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NUTRITIONAL IRON DEFICIENCY ANAEMIA IN WARTIME

PART II

THE HAEMOGLOBIN LEVELS OF 3,338 PERSONS FROM BIRTH TO 55 YEARS OF AGE

BY

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In a previous communication (Davidson *et al.*, 1942) we reported on Part I of this investigation—the haemoglobin levels of 442 infants and pre-school children (birth to 4 years) and 389 school children (5 to 12 years). We now submit data from a more extensive survey. All the haemoglobin examinations were made under standard conditions of technique and lighting by one member of the team who has had a very wide experience and whose ability to match colours is particularly good.

Since the publication of our previous paper a correction factor for the pipette, dilution tube, and colour tube of the Haldane haemoglobinometer used has been supplied by the National Physical Laboratory. This correction factor varies with the haemoglobin readings—e.g., between the ranges 53 and 87% our instrument gives readings approximately 2% low. The correction factors have been applied to all the Edinburgh figures in the present communication.

This paper is concerned solely with the incidence of iron-deficiency anaemia. Investigations into the aetiological factors concerned in its production, and therapeutic trials for its correction, will be reported in a separate communication.

Infants and Pre-school Children (from Birth to 4 Years)

An additional group of 121 infants and pre-school children has been investigated, making a total of 563. The data obtained have provided no reason for materially altering the conclusions reached in the previous paper, that the Edinburgh series (1942) shows an improvement over the Aberdeen series (1935) (Davidson and Campbell, 1935; Davidson and Fullerton, 1938).

School Children (5 to 12 Years)

The number of school children investigated has now been raised from 389 originally reported to 1,022. Of these children 917 were examined at Edinburgh Education Authority primary schools, and came mainly from working-class families, while 105 were attending private schools and came from a much higher social and economic stratum of the population. The increase in the number investigated and the result of applying the correction factor necessitate a reconsideration of this group. Table I gives the average haemoglobin levels according to age and social status in Edinburgh school children, and Table II

TABLE I.—The Haemoglobin Averages of School Children according to Age and Social Status

		Age (Years)							
		5	6	7	8	9	10	11	12
Edinburgh: Municipal primary-school children	917	81.3% (61)	81.7% (118)	83.1% (118)	81.0% (139)	83.9% (143)	83.4% (155)	82.8% (116)	84.3% (67)
Edinburgh: Private-school children	105	—	85.0% (8)	86.0% (10)	90.5% (4)	90.4% (18)	93.7% (17)	93.5% (22)	94.0% (26)

TABLE II.—Comparison of Anaemia in 3 Groups of School Children (5 to 12 Years)

		Percentage of Children in Different Haemoglobin Ranges			
Hb:		< 71%	71-80%	81-90%	> 90%
Edinburgh, 1942: Municipal primary schools	917	3.8	35.5	45.0	15.7
		39.3		60.7	
Edinburgh, 1943: Private schools	105	—	4.7	38.1	57.2
		4.7		95.3	
London: (Mackay <i>et al.</i> , 1942)	128	42.0		58.0	
Aberdeen (Davidson and Campbell, 1935)	67	0		100.0	

a comparison of the haemoglobin ranges of school children in Edinburgh (1942), London (1942) (Mackay *et al.*, 1942), and Aberdeen (1935) (Davidson and Campbell, 1935; Davidson and Fullerton, 1938).

Our previous acceptance of a haemoglobin level of 95±5 as the normal standard for the age group 5 to 12 years is supported by our finding that the average haemoglobin percentage of 105 children attending private schools was 91.7, and that 57% of these children had haemoglobin figures of 90 to 110%. The term "clinical anaemia" has been arbitrarily employed by us to connote a haemoglobin level of 80% or less in school children. On this basis 39% of municipal primary-school children and less than 5% of private-school children were anaemic. The conclusion reached in the previous paper that the haemoglobin level in children of working-class families of the age period 5 to 12 years is decidedly lower in Edinburgh (1942) than in Aberdeen (1935) still holds good. The average difference of 10% haemoglobin as reported in our previous article is now, however, reduced to 8% when the correction factor for the haemoglobinometer is applied.

It will be noted in Tables I and II that a marked difference in the haemoglobin levels and ranges is found when the 917 children drawn mainly from working-class families are compared with the 105 children from the well-to-do classes. Accordingly the conclusion in our previous paper that economic status was no longer the principal factor influencing the nutrition of the individual must be reconsidered.

We have now repeated the haemoglobin estimations of children at two municipal primary schools examined in 1942, and it is of interest to note that the haemoglobin levels have improved during the past 12 months. Further investigations into this finding are being undertaken.

Haemoglobin Ranges of Adolescent and Adult Males and Females of Various Occupations

Table III shows the haemoglobin ranges of 1,753 individuals grouped according to occupation. The table is arranged in this way rather than according to age groups because of the wide variation in haemoglobin ranges found in persons of the same age group working and living under different conditions.

The schoolboys and schoolgirls (13 to 18 years) were attending private schools used by people of the well-to-do classes. The male and female students, the nurses, and the maids were all working in a large voluntary teaching hospital. The female factory-workers were employed in three different establishments. The 62 individuals in factory A were employed in a foundry, necessitating very heavy physical work. We

the factory medical officer as regards the particular need for iron, and the groups whose haemoglobin values are displayed in Table III represent an unselected cross-section of these employees.

Factory C consisted of a laundry in which 48 women were employed. Of the 123 male factory-workers working in factory B 85 had received no iron and 38 had had the supple-

TABLE III.—Haemoglobin Ranges according to Occupation

	No.	< 60%	61-70%	71-80%	81-85%	86-90%	91-100%	101-110%	> 110%	Av. Hb %
Schoolboys (13-18 years)	159	—	—	—	0.6% (1)	4.4% (7)	52.2% (83)	41.5% (66)	1.3% (2)	99.5%
Schoolgirls (13-18 years)	121	—	—	6.6% (8)	10.7% (13)	17.4% (21)	51.2% (62)	14.1% (17)	—	93.2%
Female students	100	—	—	1.0% (1)	11.0% (11)	17.0% (17)	53.0% (53)	18.0% (18)	—	93.8%
Nurses	100	—	—	1.0% (1)	18.0% (18)	15.0% (15)	57.0% (57)	9.0% (9)	—	92.3%
Maids	59	1.7% (1)	1.7% (1)	10.1% (6)	11.9% (7)	16.9% (10)	50.9% (30)	6.8% (4)	—	90.3%
Female factory-workers (A), nulliparous	62	—	1.6% (1)	3.2% (2)	14.5% (9)	11.3% (7)	53.2% (33)	16.2% (10)	—	93.1%
Female factory-workers (B) (no iron), nulliparous	65	—	7.7% (5)	13.8% (9)	13.8% (9)	29.3% (19)	32.3% (21)	3.1% (2)	—	87.3%
Female factory-workers (B) (on iron), nulliparous	201	—	5.4% (11)	10.0% (20)	11.9% (24)	22.4% (45)	46.8% (94)	3.5% (7)	—	89.3%
Female factory-workers (C), nulliparous	48	—	—	6.2% (3)	2.1% (1)	39.6% (19)	41.7% (20)	10.4% (5)	—	91.8%
Multiparous women	45	—	6.7% (3)	8.9% (4)	6.7% (3)	20.0% (9)	51.0% (23)	6.7% (3)	—	90.9%
Pregnant women	570	6.3% (36)	17.7% (101)	48.3% (275)	16.5% (94)	7.0% (40)	4.2% (24)	—	—	75.8%
Male students	100	—	—	—	—	—	13.0% (13)	71.0% (71)	16.0% (16)	105.7%
Male factory-workers (B)	123	—	—	0.8% (1)	0.8% (1)	5.7% (7)	39.0% (48)	49.6% (61)	4.1% (5)	100.5%

were informed that the incidence of anaemia in this group was high, but, as will be seen from Table III, less than 5% were suffering from clinical anaemia (below 80% haemoglobin). The pallor of their faces, which was so noticeable, was apparently due to fatigue and not to anaemia. It should be noted that the majority of these workers had been employed in the foundry for only a few weeks before examination, and this might account for the wide difference in the incidence of anaemia in factories A and B.

ment of iron. As no significant difference in the haemoglobin levels in these two groups of males was found it was not considered necessary to give the groups separately in the table. No beneficial effects would be expected from the iron supplement, since clinical anaemia was present to an insignificant degree. The haemoglobin levels of 45 multiparous women examined at factories A and B and at welfare centres are shown separately in Table III. The 570 pregnant women were examined at four separate ante-natal clinics in Edinburgh

in order to get a cross-section of the population. Their haemoglobin levels according to age are shown in Graph I, and according to month of pregnancy in Graph II.

Incidence of Clinical Anaemia

In a leading article in the *British Medical Journal* (1943, 1, 449) doubt was expressed as to whether Price-Jones's (1931) figures of 98% for a female and 105% for a male should be accepted as normal standards of haemoglobin for the population as a whole. The figures which we have accepted as average normal, but not necessarily optimal, standards are for females 95% $\pm$ 5, and for males 100% $\pm$ 5. We believe that the evidence afforded by this paper supports the contention that such standards can be maintained even under wartime conditions, since 50 to 70% of the females in the different groups examined have figures of 90% and higher, and the average haemoglobin of 382 males was slightly over 100%. If haemoglobin levels of this magnitude are found after nearly four years of war with its concomitant dietary restrictions and difficult working conditions, then there is reason

to believe that average haemoglobin levels even higher than those proposed by Price-Jones might obtain in days of peace. In the same leading article it was also suggested that the term "anaemia in females" should be restricted to haemoglobin levels below 80%—a figure 15% below the standard accepted by us for normal women. We accept this definition as a basis for discussion although we realize that the level chosen is purely

GRAPH I.—Average haemoglobin levels from birth to 54 years in Edinburgh (1942-3) and Aberdeen (1935).

After arrangements had been completed for examining the haemoglobin levels of workers in factory B it was discovered that the factory medical officer had offered 10 gr. of Blaud's pill daily to any worker who wished it. It was found that about 75% of the employees had been taking the iron supplement for at least three months before the haemoglobin levels were estimated. No selection of employees had been made by

arbitrary. We would suggest on the same basis that a figure of 85% haemoglobin or less be accepted as the level of "clinical anaemia" in males. The haemoglobin levels lying between these figures and the normal standards suggested above would then be considered as subnormal. Although we are not aware of any evidence that such subnormal haemoglobin levels have any proved adverse influence on the well-being of men and women, we consider on general principles that it is unwise to be satisfied with figures below the accepted standards of normality.

GRAPH II.—Haemoglobin levels of pregnant women according to month of pregnancy.

With regard to what should be accepted as normal haemoglobin levels for pregnant women marked difference of opinion exists because of the influence of the varying physiological dilution of the blood which occurs with advancing pregnancy. According to Dieckmann and Wegner (1934), a 5%, 10%, and 15% dilution of the blood takes place during the first, second, and third trimesters of pregnancy respectively. If a group of pregnant women in which approximately equal numbers are in the different trimesters be examined, then a deduction of 10% of the haemoglobin level should be made. On this basis "clinical anaemia" due to pregnancy may be said to exist when the haemoglobin level falls below 70%—i.e., 10% below the level of "clinical anaemia" in non-pregnant women.

Applying the above standards to the figures given in Table III, the incidence of "clinical anaemia" is found to be insignificant in female students and nurses, and varies from 6.6% in schoolgirls (13 to 18 years) to 21% in female factory-workers. The incidence of anaemia in 360 adolescent females (13 to 19 years) and 450 adult females (20 to 54 years) was 12% and 7% respectively. Approximately 60% of the total had a haemoglobin value greater than 90%. The incidence of "clinical anaemia" in 212 adolescent males and 170 adult males was less than 1%, and of these 95% had a haemoglobin level exceeding 90%. The incidence of "clinical anaemia" in 570 pregnant women was 24%.

Although it will be seen that a considerable degree of "clinical anaemia," as defined above, was present in school children and in certain groups of females, both pregnant and non-pregnant, it should be noted that the great majority of such persons made no complaint of ill-health and were apparently carrying out their work in the school, factory, or home in a satisfactory manner.

Comparison of Incidence of Anaemia in Edinburgh (1942) and Aberdeen (1935)

In assessing the effects of war conditions on the incidence of anaemia in the population at large it would be of great advantage to compare the findings of the Edinburgh survey (1942) with similar pre-war investigations. For accuracy in such comparisons it would be necessary to use a standard technique and to have the pipette and graduation and colour tubes calibrated and checked according to some accepted

standard, as was done in the present survey. It is most desirable that this principle should be generally accepted from now onwards. An attempt was made to obtain the instrument used in Aberdeen in 1935 in order to have it checked by the National Physical Laboratory, but unfortunately only the Haldane colour tube was available for testing. The correction figure supplied by the National Physical Laboratory shows that it gave readings approximately 2% too high. It is impossible to say whether this error can be accounted for by a slight fading of the colour tube during the past eight years or whether it was present in 1935. Since the pipette and dilution tube are not available for checking, it is impossible to assess the accuracy of the figures obtained in 1935. An extensive experience with the instrument concerned showed that haemoglobin figures of $100\% \pm 5$ and $95\% \pm 5$ for average normal males and females respectively were regularly obtained, together with a colour index of unity. Accordingly we believe that the instrument was in fact reasonably accurate. Hence we feel justified in making the following comparisons, provided the limitations discussed above are kept in mind. The Aberdeen figures shown on Graph I are the original uncorrected ones.

(a) The haemoglobin levels of infants and pre-school children in Edinburgh (1942) are slightly higher than those found in a similar age group in Aberdeen (1935).

(b) The incidence of "clinical anaemia" in municipal primary-school children in Edinburgh (1942) is considerably higher than in Aberdeen (1935).

(c) The incidence of "clinical anaemia" in adolescent and adult males in Edinburgh (1942) and Aberdeen (1935) is insignificant, but the haemoglobin levels are somewhat higher in the Edinburgh series.

(d) No significant change was observed in the haemoglobin levels of adolescent and adult females examined in Edinburgh (1942) and in Aberdeen (1935). Thus a haemoglobin level of less than 85% was found in 23% of 306 adolescent females and 18% of 450 adult nulliparae in Edinburgh, as compared with 18% of 450 adolescent females and 25% of 50 adult nulliparae in Aberdeen.

(e) The haemoglobin levels of pregnant women examined in Edinburgh (1942) are slightly lower than those of a similar group examined in Aberdeen (1935).

Summary

The haemoglobin levels of 3,338 individuals examined in Edinburgh in 1942-3 are reported. These comprise: 563 infants and pre-school children (birth to 4 years); 917 municipal primary-school children (5 to 12 years); 105 private-school children (5 to 12 years); 518 adolescent males and females (13 to 19 years); 620 adult males and females (20 to 54 years); 45 multiparous women; 570 pregnant women.

The pipette, dilution tube, and colour tube of the Haldane haemoglobinometer used in this investigation were examined by the National Physical Laboratory and a combined correction factor was supplied. This factor has been applied to all the haemoglobin figures of the Edinburgh series shown in the tables and graphs of the present communication.

Standards of normality of haemoglobin levels for individuals according to age and sex are discussed and defined, and arbitrary figures below which clinical anaemia may be said to be present have been selected.

"Clinical anaemia" was found to be present in 39% of municipal primary-school children; approximately 5% of private-school children; 12% of adolescent females; 7% of adult females; 24% of pregnant women; and less than 1% of adolescent and adult males.

We wish to express thanks to our medical colleagues, to the Medical Officer of Health for Edinburgh and his staff, and to the head masters and staffs of schools for the facilities and help afforded during this investigation.

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