as the country nurses found it very difficult to supplement their diet in any way. The protein content of the two diets was also very different. In the London diet the total protein was 63·5 g. a day, of which 41·0 g. were animal protein. The corresponding figures for the country diet were 46·7 g. total protein, with only 28·0 g. of animal protein, showing that the reduction in comparison with the town diet was greater in animal than in vegetable protein.

The other most striking differences between the two diets were that the London diet provided greater variety, and larger amounts of porridge oats and lentils than the country diet, and that the country diet provided no baked or haricot beans but larger amounts of white bread and also of greens, salads and carrots.

The iron intake judged by optimal standards was low at both hospitals. The daily intake of iron, both total and 'available', was not very different in the two diets, owing to the greater amount of liver provided in the country in the period reviewed. The figures were 10·77 and 7·62 mg. daily for total and 'available' iron respectively in the London diet, and 9·21 and 6·45 mg. in the country diet.

The diets of the students were more difficult to assess. The London students certainly had more animal protein than similar women living on their rations only. At the refectory in London most students had a midday meat meal daily, and for those living in

Table 3. *Nurses' diets in London and country hospitals. Average weekly intake per head*

	London					Country				
Food	Oz.	Calories	Protein g.	Iron mg.	'Available' iron mg.	Oz.	Calories	Protein g.	Iron mg.	'Available' iron mg.
Rationed meat, uncooked	16	800	96·0	16·00	1·60	13·3	665	66·5	13·30	1·33
Rabbit, cooked	5	130	19·5	1·40	0·59	—	—	—	—	—
Liver, uncooked	1·5	61	7·00	5·92	5·92	3·0	122	14·0	11·85	11·85
Sausages, 33% meat uncooked	2	196	1·6	0·47	0·39	1·0	98	0·8	0·23	0·19
Fresh fish, uncooked	6	114	24·6	0·66	0·66	3·2	61	13·1	0·35	0·35
Kippers, uncooked	8	248	28·8	1·76	1·76	4·0	124	14·4	0·88	0·88
Bacon, uncooked	4	696	12·0	1·12	0·32	4·0	696	12·0	1·12	0·32
Ham, cooked	2	246	9·2	1·42	0·21	2·0	246	9·2	1·42	0·21
Cheese	3	360	21·3	0·48	0·48	3·0	360	21·3	0·48	0·48
Milk	75	1425	67·5	1·50	1·50	50·0	950	45·0	1·00	1·00
Total from foods yielding first-class protein	—	4276	287·5	30·73	13·43	—	3322	196·3	30·63	16·61
White bread	15	1110	33·0	4·20	3·72	29·4	2176	64·8	8·23	7·35
Brown bread, Hovis	12	840	38·4	10·08	9·58	—	—	—	—	—
Wheatmeal bread	—	—	—	—	—	4·2	273	10·1	3·23	2·55
Porridge oats, dry weight	6	738	22·8	7·02	6·74	1·9	134	7·2	2·22	2·13
Boiled potatoes	72	1800	28·8	10·08	9·78	72	1800	28·8	10·08	9·78
Baked potatoes	8	256	5·6	2·00	1·94	—	—	—	—	—
Beans, baked and haricot, uncooked	3·5	133	9·1	2·94	2·69	—	—	—	—	—
Lentils and peas, uncooked	1·9	175	12·0	2·95	2·18	1·4	129	8·8	2·16	1·60
Vegetables (greens, salad, carrots, parsnips, marrow, runner beans, tinned peas and vegetable pie)	26·0	136	6·6	3·26	2·91	46·0	207	9·8	5·80	4·78
Total from foods yielding second-class protein	—	5188	156·3	42·53	39·54	—	4719	129·5	31·72	28·19
Fats (butter, margarine and lard)	8·0	1880	0·6	0·36	0·36	8·0	1880	0·6	0·36	0·36
Sugar and jam	16·0	1716	0·8	1·80	—	16·0	1716	0·8	1·80	—
Total weekly intake	—	13,060	445·2	75·42	53·33	—	11,637	327·2	64·51	45·16

Table 4. *Nurses' diets in London and country hospitals. Average daily intake per head*

	Calories	Protein g.	Iron mg.	'Available' iron mg.
London				
Foods yielding first-class protein	611	41·0	4·39	1·92
Foods yielding second-class protein	741	22·3	6·07	5·65
Fats and sugar	513	0·2	0·31	0·05
Total daily intake	1865	63·5	10·77	7·62
Country				
Foods yielding first-class protein	475	28·0	4·37	2·37
Foods yielding second-class protein	674	18·5	4·53	4·03
Fats and sugar	513	0·2	0·31	0·05
Total daily intake	1662	46·7	9·21	6·45
Widdowson & Alington's surveys of diets of middle-class women				
1941: Total daily intake	2137	64·0	12·2	9·2
Animal protein	—	33·8	—	—
1935: Total daily intake	2187	67·3	11·4	7·9
Animal protein	—	46·0	—	—

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entirely the diet was approximately that of the nurses, with perhaps a more liberal amount of meat. The students living out did not surrender their ration cards to the hospital, so that there was no doubt that they too were obtaining more meat and animal protein. The position of the students out of London was quite different, for at no place where they worked was there a canteen serving a meat meal in the middle of the day, so that they either brought sandwiches or had a vegetarian lunch. Further, many students said they were doubtful whether they always got their full meat ration, as the households where they were billeted had the principal meal in the middle of the day, so that the students who were away missed it and only had a light meal at night. In fact, after careful inquiry it was certain that, like the nurses, though from other causes, the students out of London had a diet lower in animal protein than their colleagues in London.

An attempt was made to give iron to the nurses at the hospital in London. The trial was not very successful. However, sixty-one women took some iron over a period of 6 weeks: their mean haemoglobin values before and after treatment were 90·9 and 94·7% respectively. The difference between the means, 3·8%, is not quite statistically significant, being only 2·77 times its standard error. More important was the result of iron therapy in a few individual cases with low initial haemoglobin values: with one or two exceptions these showed a satisfactory response to iron which was taken regularly.

Group 2. *Factory workers*

The 159 women examined fell into the same age group as the nurses and students. Workers under 18 years of age have been excluded from the present series and are considered with the children. The mean haemoglobin value of this group of women was 94·0%, a figure significantly higher than any mean obtained in the preceding group. The variability within the group was, however, high, which suggests that the women did not form a very homogeneous group.

Group 3. *Housewives*

The third group, composed of thirty-two mothers of children attending clinics at the Queen's Hospital for Children, was small, but of interest as the mean haemoglobin value was 89·6%, a value approximating closely to those found for nurses and students in London.

EXAMINATION OF CHILDREN

Standards of comparison for haemoglobin values

Haemoglobin values of children vary widely with age, and there are no accepted standards for normal children of different ages. For the present work we have used as standards of comparison haemoglobin values already published for various groups of children, mainly from working-class families. The health of many of these children was certainly not optimal. Table 5 shows the sources of the series we have used for comparison.

Values for children aged 6 *months to* 5 *years*

Published observations on groups of British working-class children given no medicinal iron (Fig. 1) show that the mean haemoglobin level of infants at 6 months lay between 75 and 78%. This level then dropped fairly steadily, so that by 12–18 months of age the means lay between 69 and 72% (Mackay, 1933; Davidson *et al.* 1935; Fullerton, 1937;

Table 5. *Sources of the series of haemoglobin estimations in children used for comparison*

Investigator	Place	Date of examination	Age	Economic class	No. of estimations	Method	Comments
British							
Mackay & Goodfellow (1931)	London, E.	1926–9	6–13 mth.	Working class	243	Haldane	Children in own homes, artificially fed, receiving iron from under 4 mth. old. (Revised figure, see Mackay, 1933)
Mackay (1933)	London, E.	1926–9	6–14 mth.	Working class	1097	Haldane	Similar children, not receiving iron, average of breast- and bottle-fed
Davidson, Fullerton & Campbell (1935)	Aberdeen	1931–5	6 mth.–2 yr.	Working class	284	Haldane	Children not receiving iron. Average income for whole Aberdeen series was 11*s.* per 'man value' (Davidson & Fullerton, 1938)
	Aberdeen	1931–5	2–18 yr.	Working class	422	Haldane	
Fullerton (1937)	Aberdeen	1931–	6 mth.–2 yr.	Working class	444	Haldane	284 of these included in series above; children not receiving iron
Colver (1938)	London, S.	—	1–5 yr.	Working class	310	Haldane	Children at welfare centres, not receiving iron
Hutchison (1938)	Glasgow	—	6–12 mth.	Working class	88	Haldane	Children at welfare centre, not receiving iron
Spence (1934)	Newcastle-on-Tyne	1933	1–5 yr.	Professional class	25	Sahli-Leitz	Children in own homes
	Newcastle-on-Tyne	1933	1–5 yr.	Working class	126	Sahli-Leitz	Children in own homes and in nurseries
Brewis, Davison & Miller (1939)	Newcastle-on-Tyne	1938–9	1–5 yr.	Working class	136	Sahli-Leitz	Children in own homes and in nurseries
American and Canadian							
Usher, MacDermott & Lozinski (1935)	Montreal	—	6–15 mth.	Foundlings	?	Sahli	Children in resident nursery, one group treated with iron or iron and copper
Osgood & Baker (1935)	Portland, Ore.	—	4–14 yr.	Various	215	Osgood & Haskin, vene-puncture	Children in hospitals, resident homes and own families, including children at public grade schools
Osgood (1935)	Portland, Ore.	—	14–19 yr.	Middle class	?	Osgood & Haskin, vene-puncture	Students at high schools
Mugrage & Andresen (1936, 1938)	Denver	—	4 mth.–21 yr.	Working class?	585	Oxygen capacity, vene-puncture	All persons at 5000 ft. altitude
Guest, Brown & Wing (1938)	Cincinnati	—	3 mth.–5¼ yr.	Various	771	Palmer's carbon monoxide, vene-puncture	Children in hospitals, residential homes and own families

Hutchison, 1938). Thereafter, there was a steady rise and by 4–5 years of age the means lay between 78 and 84% (Davidson *et al.* 1935; Colver, 1938) (Table 6). The various British investigations showed a remarkable measure of agreement for children of this age group untreated with iron.

These pre-war figures for young children not receiving medicinal iron are pathologically low. This is clear from the following pre-war observations. (1) Medicinal iron given

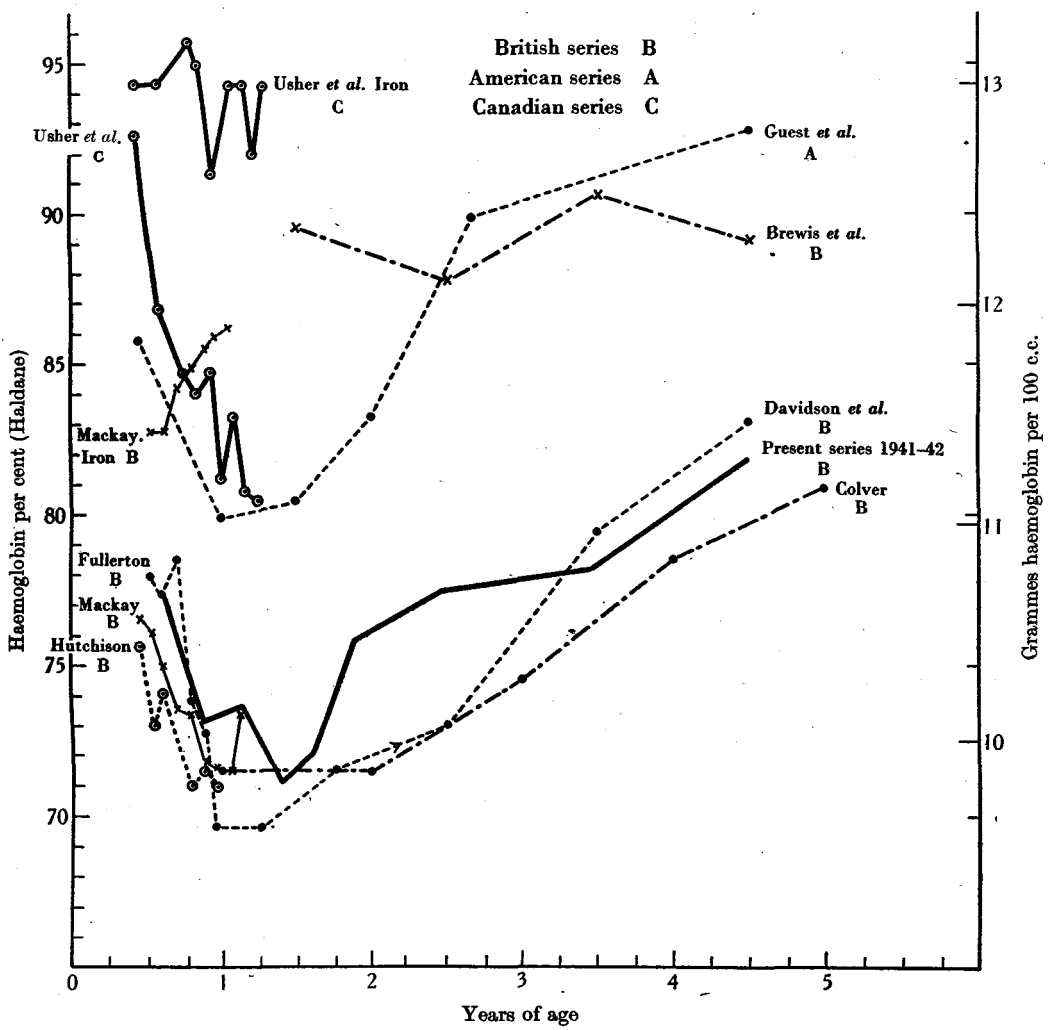

Fig. 1. Haemoglobin level from 6 months to 5 years old. Present series compared with other series.

continuously from early infancy raised the mean haemoglobin level to about 85% by the 6th month and maintained it at approximately that figure throughout the rest of infancy. For babies given iron treatment from under 4 months of age the average figure for 6–12 months was 84·0%. Controls averaged about 10% lower, and by 12 months of age were actually 17% lower than the treated cases (Mackay & Goodfellow, 1931; Mackay, 1933). (2) Babies receiving such iron treatment had a morbidity rate about half that of a control series (Mackay & Goodfellow, 1931). (3) Working-class children

aged 1–5 years, examined in 1938–9 in Newcastle-on-Tyne, showed an average haemoglobin maintained at about 89% (Brewis *et al.* 1939 and personal communication); a large majority of these children had received in infancy a dried milk medicated with very small amounts of iron, and about half the children were still receiving such milk at the time when they were examined. The iron added to the milk was sufficient to at least treble the iron intake of a baby fed on cow's milk, but nevertheless the dose of medicinal iron was so small that one supposes that other dietetic factors also contributed

Table 6. *Mean haemoglobin level of children aged 6 months to 5 years. Present series compared with other series. Variation with age*

Group and date of estimation	6 mth. to 1 yr. No.	Mean Hb g.	Haldane %	S.D.	1–2 yr. No.	Mean Hb g.	Haldane %	S.D.	2–3 yr. No.	Mean Hb g.	Haldane %	S.D.
Present series, 1941–2												
All children	70	10·40	75·4	8·80	116	10·05	72·8	10·25	95	10·70	77·5	8·38
Welfare clinic	52	10·47	75·9	8·10	49	10·47	75·9	8·18	32	11·14	80·7	7·62
Immunizing clinic	—	—	—	—	15	10·36	75·1	7·20	15	10·70	77·5	6·20
Day nursery	6	10·18	73·8	12·16	25	9·86	71·5	8·38	15	11·08	80·3	8·54
Resident nursery	12	10·19	73·9	10·20	27	9·25	67·0	14·46	33	10·10	73·2	7·89
Brewis *et al.* (1938–9)												
Very small dose of iron to most children	—	—	—	—	24	12·36	89·6	—	37	12·10	87·7	—
Davidson *et al.* (1931–5)												
No iron treatment	234	10·61	76·9	—	50	9·94	72·0	—	19	10·07	73·0	—
Colver (before 1938)												
No iron treatment	—	—	—	—	100	9·87	71·5	—	100	9·87	71·5	—

Group and date of estimation	3–4 yr. No.	Mean Hb g.	Haldane %	S.D.	4–5 yr. No.	Mean Hb g.	Haldane %	S.D.
Present series, 1941–2								
All children	48	10·79	78·8	9·88	35	11·29	81·8	9·06
Welfare clinic	21	11·69	84·7	6·77	10	11·99	86·9	8·32
Immunizing clinic	9	9·67	70·1	8·30	22	10·91	79·3	8·75
Day nursery	10	10·95	79·4	6·10	2	12·01	87·0	—
Resident nursery	7	9·66	70·0	9·90	—	—	—	—
Brewis *et al.* (1938–9)								
Very small dose of iron to most children	47	12·51	90·7	—	28	12·30	89·1	—
Davidson *et al.* (1931–5)								
No iron treatment	16	10·96	79·4	—	9	11·47	83·1	—
Colver (before 1938)								
No iron treatment	50	10·28	74·5	—	50	10·83	78·5	—

to the high haemoglobin level. These important observations justify the claim that the normal or optimal mean haemoglobin level of children of 6 months and upwards cannot be lower than 85%, and that the pre-war figures for British working-class children not treated with iron cannot be accepted as average values for children in optimal health.

Curves for mean haemoglobin values for American and Canadian children, 6 months to 5 years old, *whether treated or untreated with iron*, show similar trends to the British ones, but are usually higher than the latter (Fig. 1). Whether this is in part due to differences in technique is uncertain.

Values for children over 5 years of age and for adolescents

Few British figures exist for the mean haemoglobin level of children over 5 years old except those of Davidson *et al.* (1935), which were obtained in Aberdeen during the period of industrial depression, their subjects belonging to the poorest section of the community. In order, therefore, to study the changes in haemoglobin level occurring in this age group figures published abroad before the war are included in the present discussion (Table 5). In most series (Fig. 2), the haemoglobin level from 5 to 13 years showed a slow but fairly steady rise and by 13 years of age the value lay between 90 and 98%. At about this age, values for boys and girls diverged; boys usually reached the adult level for males between 16 and 18 years of age, girls in some series surpassed the average level for adult females when about 16 years old and then showed a slight decline to the adult level by about 19 years of age. Average levels for supposedly healthy young adults were found by many workers to be approximately 98% for women and 114% for men. In Fig. 2 the highest curve is that of Mugrage and his co-workers (1938), obtained from subjects living at an altitude of 5000 ft. This curve is included because every estimation was done by the oxygen capacity method, and because it covers the whole period from infancy to adult life. Osgood's (1935) curve shows similar trends but the rise about the time of puberty is much steeper. Various workers have demonstrated the influence of economic circumstances and of institutional life in the production of nutritional anaemia in children (Spence, 1934; Ross & Summerfeldt, 1936; Fullerton, 1937), and the shapes of the curves shown in the chart have undoubtedly been influenced in some cases by changes in the source of clinical material. There exists little evidence concerning the effect of iron medication on the average haemoglobin levels of British school children.

Clinical material

Children aged 6 months to 5 years

Between September 1941 and January 1942 haemoglobin estimations were made on 364 children under 5 years of age. The majority were children of service men, labourers, artisans or small tradespeople; they included no children of professional-class parents. Excluding two children, they fall into the following four groups:

(1) 164 children at *ten welfare centres*; (2) 61 children at *three diphtheria immunization clinics*; (3) 58 children at *two day nurseries*; (4) 79 children at *three residential nurseries*.

No selection of children was made by the writers at the clinics and institutions, consecutive children being examined. With the exception of the nursery training centre discussed below, no children were admitted or were in attendance on account of illness.

(1) *Welfare centres.* Of these six were situated in industrial districts in London, two in the suburbs and two in country towns. They were run by experienced staffs, and at all some effort was made to prevent nutritional anaemia by advice on diet. Mixed feeding, including vegetables, eggs, and sometimes meat was frequently advised from the 6th to 7th month, and sometimes earlier. Farex, a cereal containing 4·2 mg. of 'available' iron per ounce, was obtainable at several centres, but the cost often proved prohibitive. Systematic iron administration was rare and medical officers emphasized the difficulty of carrying it out under existing conditions.

(2) *Immunization clinics.* The children seen at these clinics lived at home and were of similar economic status to the children at the welfare centres. We do not know what

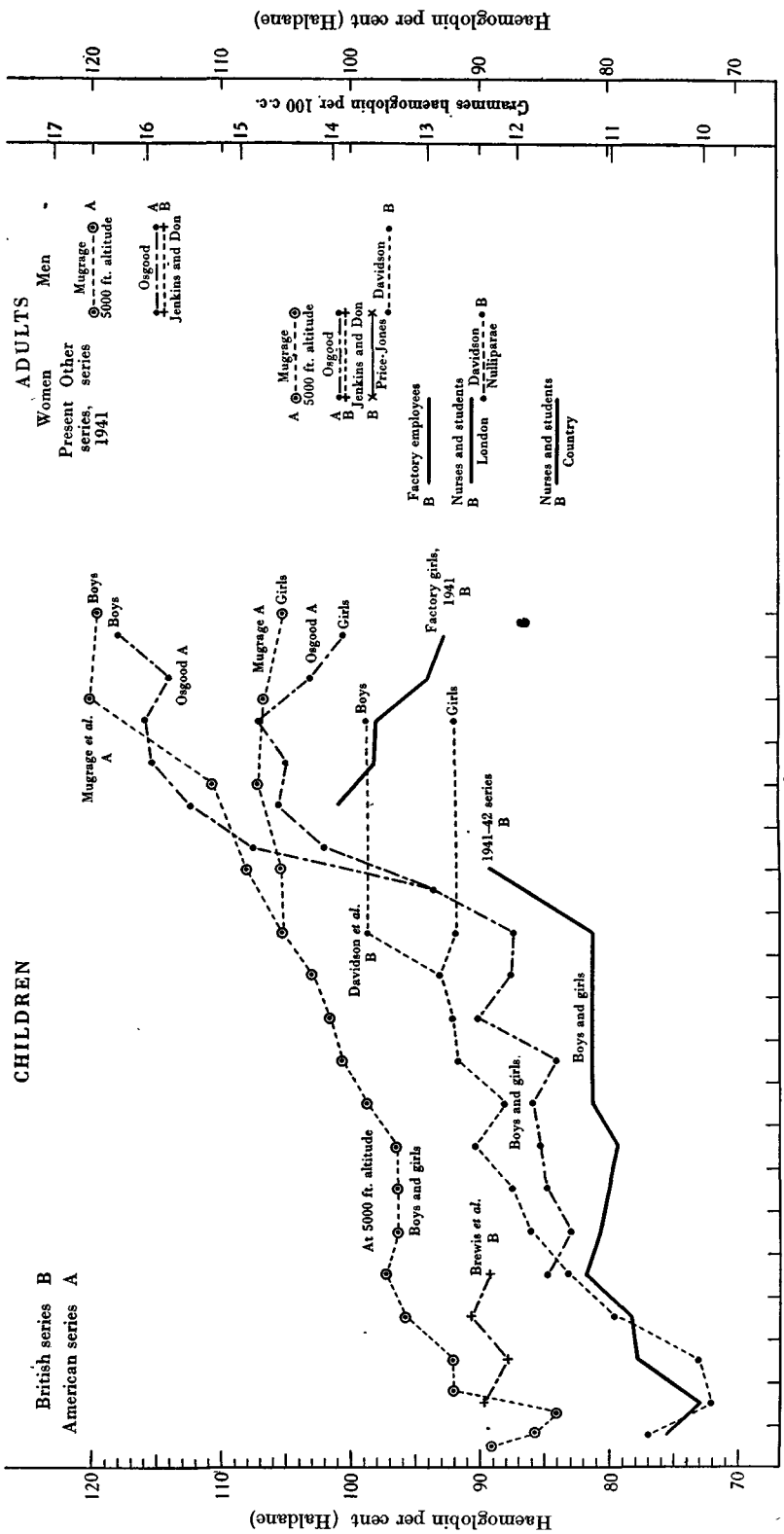

Fig. 2. Haemoglobin level from 6 months to adult life. Present series compared with other series.

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proportion attended a centre; some came from a borough where welfare work had largely lapsed.

(3) *Day nurseries.* These should be representative of their kind. Children spent about 10 hr. out of the 24 in the nurseries, and had most of their food there. One nursery was run by a voluntary association in central London, the other, under the public health authority, was in a large and specially planned building in a suburb, and was considered a model of its kind. Farex was ordered for some children, but very few had received any iron medication. The records we saw showed that the incidence of infection was much higher than in the welfare group.

(4) *Residential nurseries.* These provided samples of different types of homes. One was a religious orphanage where the children had been inmates from early infancy. The second was under the public health authority and was for children evacuated from London, and these children too had probably been inmates of a nursery for a considerable time. The third was a large nursery training centre on the outskirts of a country town, and the children examined had been resident for terms varying from 1 week up to a year and more: originally sent there for convalescence prior to evacuation elsewhere, many seem to have stayed on indefinitely. All these residential nurseries had large grounds. No record of illnesses was available at the orphanage. At the other two nurseries, although records were far from complete, it was clear that the infection rate was high. At none of the nurseries was iron given systematically.

It was not possible to obtain reliable information about the diets at the day and residential nurseries, particularly as food supplies available had varied widely in the preceding months.

Children aged 5–15 *years. County Council school group*

This group consisted of 128 school children attending state-aided schools: 64 were examined at five schools in neutral areas, 52 at immunization clinics, and 12 at a minor ailment centre. Only 14 of these children were having school dinners.

Girls aged 14–18 *years. Factory group*

The 38 girls in this group were examined at the factory already described: they lived in their own homes.

Results of the examinations

Children aged 6 *months to* 5 *years. Clinics and nurseries*

Fig. 1 and Table 6 show that the mean haemoglobin curve of the 364 children examined approximates closely to those of the pre-war British series already discussed. The incidence of low haemoglobin values in our war-time children is similar to that among Newcastle working-class children in 1933 (Spence, 1934) and much higher than that in the Newcastle series of 1938–9 (Brewis *et al.* 1939).

The incidence of anaemia in our pre-school children differs with age (Table 7 and Fig. 1). The lowest haemoglobin levels were in children under 2 years old; 27% of these had a haemoglobin value of under 70%, whereas only 15% of those aged 2–5 years had such a low value. This high incidence of anaemia in children under 2 years old accords with the experience of a decade and more ago, both in this country and in America.

The mean haemoglobin values at different ages are shown in Table 6 for all the groups under 5 years old studied. At each age the welfare group had the highest, and the resident nursery group the lowest average haemoglobin value. After the 12th month the

difference between welfare and resident nursery groups is significant at each age for which figures are available. The haemoglobin levels of the day nursery children and the immunization clinic children were intermediate between those of the other two groups. The incidence of severe anaemia (reckoned as haemoglobin under 60%) is shown in Table 7. It was least in the welfare group (1 in 55), though the number of children under 2, among whom anaemia is always more prevalent, was greater in this than in any other group. In contrast the incidence of severe anaemia was very high in the nurseries, 1 in 14 among the day nursery children and 1 in 9 among the resident nursery children.

Table 7. *Haemoglobin level of children aged* ½–5 *years.* 1941–2 *series grouped to show the frequency distribution of haemoglobin levels in welfare centres and in nurseries*

	All cases						Welfare centres		Immunization clinics		Day nurseries		Residential nurseries	
	½–2 yr.		2–5 yr.		½–5 yr.		½–5 yr.		½–5 yr.		½–5 yr.		½–5 yr.	
Total cases haemoglobin	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Over 80%	49	26·4	81	46·0	130	35·9	71	43·3	19	31·1	25	43·0	15	19·0
70–79%	87	46·8	68	38·6	155	42·8	73	44·5	31	50·8	19	32·8	32	40·5
60–69%	35	18·8	23	13·0	58	16·0	17	10·4	8	13·1	10	17·2	23	29·1
Under 60%	15	7·9	4	2·3	19	5·2	3	1·8	3	4·9	4	6·9	9	11·4
Total cases	186	99·9	176	99·9	362	99·9	164	100·0	61	99·9	58	99·9	79	100·0
Percentage of total cases under 2 yr. old					—	51·4	—	61·6	—	24·6	—	53·4	—	49·4

Table 8. *Average haemoglobin level of children and adolescents aged* 5–19 *years*

Group and sex	No.	Mean g. %	Mean Haldane %	S.D.	C.V.	Max.	Min.	Percentage of cases with Hb below 80·0%	Percentage of cases with Hb below 70·0%
1941–2, present series									
5–13 yr. M. & F.	90	11·1	80·3	7·39	9·2	100	49	42·0	8·9
13–15 yr. M. & F.	38	12·3	89·3	7·01	7·9	105	71	7·9	0
14–18 yr. F. (factory)	38	13·8	98·7	10·05	10·2	122	82	0	0
14–17 yr. F. (factory)	28	13·8	99·8	10·03	10·0	122	82	0	0
17–19 yr. F. (factory)	31	13·1	94·5	7·80	8·2	110	67	0	0
1931–5, Aberdeen series									
5–12 yr. M. & F.	58	12·3	89·4	—	—	—	—	1·7	0
12–18 yr. F.	246	12·6	91·7	—	—	—	—	6·1	0·8

Children aged 5–13 *years. County Council school group*

The average haemoglobin level of 90 children in this group (Table 8, Fig. 2) was 80·3%, nearly 10% lower than that of Davidson's group of 58 children in Aberdeen (1935). In a further group of 158 Aberdeen children, including the 58 children already mentioned, only 3, or 1·9%, had a haemoglobin level below 80% (Davidson *et al.* 1933, 1935). In our group about 2 in 5 had less than 80% and about 1 in 11 had less than 70% haemoglobin. Whereas the haemoglobin level of the Aberdeen school children of 1931–5 rose during this age period, the level of our children remained almost stationary.

Children aged 13–15 *years County Council school group*

The average haemoglobin level for the 38 boys and girls in this group was 89·3% (Table 8, Fig. 2). This value is far below those of the high school boys and girls in Osgood's (1935) series and lower even than that of Davidson's girls (Fig. 2).

Girls aged 14–18 *years. Factory group*

The average haemoglobin level of 38 girls under 18 years old at the factory (2 only under 15 years) was 98·7%. The mean haemoglobin value averaged about 7% higher than that of Aberdeen girls aged 12–18 of the poorest class in 1931–5, and about the same amount lower than that of Osgood's high school girls (Table 8, Fig. 2).

DISCUSSION

Women. The findings recorded in this paper indicate an increase in anaemia among the women and children studied, compared to the pre-war incidence in similar groups. Among the women there was less severe anaemia than among the children, but a significant lowering of the mean haemoglobin value in comparison with pre-war standards, which was more marked in certain groups than in others. The mean haemoglobin value of all the women observed was 89·5% in comparison with Price-Jones's (1931) mean of 98·3% or nurses and women students or Jenkins & Don's (1933) value of 100·5% for British women in different parts of the country (Table 1). If, however, the present series is compared with a group of 50 nulliparous women studied by Davidson *et al.* (1935) in Aberdeen it is seen that the mean haemoglobin value of both groups is approximately the same, 89·5% for the present series and 89·7% for the Aberdeen women (Fig. 2). This is a remarkable finding, as the Aberdeen women belonged to the poorest class, and the estimations were made during the depression, when poverty was extreme in that city, whereas our series was composed of groups of middle- and working-class women, nearly all either in comfortable circumstances or in good work. A consideration of the groups of nurses and students shows that the mean haemoglobin value of the London group has dropped from pre-war standards. This drop, though significant, is not very great. But, when the figures for the women in the country are considered, it is clear that in this group a low grade anaemia is becoming a factor of importance. Unfortunately the type of anaemia was not determined in the majority of the women, haemoglobin estimations alone being carried out, but in most cases where a complete count was done, the anaemia was found to be normocytic and orthochromic, and the colour index about unity. Further, certain of these cases were treated with iron alone and the majority responded well.

The sickness rate of the country nurses was slightly higher than that of the London nurses (Table 2). The significance of this is difficult to assess, particularly as numbers were small. Infection is known to inhibit haemopoiesis and anaemia to result in a greater liability to infection. The nature of the major disabling complaints in both institutions (appendicitis, diphtheria, tonsillectomy and a pleural effusion in the country, and an operation on the knee, whooping cough, pleurisy and glandular fever in the town) suggests that the difference in the sickness rates was largely due to chance and not likely to explain the higher incidence of anaemia among the country women.

A consideration of the conditions of life of this community of nurses and students, both in London and the country, suggests that the one common factor that might have accounted for the greater degree of anaemia among the nurses and students in the country was the diet. There are figures for the nurses' diets showing that during the 3 months immediately preceding the investigation there was a marked difference between the town and country. The town nurses had not only a more varied and ample diet, but one that contained far larger amounts of animal and good vegetable protein (Table 4). For the students' diets there are no figures, but reasons have been given for thinking that the country

students also suffered from a relative deficiency of good biological protein in their diets. The actual iron intake did not differ greatly between the two groups. It was low, under 11 mg. total and 7·7 mg. so-called 'available' iron daily, in both groups, in comparison with Sherman's (1933) figure of 15 mg. as a minimal daily intake for health. Though figures have been given for 'available' and total iron we believe the term 'available' should be abandoned, since it seems that the 'available' iron of cereals may not be utilizable (Widdowson & McCance, 1942) and that the 'non-available' iron of meat and even blood may be utilizable (Black & Powell, 1942). The daily total iron intake in the case of the London nurses was only very slightly lower than that of the middle-class women surveyed in 1935 by Widdowson & Alington (1941), but unfortunately no haemoglobin estimations were done on their women.

The most striking deficiency in the country diet was a lack of first-class protein, but the anaemia did not appear to be due directly to the protein deficiency, as it responded to iron therapy alone in the majority of cases treated. It was possibly a conditioned iron deficiency state related to a low protein intake. In this connexion the work of a group of Swedish observers (Hellström, 1937) is of interest. In a survey of different regions in the north of Sweden it was found that the incidence of anaemia varied inversely with the animal protein content of the diet. All the diets contained appreciable amounts of milk, and any increase in animal protein was due to the addition of meat and fish. Such addition would appreciably increase the iron intake. There was a uniform rise in the haemoglobin level as the diet became more varied. The women, as in most poor communities, would eat relatively less protein than the men, and they suffered more frequently and more severely from anaemia. The Swedish workers showed that in the groups whose diets were low in animal protein there was a high incidence of achlorhydria, which decreased as the animal protein content of the diet increased. In their opinion this gastric achlorhydria played an important part, especially in the women, in the aetiology of the anaemia, probably through decreasing iron absorption. The anaemia varied in type, but, as in our cases, was generally orthochromic, the colour index in 80% of the women on the lowest protein diet lying between 8·5 and 1·14. Again, as in our cases, this anaemia responded to iron therapy, but in many cases the iron failed to raise the haemoglobin above 70–80% (Haldane). The authors were of the opinion that in addition to the iron deficiency there was an unknown factor operative in the production of the anaemia.

Vitamin C was not considered to be an aetiological factor among the nurses in our series, for, though it was impossible to estimate the vitamin C intake in the two diets, it was certainly higher in the country diet, where the supply of fresh vegetables and salads was greater.

The results obtained in groups 2 and 3, comprising factory workers and East End housewives, are also interesting. The factory workers had the highest mean haemoglobin value of any group studied, but the figure, 94·0%, is significantly lower than our pre-war standard figure. The relatively high haemoglobin value for this group is particularly remarkable as 40% of the women were married, and probably many had had children, and such women in the Davidson *et al.* series in Aberdeen (1935) had lower mean haemoglobin values than nulliparae. Nothing is known about the diet of the women in this group except that few used the factory canteen. The district was in the country and it is possible that their diet was supplemented by eggs, rabbits and other unrationed food which was obtainable from home sources in many country areas.

Children aged 6 months to 5 years. The facts set forth in this paper leave no room for doubt that there is at present a high incidence of anaemia among children under 5 years of age. Ten to fifteen years ago, when no systematic iron treatment was given, there was widespread anaemia among young children, and figures for mean haemoglobin values drawn from different parts of the country showed remarkable agreement. Our 1941–2 figures, taken as a whole, are of the same order as these earlier averages. It is our belief, based on hospital experience and the impressions of colleagues, that a marked decrease in the incidence of anaemia occurred in many areas between 1932 and 1939 as a result of prophylactic measures. Few figures exist to prove this, but the Newcastle investigations of 1933 (Spence, 1934) and of 1938–9 (Brewis *et al.* 1939) show that immediately before the war more than four times as many children in the sample groups examined reached approximately normal haemoglobin standards as in the earlier survey. The same conclusion can be drawn from the fact that though cases of marked nutritional anaemia were common in the East End of London in 1930, one of us in 1938–9 searched in vain for such cases. Our war-time children show a retrogression, their haemoglobin levels being of the same order as those of untreated children a decade ago.

A study of the causes leading to the pre-war decline in anaemia may suggest reasons for the present increase. Much of the pre-war decrease was due to the action of the Ministry of Health, which in 1932 issued a circular advising the routine administration of iron or iron medicated milk to infants and young children and pointing out the reduced morbidity rate produced by these means. As a result of this advice, between 1932 and 1938 iron was widely, if not very systematically, given in welfare centres all over the country. During the same period the food-iron in the diet of infants and young children was considerably increased, as a result of earlier weaning on to iron-containing foods, including meat. More attention too was given to the treatment of anaemia in pregnant women. All these factors contributed to the reduction of the incidence and severity of nutritional anaemia in infants and young children.

What then has reversed the process? The main cause is probably the great decrease in iron administration. No dried milk containing iron is available under the National Milk Scheme. Cheap or free milk provided under the scheme has displaced the dried milk containing iron previously distributed from the welfare centres, and the administration of the scheme has militated against attendance at these centres. Further, evacuation and repeated changes of address, disorganization and overcrowding of welfare centres, have also contributed to preventing regular prophylaxis. It is common knowledge that in many areas the proportion of children attending clinics is small. Further, the shortage of meat and eggs has meant much less food-iron in the diets of young children. Nevertheless, children now attending welfare centres often receive some medicinal iron and do get advice as to diet. This would explain the fact that of all the children under 5 years in our series those attending welfare centres had the highest mean haemoglobin value, and it is probable that the nutritional level of the children at the clinics we attended was better than the average of children of similar economic status in the country as a whole. It is worth emphasizing that there is no reason to doubt that the prevalent anaemia of infants is primarily an iron deficiency anaemia like that of 10–15 years ago.

The very high incidence of anaemia in the day and residential nurseries is probably due to more than one factor. We have no evidence that selection played a part in producing this high incidence, though, of course, economic need is often a factor in causing a mother

to go to work and leave her child in a nursery. Anaemia is known to decrease resistance to infection, and the close association of large numbers of young children exposes them to infection, which in turn increases anaemia. Such a vicious circle existed in the nurseries, and as little or no iron medication was given, the circle remained unbroken. A similar vicious circle in a resident nursery where iron had not been given was noted by Fullerton in 1937: there too the incidence of anaemia was extremely high. Guest *et al.* (1938) also noted that the haemoglobin values of babies over 10–12 months old who were living in institutions were consistently lower than those of babies living at home. Whether or not the food iron of the nursery children we examined was lower in quantity than that of the welfare group we were unable to judge.

Children and adolescents aged 5–18 *years.* The only pre-war British figures available to us for this age group are those of the Aberdeen workers (1935), which were obtained during the industrial depression, and the children studied came from the poorest class. Since the mean haemoglobin level of our children of 5–13 years was about 10% lower than the Aberdeen figures, and much lower than the American figures for similar age groups, it is safe to assume that many of our children were anaemic. It is an important fact that in a group of ninety school children studied during the winter of 1941–2 two out of five had less than 80% haemoglobin as against three out of 158 in Aberdeen during the depression a decade ago. Our 13-year-old boys had a haemoglobin level approximately 10% lower than the Aberdeen boys (Davidson *et al.* 1935) and nearly 20% lower than Osgood's high-school boys (1935). Our 13- and 14-year-old girls also were more anaemic than the Aberdeen girls of this age.

If, as we suppose, this anaemia is nutritional in origin, we would expect its incidence to vary from group to group and from place to place, depending on the availability and consumption of various foodstuffs in the preceding months. Hence with our small total numbers it would be unsafe to claim that the increase in anaemia is general among school children, but other groups of children should be investigated, as the increased incidence of anaemia may well be widespread.

The adolescent girls of 14–18, working at the factory, were the only group of persons in all our series whose haemoglobin averages were definitely higher than those of the British pre-war group with whom we compared them. The latter consisted of Aberdeen girls whose diet was certainly poor, as they were drawn from the poorest economic class during the depression. The factory girls were living in their homes in a town on the outskirts of London: our evidence is insufficient to explain their relatively high haemoglobin level. In Osgood's and in Mugrage's series, as in our own, girls of this age had higher haemoglobin levels than adult women.

The aetiology of the prevalent anaemia

The most important factor in the aetiology of this anaemia is, we believe, a low iron intake, but it seems unlikely that the small difference in iron intake alone accounted for the difference in haemoglobin level between nurses in London and at the base hospital. The diets at both hospitals had a low iron content, but the country diet was very poor in protein, especially animal protein, and, as mentioned above, the incidence of achlorhydria is high in women on such diets and would lead to poor iron absorption. Possibly some other dietetic factor concerned with iron utilization was also deficient, and the recent work of Widdowson & McCance (1942) has emphasized that compounds precipitating

iron and so inhibiting its absorption are also of primary importance in iron metabolism. The anaemia, however, responded to iron therapy and can therefore be classed as an iron-deficiency anaemia, though probably a conditioned one.

The slightly higher sickness rate in the country was not considered to be an aetiological factor in the production of the anaemia observed.

Among the children studied no therapeutic trials or detailed blood examinations were made. It is, however, probably safe to conclude that the anaemia in the children under 5, like the anaemia prevalent a decade ago, was a nutritional iron deficiency anaemia. Infection certainly played its part in the production of anaemia among the children and also undoubtedly resulted from the lowered resistance of the anaemic child. Moreover, any cause of poor health in young children usually diminishes acid secretion in the stomach, thus decreasing iron absorption. But, as Mackay & Goodfellow (1931) have shown, the administration of iron to young children will not only increase their mean haemoglobin level but will also halve their morbidity rate, so that iron deficiency may be considered the most important factor in the aetiology of this type of anaemia. Probably the anaemia among infants was in part due to anaemia of their mothers during pregnancy, for Strauss (1933) has shown that the infants of women who have suffered from severe and untreated hypochromic anaemia during pregnancy develop a severe grade of anaemia in the first year of life, which can be cured by giving iron to the baby. Among the school children the anaemia may well have been due to the same causes as those operating to produce anaemia among women.

It is concluded, therefore, that the anaemia now prevalent among women and children is primarily an iron deficiency anaemia, though in the case of the women and older children it is probably a conditioned iron deficiency state.

PREVENTIVE MEASURES

The prevention of nutritional anaemia should be attempted both by increasing the intake of iron-containing foods and by widespread iron administration for those who require it. The question of fortifying bread and other cereal foods with iron needs consideration, and also the substitution of soya flour for part of the cereals now imported, since soya contains iron utilizable in haemoglobin building (Mackay, 1940) as well as a high percentage of protein and fat.

Every effort should be made to instruct the public both on the special need of children and of women of child-bearing age for iron, and on the types of iron-containing foods available. Stress should be laid on the importance of the mother of each family and of children from 1 year and upwards having their full ration of meat. With the more stringent rationing forecast by the Ministry of Food, supplementing the diets of school children and pregnant or nursing mothers by communal meals or otherwise becomes increasingly important. Emphasis should be laid on the need for giving eggs, meat and other iron-containing foods to babies from 6 months of age onwards. But these dietetic measures alone do not prevent anaemia in infants and young children. The benefit to babies of regular iron administration from the second to the twelfth month or longer is established. Hence iron fortified dried milk and an iron and ammonium citrate mixture should be provided under the national milk and cod-liver-oil schemes. Particular attention should be given to preventive measures in war nurseries, where the risk of infection is so high.

The dietetic surveys at the two hospitals make it clear that the diets of all institutions should be investigated, particularly from the point of view of their animal protein content. The greater incidence of anaemia among the nurses and students at the country hospital, and the deficiencies of the diet at this hospital as compared with that of the hospital in London, suggest that it is especially important to look into the diets supplied at emergency hospitals and other institutions where emergency catering may not be adequate. The fact that factory hands and East End mothers with no canteen facilities had similar or higher mean haemoglobin values than those of the London nurses and students suggests that the diet of the general population is on the border line of adequacy for iron and for protein, or some factor associated with protein, for though these groups had higher mean haemoglobin values than the nurses and students in the country, they are all significantly more anaemic than the groups of women studied before the war.

Established cases of anaemia require treatment with suitable iron preparations, preferably ferrous salts, and as anaemia is now so prevalent such preparations should be made readily available in welfare centres, school clinics and ante-natal centres for the use of doctors dealing with large groups of women and children.

Summary and conclusion

1. Between September 1941 and January 1942 haemoglobin estimations were made by the Haldane method on 544 women and 530 children, and the values obtained compared with those for similar groups investigated before the war.

2. The women investigated were grouped as follows: (*a*) 353 nurses and students at a London teaching hospital and its base in the country, (*b*) 159 workers at a factory in a small town near London, and (*c*) 32 housewives, mothers of children attending a hospital in the East End of London.

3. The mean haemoglobin value of the 544 women was 89·5% and the range was from 56 to 120%. The mean is very similar to that obtained by Davidson *et al.* in 1937 for a group of nulliparous women from the poorest class in Aberdeen. In contrast Price-Jones's (1931) mean figure of 98·3% for 100 supposedly healthy nurses and women students, and Jenkins & Don's (1933) mean figure of 100·5% for 116 women are significantly higher than the mean of the present series. The percentage haemoglobin was below 90 in 54%, and below 80 in 10% of our cases. In Price-Jones's series no haemoglobin value was below 90%, though in Jenkins and Don's series it was below 90 in 9% and below 80 in 1% of the cases.

4. The mean haemoglobin value of all the nurses and students was 87·2%. The mean for those working in London was 90·6% and for those working in the country was 84·1%: the difference between these means is significant. The mean values of the nurses and students working at the same hospital approximated closely, as did the mean value for the auxiliary nurses to that of the professional nurses at the same hospital.

5. The mode of life and conditions of work in the two hospitals did not differ materially. A comparison of the diets of the nurses at the two hospitals showed that in London, over a period of 3 months, the average daily intake yielded 1865 calories and 63·5 g. of protein, of which 41 g. were first-class protein; whereas in the country, for the same period, the diet yielded 1662 calories daily and 46·7 g. of protein, of which 28 g. were first-class protein. It was estimated that the London group had a daily iron intake of 10·8 mg. and the country group one of 9·2 mg.

6. The mean haemoglobin values of the factory workers and the London housewives were 94·0 and 89·6% respectively.

7. A small number of nurses and students with low haemoglobin values had regular iron medication and the majority showed a satisfactory response to treatment.

8. There were in the present series 364 children aged 6 months to 5 years. They were examined at welfare centres, diphtheria immunization clinics and day- and residential-nurseries. The curve of their mean haemoglobin values at successive ages approximates to corresponding curves of 10 years ago for British children not receiving medicinal iron. In our present series the average haemoglobin level at 6–12 months was 75·4%. Between 1 and 2 years of age the level had dropped to 72·8%, and thereafter it gradually rose, reaching 81·8% between 4 and 5 years of age. The lowest levels were found in children under 2 years of age. Since iron treatment of such infants will not only raise their mean haemoglobin level, but also halve their morbidity rate (Mackay & Goodfellow, 1931), the haemoglobin level of these untreated babies must be considered pathologically low. The incidence of severe anaemia was lower in the welfare group than in the other groups and was highest among the children in the residential nurseries.

9. The mean haemoglobin level of 90 school children aged 5–13 years was 80·3% (about 10% lower than Davidson's (1935) mean for poor children in Aberdeen), of 38 school children aged 13–15 years 89·3% and of 38 adolescent girls working at the factory already mentioned 98·7%.

10. In all the groups of women and older children, with the exception of the small group of girls working in a factory, the mean haemoglobin values were significantly lower than those of previous groups with which we could compare them. We believe that this general lowering of the mean haemoglobin values of the older subjects and the low curves obtained for the younger children are the expression of a nutritional anaemia. We also believe that iron deficiency is one important aetiological factor, but that other factors have also played a part in the production of this anaemia. It is probable that among women and school children other dietetic deficiencies are implicated, and that in nurseries a high incidence of infection has increased the incidence and severity of an anaemia primarily due to an iron deficiency.

11. We believe that the bearing of this anaemia on the health of the nation is of sufficient importance to call both for official action at the present time, and for further investigation.

Our thanks are due to all those who by their co-operation made this work possible. We have by request refrained from giving the names of the clinics and institutions we visited, and we trust that all those who have had a share in this investigation will accept this acknowledgement of our indebtedness to them for their generous help.

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