A survey in general practice of the first year of life

with particular reference to haemoglobin levels and their relationship to types of feeding and morbidity

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Fyvie

THE mean haemoglobin level of the blood from the umbilical cord at birth is in the region of 114 per cent. Examination of the infant venous blood several hours later shows a slightly higher mean of 129 per cent haemoglobin. This is probably caused by a diminution in plasma volume. Mackay's figures by heel prick suggest a haemoglobin at birth of around 140 per cent.

A rapid fall in the haemoglobin level occurs in the first few weeks of life, to a level at 2–3 months of 75–80 per cent. This fall is greater in premature infants and infants of low birth weight, and leads to anaemia of prematurity at two months. The fall is considered to be due partly to increased red cell destruction, but more importantly to diminished erythropoiesis associated with the transference of responsibility for red blood cell production from the foetal centres, viz. liver, spleen, thymus, kidney, etc. to the bone marrow. It is associated with an increased blood volume, and is neither prevented nor reversed by the administration of iron (Hutchison). After three months, there is a gradual rise in haemoglobin to around a mean of 85 per cent. Subsequent readings up to one year show a haemoglobin level in the 85–90 per cent range. This latter figure will be dependent on adequate iron intake.

Mackay in a survey of some 1,500 London children in 1933 demonstrated a difference in haemoglobin levels between infants who had received iron supplements and those who had not. She focussed attention on the prevalence of iron deficiency anaemia in the first year of life, and demonstrated the inadequacy of both breast and artificial feeding in preventing nutritional anaemia. Strauss in 1933 showed that infants born of mothers suffering from iron deficiency anaemia had normal haemoglobin values at birth but failed to maintain them. Guest and Brown, in 1936, confirmed that the incidence of iron deficiency in the first year was greater than had been recognized. Horan, in 1937–39, studied 249 Birmingham children, mostly from artisan families, and suggested a range of normal haemoglobin levels at various ages from which the need for prophylactic iron during the first year of life could be estimated. She was able to demonstrate that at one year the difference between haemoglobin levels of artificially fed infants, and of those artificially fed but with iron supplement, was statistically significant. In 1957, Lahey considered iron deficiency anaemia to be present from two months if the haemoglobin level fell below 72 per cent, and Sturgeon (1959) in his series suggested that haemoglobin concentration studies offered the most sensitive criterion for the existence of iron deficiency anaemia in a group of normal infants. Beal and her co-workers in Colorado (1961) suggested that 0.5mg/Kg/day was an adequate iron intake for normal infants to prevent iron deficiency anaemia; she also commented on the fact that lower doses appeared to increase iron utilization. Studying a group of Norwegian children, Moe (1963) suggested that infants receiving less than 10 mg per day will develop iron deficiency anaemia after eight months. Moe also suggested that rather than mean haemoglobin concentrations, a better method of estimating the presence of

*The participating doctors were: Dr C. I. Cruickshank, Dr Lewis Mackie, Dr J. A. M. Stewart, Dr G. M. Gill, Dr K. T. Gruer, Dr A. G. Laing, Dr A. J. Taylor.

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iron deficiency anaemia in any study was to examine the distribution of haemoglobin at different age levels.

Scope of study

It was, therefore, felt that a study of haemoglobin levels in a general-practice population of infants would be of interest. Eight single-handed practitioners and one member of a partnership of three agreed to participate.* The geographical area involved was situated in central Aberdeenshire and, apart from the presence of village communities, was essentially rural. The population was native and virtually static. The area provided a good field for investigation, in that the population is generally healthy. There is no overcrowding, and social amenities are of a good quality. Unemployment is relatively low. None of the practices has a full list, and the services provided by the hospitals and the local authority in the area are of a high standard.

All children born into each of the single-handed practices in the course of the calendar year 1965 were considered eligible for inclusion in the survey. In the case of the partnership, every child whose mother attended the participating partner in the antenatal period was considered eligible for inclusion. Each child was studied for a twelve-month period. Children whose parents moved within the survey area were retained, but those who left the district have been excluded.

The total number of infants considered eligible for study was made up of 84 males and 61 females. Six males and two females were subsequently rejected for the following reasons:

1—multiple congenital abnormalities, mongolism and congenital heart disease;
1—exchange transfusion and Rh. incompatibility;
5—low birth weight or prematurity;
1—incomplete records.

Readings recorded after the start of iron therapy have been excluded.

Recordings were made on a card which was designed to hold information about the parents, the antenatal period and the puerperium, and details of the haemoglobin levels and method and type of feeding. Immunization procedures and the prescription of iron therapy were also noted. The reverse side of the card was designed to record morbidity by placing an appropriate code number in a column opposite the age in months. The degree of severity of illness was left to the individual doctor to decide and was graded 'A', 'B', or 'C'. Place of consultation was noted. A pilot study was run for three months, to obtain experience in the use of the card and as much uniformity of observation as possible.†

Method

In such a survey, which involves recordings being made by several observers, the need for strict standardization of technique is obvious. Every effort was made to achieve this aim. An EEL photo-electric colorimeter was used by each participating practice and each machine was repeatedly checked against one single known standard. Matched sets of optically-standardized test tubes were used, and again each set was tested in the machine in which it was to be used against a known standard. Upon completion of a reading, each test tube was washed and rinsed with distilled water, according to a set pattern. The method of reading the machine was also standardized. Throughout the period of the survey, each machine was tested at regular intervals against a known standard. The haemoglobin was measured by the cyanmethaemoglobin technique.

A standardized Aculute solution was prepared at monthly intervals and made available from a central stock held in one of the hospitals in the district. The technique

*During the period of study, two of the single-handed practitioners felt unable to continue, one due to ill health and one due to pressure of work.

†Copies of this card are available on request.

of heel stab was used to obtain capillary blood. Prior to carrying out the heel stab, the skin was thoroughly cleansed with ether and allowed to dry. A sterile Medipoint disposable lancet was employed. No pressure or squeezing was applied to the heel. Using a standard 0.02 ml pipette, blood was drawn up and added to 4 ml Aculute solution, contained in a capped disposable plastic tube. The mixture was allowed to stand for a minimum of ten minutes before readings were taken against a standard of the same solution. Use of the plastic containers allowed specimens to be collected during domiciliary visits and subsequently tested when convenient. The results were scaled so that 14.6 G haemoglobin was taken as 100 per cent.

Five haemoglobin readings were sought for each child during the year of study, at 2 weeks, 3 months, 6 months, 9 months and 1 year. For various reasons, it was not possible in every case to obtain all five readings, and this accounts for the fact that on the tables following there may be a discrepancy between the numbers of children in each group being studied and the actual number of readings recorded.

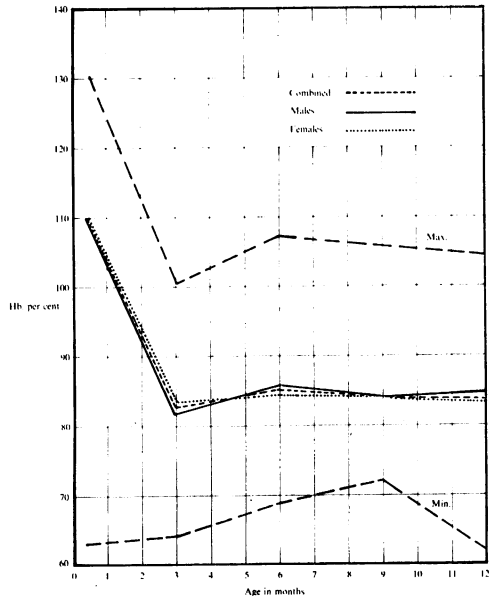

Figure 1
Mean haemoglobin levels. Total survey

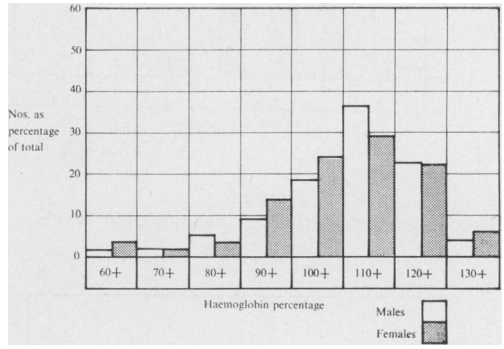

Figure 2
Percentage distribution of haemoglobin levels. Two weeks

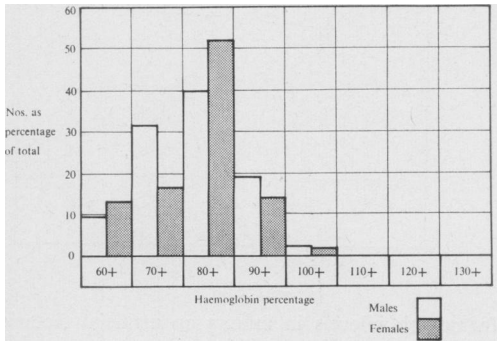

Figure 3
Percentage distribution of haemoglobin levels. Three months.

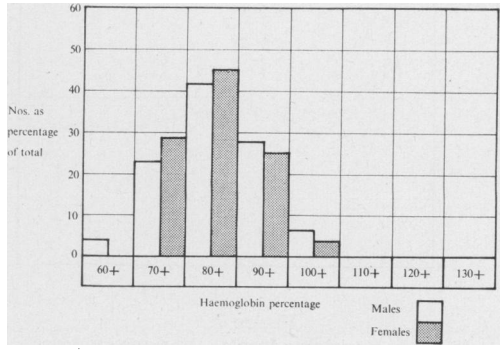

Figure 4
Percentage distribution of haemoglobin levels. Six months.

It is perhaps at this juncture worth while pointing out how well the large majority of mothers co-operated in this study when the object of it was explained. Initial concern by the participating doctors as to the attitude of the mothers when the implications had been put to them, proved quite unjustified. Indeed, it was not unknown for a mother to remind us that a blood test was due.

Findings

Figure 1 outlines the levels recorded in our survey for both males and females, and the combined means. No significant differences are noted between males and females. The fall in haemoglobin between two weeks and three months is demonstrated.

Figures 2, 3, 4, 5, and 6 show the distribution of haemoglobin levels in the two sexes at various age points.

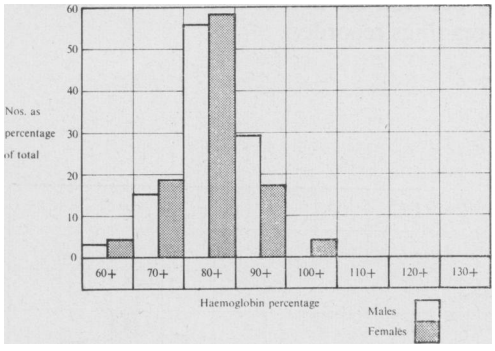

Figure 5
Percentage distribution of haemoglobin levels. Nine months.

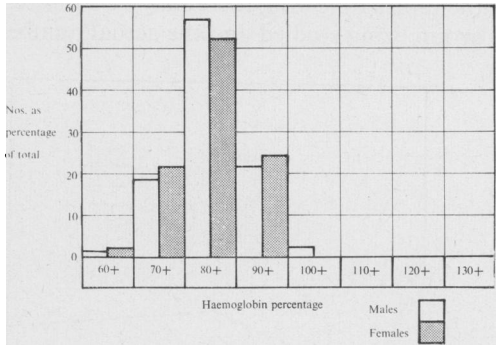

Figure 6
Percentage distribution of haemoglobin levels. One year.

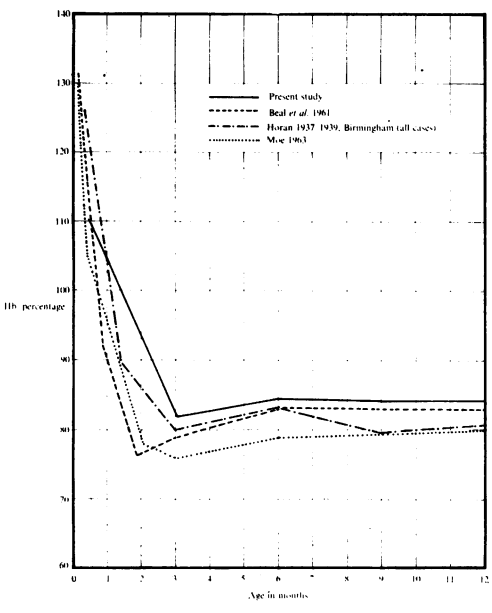

Figure 7
Mean haemoglobin levels. Various studies.

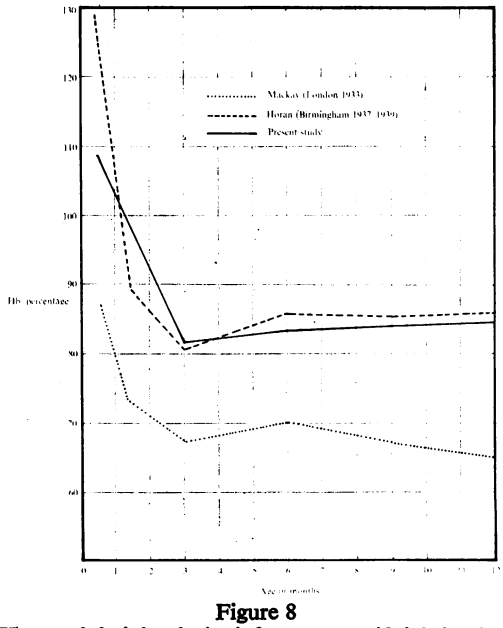

Figure 8
Haemoglob inlevels in infants on artificial feeding. Comparable studies

Between the age of two weeks and one year the haemoglobin levels tend downwards, a finding that agrees with previous survey results. It is worth emphasizing that at one

year of age 21 per cent of males and 24 per cent of females have haemoglobins below 80 per cent.

Comparison of results of this study and others of a similar type is given in figure 7; the overall pattern is clearly similar, although the actual levels for the present study are somewhat higher than the others. Several factors may be involved in bringing this about; for example, it might be that living standards and social conditions are generally better in the population studied compared to others reported, but in the absence of exact information on observer error, this explanation must remain a hypothesis.

Feeding methods have been recorded and the result of the present study compared with previous investigations. Figure 8 compares findings from two early investigations and our own in respect of artificially fed infants whose feeds did not contain iron supplements. One point of interest is the marked difference between the 1933 study of McKay and the two later but widely separated studies. Whether this reflects a real difference in haemoglobin levels, or is due to differences in methods of measurements, is unfortunately not possible to say.

As no feeding regime was laid down for the infants under investigation, it has not been possible to obtain comparative figures for feeding throughout the whole year under review. It was, however, possible to consider the types of feeding for the first six weeks of life; three distinct groups were studied, viz.:

(1) breast fed;
(2) artificially fed with National Dried Milk; and
(3) artificially fed with a proprietary iron-supplemented milk.

Accurate values are difficult to obtain but breast milk contains approximately 1.1 mg of iron per pint, National Dried Milk may contain up to 0.1 mg/pint and the proprietary preparation contained 6.8 mg/pint. Children of each group were followed up for the complete year and the haemoglobin values compared. Notably higher figures from the age of three months were found for the infants who had been fed for the first six weeks on the iron-supplemented preparation. These findings are shown graphically in figure 9.

From table I it can be seen that in the group of infants on iron-fortified milk to six weeks of age, 80 per cent or more showed haemoglobin readings of 80 per cent or more at six months, nine months and at one year.

Analysis of the haemoglobin levels when the infants were classified according to birth-weight is shown in table II. The haemoglobin at two weeks shows a rise from the lower birth-weight groups to the higher ones. There is, however, a levelling out in the subsequent months, and at the end of the first year little difference is noted.

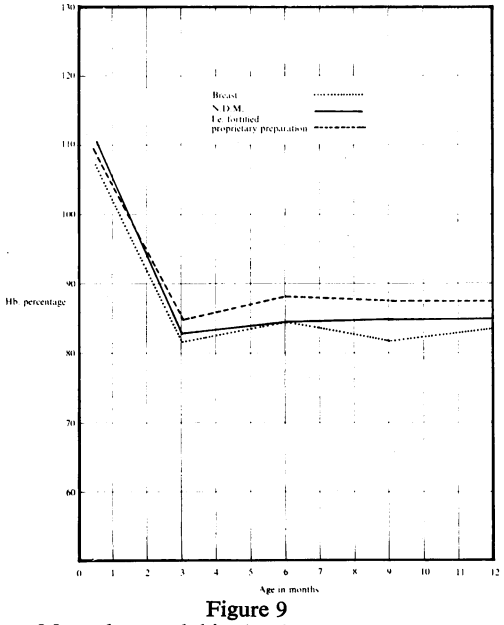

Figure 9
Mean haemoglobin levels/type of feeding for first six weeks.

The occupations of the fathers were accurately recorded, and it was thus possible to classify each infant according to social class, using the Registrar General's criteria. The distribution of the classes in the population studied compares closely with the Registrar General's figures.

TABLE I

PERCENTAGE OF INFANTS WITH HAEMOGLOBIN OF 80 PER CENT (11.7G.) OR OVER ACCORDING TO TYPE OF FEEDING FOR FIRST SIX WEEKS

Age	*National dried milk* (*67*)	*Breast* (*20*)	*Fe. fortified proprietary* (*23*)
6 months	*67.2* (41 out of 61 readings)	*68.4* (13 out of 19 readings)	*82.6* (19 out of 23 readings)
9 months	*80.0* (48 out of 60 readings)	*73.7* (14 out of 19 readings)	*91.3* (21 out of 23 readings)
1 year	*78.3* (47 out of 60 readings)	*73.7* (14 out of 19 readings)	*82.6* (19 out of 23 readings)

TABLE II

MEAN HAEMOGLOBIN LEVELS ACCORDING TO BIRTH WEIGHT — MALES AND FEMALES

Age	*Birth weight in pounds:*				
	5.5 – 6.5 (*15*)	*6.5 – 7.5* (*55*)	*7.5 – 8.5* (*43*)	*8.5 – 9.5* (*21*)	*9.5 +* (*3*)
2 weeks ..	*102.3*	*108.1*	*112.0*	*114.7*	*114.7*
3 months ..	*84.3*	*80.6*	*84.1*	*81.5*	*80.3*
6 months ..	*84.8*	*83.9*	*85.6*	*87.5*	*86.0*
9 months ..	*85.4*	*83.1*	*85.8*	*86.1*	*86.7*
1 year ..	*84.4*	*83.5*	*85.4*	*84.9*	*89.5*

Grouping classes 1 and II, III, IV and V, the mean haemoglobin readings were compared and no significant variation was found (table III).

It was noted that of the 24 children who received iron-fortified milk for the first six weeks of life, 33 per cent (8) were from parents in social classes I and II, 29 per cent (7) were from social class III, and 38 per cent (9) were from social classes IV and V.

Haemoglobin levels and morbidity

The relationship between haemoglobin level and health was examined by comparing first consultation rates at various periods of infant development. Consultations due to congenital abnormalities and injuries were not included in the morbidity count.

Inception (first consultation) rates were worked out for three-month periods and related to grouped haemoglobin levels at the beginning of the period. Because of small numbers, the

TABLE III

MEAN HAEMOGLOBIN LEVELS ARRANGED ACCORDING TO REGISTRAR GENERAL'S SOCIAL CLASSES

Age	*Social class*			
	I & II (*31*)	*III* (*60*)	*IV & V* (*41*)	*Armed forces* (*5*)
2 weeks ..	*109.5*	*111.8*	*108.8*	–
3 months ..	*88.3*	*81.7*	*82.1*	–
6 months ..	*84.6*	*85.8*	*84.4*	–
9 months ..	*84.0*	*85.2*	*84.4*	–
1 year ..	*84.9*	*85.0*	*83.0*	–

(Figures for Armed Forces not given, on account of insufficient continuity)

Percentage distribution of social classes:

		Survey	*Scotland*	
Class	I	*22.7*	*3*	*21.7*
	II		*18.7*	
	III	*43.8*	*40*	
	IV	*29.9*	*26.8*	*34.2*
	V		*7.4*	
Armed forces		*3.6*		

Registrar General's social classes were re-grouped into upper (I, II and 'white collar' III) lower (manual III, IV and V). The findings are shown in tables IV–VII.

TABLE IV

HAEMOGLOBIN LEVELS AT AGE TWO WEEKS, AND MORBIDITY IN THE FIRST THREE MONTHS OF LIFE, BY SOCIAL CLASS

Haemoglobin	*Social class*	*No. of incid-ents of illness*	*No. of infants at risk*	*First consult-ation rate per cent*
84 per cent or less	Upper	1	1	*100*
	Lower	2	4	*50*
85 per cent or more	Upper	36	41	*88*
	Lower	83	80	*104*
Totals		122	126	*97*

11 infants were excluded: 1–on iron therapy
3–no Hb. reading
2–Hb. reading false
5–left district

TABLE V

HAEMOGLOBIN LEVELS AT AGE THREE MONTHS, AND MORBIDIY AT 3–6 MONTHS OF AGE, BY SOCIAL CLASS

Haemoglobin	*Social class*	*No. of incid-ents of illness*	*No. of infants at risk*	*First consult-ation rate per cent*
84 per cent or less	Upper	16	24	*67*
	Lower	37	47	*79*
85 per cent or more	Upper	10	20	*50*
	Lower	24	34	*71*
Totals		87	125	*70*

12 infants were excluded: 3–on iron therapy
9–left district

TABLE VI

HAEMOGLOBIN LEVELS AT AGE SIX MONTHS, AND MORBIDITY AT 6–9 MONTHS OF AGE, BY SOCIAL CLASS

Haemoglobin	*Social class*	*No. of incid-ents of illness*	*No. of infants at risk*	*First consult-ation rate per cent*
84 per cent or less	Upper	14	24	*58*
	Lower	31	37	*84*
85 per cent or more	Upper	10	20	*50*
	Lower	40	42	*95*
Totals ..		95	123	*77*

A further two infants left the district and were excluded.

TABLE VII

HAEMOGLOBIN LEVELS AT AGE NINE MONTHS, AND MORBIDITY AT 9–12 MONTHS OF AGE, BY SOCIAL CLASS

Haemoglobin	*Social class*	*No. of incid-ents of illness*	*No. of infants at risk*	*First consult-ation rate per cent*
84 per cent or less	Upper	9	24	*38*
	Lower	19	32	*59*
85 per cent or more	Upper	12	20	*60*
	Lower	26	45	*58*
Totals ..		66	121	*55*

A further two infants left the district and were excluded.

Within social class groups there is no consistent difference between morbidity rates and haemoglobin levels, but when haemoglobin levels are kept constant the consultation rates of lower class infants tend to be higher than in the upper social class; these findings suggest that a social class factor, possibly the quality of maternal care as reflected for example in infant nutrition, rather than the biological factor of haemoglobin level, may be responsible. Though most of the morbidity recorded was, as expected, upper respiratory infection, numbers were too small to allow analysis of specific illnesses. Our findings are broadly in line with the results of such large-scale studies as those by

Spence, Walton, Miller and Court (1954) and by Douglas and Blomfield (1958), but further work is required before the precise nature of this association can be specified.

Discussion

The feasibility of such a study in a general-practice population of infants has been demonstrated. Difficulties were encountered in the actual organization of the project, mainly because the participating doctors were committed in their respective practices and the opportunities for all to be present at one time were few. This demanded use of the telephone, which can never be a satisfactory substitute for group discussion. Consequently, the time spent in planning was longer than it might otherwise have been. As the study extended over a two-year period, it had to be continued regardless of the work-load of each practitioner in the running of his practice at the same time. This, at times, constituted a threat to the continuation of the study, as the enthusiasm for a satisfactory outcome tended to wane during epidemics. The possibility of increased observer error at such times must also be borne in mind in planning such a project.

As mentioned earlier, parental co-operation was excellent, and in this respect the help of the district nurses in the area proved to be an invaluable asset.

Conclusions

The figures recorded for the mean haemoglobin levels for the various age groups have shown agreement with those of earlier workers, and provide a guide to the levels to be expected in a healthy infant population in a relatively prosperous rural area in Scotland.

With regard to feeding, the figures of the present study show a rather interesting feature in that the group of children, who for the first six weeks of life were fed on an iron-fortified milk, continued to show higher mean haemoglobin levels throughout the first year. The finding, however, that of these infants the highest proportion, when grouped according to social classes, was found in social classes IV and V, suggests that factors other than intelligence or affluence of parents may be involved. Only a more carefully controlled study could shed more light on this subject.

Apart from influencing the level of haemoglobin at two weeks of age, the birth-weight of the infants studied did not appear to affect the subsequent haemoglobin levels. Likewise, the social class of the parents did not appear to influence the haemoglobin levels found, and there was no evidence from the present study that the lower social classes tend to have lower haemoglobin levels. There was, however, the expected relationship between social class and morbidity in the first year of life, but no apparent direct association between morbidity and haemoglobin level.

Summary

A general practice study of the first year of life has been described, with particular reference to changing haemoglobin levels.

Comparison has been made between breast, artificial feeding with National Dried Milk, and artificial feeding with an iron-supplemented proprietary milk, and the results discussed.

Consideration has also been given to the influence of birth weight and social class on the various haemoglobin levels.

A study of morbidity and haemoglobin levels revealed no direct relationship between these variables.

Acknowledgements

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social medicine, Aberdeen University, and the general practitioners who took part in the survey; also the invaluable secretarial help given by Mrs S. C. Pyper.

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Dr Walter Radcliffe has sent the following tariff of a Nigerian Snake doctor which was sent to him by his daughter who practises as a physiotherapist in Lagos:

Try and see wonderful snake (chairman of Nigeria).

Snake medicine

Snake medicine	£2	5/–	1/–
Scorpion medicine		3/–	
Market medicine	£3 &	7/–	
Learning medicine		14/–	
Medicine for Prevention of direct evil		14/–	
„ for Prevention of direct poison		10/–	
„ to drive craft		14/–	
„ for Gorrnorea	£2	10/–	
„ for net ball		10/–	
„ for ring worm		10/–	
„ for Motor Accident		10/–	
„ for Promotion		13/–	
„ for General Love	£2		
„ for Examination	£3	14/–	
„ for General disease		20/–	
„ for Prevention of bad dream		6/–	
„ to display ball		5/–	
Pile		5/–	
To go in contact with woman and no disease		10/–	
Pillow prevention		14/–	
Medicine for Office love	£3		
Medicine for within		4/–	
to prevent bad Juju	£2		
Girl follow me	25/–	14/–	10/-
Medicine for fever	£4		
Medicine for Woman conception	£2		
Medicine to drive poverty	£2		
Medicine to catch thieves	300/–	140/–	
Medicine for tured penies	20/–	5/–	
Medicine for cough		5/–	
Medicine for backache		5/–	

Visiting houses, Morning 7 am–9 am
Evening 7 pm–9 pm