Prevalence and type of anaemia in female cotton mill workers in Beijing, China

BY RUOWEI LI[1], XUE-CUN CHEN[1], HUAI-CHENG YAN[1], PAUL DEURENBERG[2], LARS GARBY[3] AND JOSEPH G. A. J. HAUTVAST[2]

[1] *Institute of Nutrition and Food Hygiene, Chinese Academy of Preventive Medicine, Beijing, People's Republic of China*

[2] *Department of Human Nutrition, Wageningen Agricultural University, The Netherlands*

[3] *Department of Physiology, Odense University, Denmark*

(*Received 1 October 1992 – Accepted 9 January 1993*)

The present study investigates the prevalence and type of anaemia in Chinese female cotton mill workers. The prevalence of anaemia is reported in 447 non-pregnant female workers aged between 19 and 45 years. The mean value for haemoglobin (Hb) was 123 (SD 15) g/l and 150 of the total 447 subjects had Hb values below 120 g/l; thus 34% of the population was anaemic according to World Health Organization (WHO, 1975) criteria. The mean value for free erythrocyte protoporphyrin (FEP) was 419 (SD 215) μg/l; 55% of the total population had FEP values higher than 350 μg/l and 72% among the anaemic subjects. Serum ferritin (SF) was tested in all the women with a Hb value less than 120 g/l and 71% of them had SF values below 12·0 μg/l. Eighty women diagnosed as either Fe deficient or with Fe-deficient anaemia were selected for a diagnostic supplementation trial. They were randomly assigned to $FeSO_4$ (60 or 120 mg Fe/d) or placebo treatment for 12 weeks. Fe supplementation increased mean Hb values from 114 to 127 g/l ($P < 0·001$) and SF levels from 9·7 to 30·0 μg/l ($P < 0·001$), and decreased mean FEP values from 570 to 277 μg/l ($P < 0·001$). The response rate of Hb in the whole Fe-treated group or Fe-treated subjects with an Hb level less than 120 g/l was 90% or 92% respectively. These findings indicate that the type of anaemia in this population was mainly Fe deficiency. It was also found that in this population the severity of anaemia, not the prevalence, was significantly related to the use of intra-uterine devices (IUD).

Anaemia: Iron: Chinese female workers

China has the largest female work force in the world. Women, who constitute about 40% of the total labour force, have played a considerable role in developing the country and their fields of employment have extended far beyond the traditional spheres (United Nations Children's Fund, 1989). The nutritional status of female labourers is presumably closely related to their working and living conditions but, unfortunately, information on their nutritional status is very limited.

According to the Second National Chinese Dietary Survey in 1982 (Institute of Nutrition and Food Hygiene, 1985) the average food consumption of adults in both rural and urban areas was found to be adequate except for Ca and riboflavin. However, specific data by region of the country or for women of child-bearing age are not available. Indirect per capita nutrient availability calculation in 1985 produced results similar to the 1982 survey, except that the mean intake of protein was estimated at about 82% of the Chinese recommended daily allowance (RDA) established by the Chinese Nutrition Society in 1988 (Jian, 1990). The nationwide nutrition survey in 1982 also showed that 92% of dietary energy came from plants and only 8% from animals. The main source of energy was from

cereals, accounting for 71%, which was even higher among people living in rural areas. Therefore, the bioavailability of much of the Fe in the average Chinese diet may be restricted. In addition to the problem of limited Fe absorption, excessive menstrual blood loss is one of the likely causes of Fe deficiency (ID) among Chinese women. It was reported that modern contraceptive practices can significantly modify menstrual blood loss. For example, the mean menstrual blood loss is reduced by half in subjects taking oral contraceptives, but is doubly increased in subjects using intra-uterine devices (IUD) (International Nutritional Anaemia Consultative Group, 1984). The latter practice is more common among Chinese women because of the safety, efficacy, economy and ease of using intra-uterine devices. There were approximately eighty-four million women using an IUD in 1987 all over the world, of whom about sixty million were in China (World Health Organization, 1992).

The present study, conducted from 1989 to 1991 in Beijing, was designed to investigate the prevalence of anaemia, its type and the contributing factors for Fe deficiency in Chinese female menstruating cotton mill workers.

SUBJECTS AND METHODS

General information

The study was carried out in one of the three largest textile factories in China. These three cotton mills are located in the eastern suburb of Beijing and all have a similar structure. In each factory about 8000 employees are manual workers, of whom more than 80% are females. The major work in the factory is carried out in the yarn-spinning workshop, where almost all the workers are females. Both the quantity and quality of their work reflect the general workload of female textile labourers. Therefore, the female employers in the yarn-spinning workshop were selected as the study population. The activities in this workshop are generally very monotonous; the women mainly work with their arms and hands while standing and walking along the machines. Since the machines never stop, the workers work in a running shift with 2 d morning shifts (6.30–14.30 hours), 2 d afternoon shifts (14.30–22.30 hours), 2 d night shifts (22.30–6.30 hours) and 2 d off for each worker.

Screening test

All the non-pregnant female labourers aged between 19 and 45 years working in the yarn-spinning workshop were invited to come to the factory clinic for examination. The response rate was 95%. Thirty of 558 female workers did not show up simply either because they could not leave the job at that time or because they were afraid of blood sample collection. Due to technical problems haemoglobin (Hb) and free erythrocyte protoporphyrin (FEP) could only be determined in 447 subjects. Serum ferritin (SF) was tested in all the subjects with Hb values less than 120 g/l (n 150) and, in addition, in 118 subjects with Hb values more than 120 g/l; therefore, SF was tested in total in 268 subjects.

Diagnostic supplementation trial

Since the diagnosis of ID and Fe-deficiency anaemia (IDA) based on the cut-off values for Hb, FEP and SF is rather arbitrary, the response to Fe supplementation was also studied to investigate the type of anaemia in this population. From the screening tests on Hb and FEP (n 447) and SF (n 268), 147 subjects were diagnosed either as Fe deficient or as having IDA based on the following criteria (Cook, 1982; DeMaeyer, 1989): IDA was regarded as being present when the Hb concentration was below 120 g/l and either SF $< 12{\cdot}0$ μg/l or FEP > 350 μg/l. When Hb level was normal, but both the values of SF $< 12{\cdot}0$ μg/l and

FEP > 350 μg/l, Fe status was categorized as Fe deficient. Of the 147 subjects, eighty-three women were selected for a diagnostic supplementation trial after a routine medical check-up. They were randomly divided into two groups and treated for 12 weeks with either Fe or a placebo. Three subjects dropped out of the study. One subject was not willing to participate in the intervention trial. One became pregnant and one resigned from the job. Finally the data of eighty subjects were used in statistical analysis. Both before and after treatment body weight, body height and fat-free mass (FFM) were measured and capillary blood was collected in the morning, in the fasting state, after emptying the bladder, and after an overnight stay in the factory hospital.

$FeSO_4$ pills containing 60 mg Fe and placebos were provided by Lomapharm Medicine, Emmerthal, Germany. The supplementation trial was done over the whole year but in each season the placebo and Fe-treated subjects received pills simultaneously. Neither the medicine distributor nor the subjects were aware of the identity of the pills which were distributed every day to each subject under supervision; i.e. the subjects had to take the pills in front of the distributor. ID and mild IDA (above 80% of the cut-off Hb value) subjects were given one pill daily either Fe (n 34) or the placebo (n 36); moderate (between 60 and 80% of the cut-off Hb value) subjects were given two pills daily, either Fe (n 6) or the placebo (n 4). In the intervention trial no subjects had severe IDA. During the days off (2 d in every 8 d) the subjects took the pills at home. If they forgot to take the pills at home they were instructed to bring them back.

Dietary and socio-demographic survey

In order to investigate the contributing factors for ID, information on food intake, health history and socio-demographic information were obtained by structural interview from the eighty ID and IDA cases and in addition from eighty controls who were also involved in the screening test having a Hb at or above 120 g/l and either SF $\geqslant$ 12·0 μg/l or FEP $\leqslant$ 350 μg/l. The controls were matched with the ID and IDA subjects for age, sex and type of work.

The dietary history method (Haraldsdottir, 1988) was used to assess the subjects' food intake over the previous month. A questionnaire according to the characters of the Chinese diet was carefully prepared. The information was obtained by one person with relevant training in the food and nutrition fields. The individual interview lasted about 1–1·5 h. It started with a 24 h recall, then each meal was discussed in turn to find out which foods were used and how often, what alternatives might be used on other days of the week and any irregularities in the eating pattern, so that a menu was established for the whole month. Usual portion sizes were estimated with the aid of different types of food containers and information given was cross-checked using a list of individual foods as a memory aid.

Haematological measurements

Capillary blood was obtained by left ring finger stick using disposable blood lancets (Lameris, Utrecht, The Netherlands). The first drop of blood was discarded and spontaneous flow of blood was provided. Hb was determined in duplicate by HemoCue method (Laifer *et al.* 1990).

SF was determined in duplicate with a commercially available enzyme immunoassay (ELISA) kit (Ramco, Laboratories Inc., Houston, USA; Li *et al.* 1978) using a Titertek Multiskan R plus (EFLAB; Labsystems and Flow laboratories, Helsinki, Finland).

FEP was determined by fluorescent spectrophotometry (Model 12F-510; DaoJin, Tokyo, Japan), using the method of Piomelli *et al.* (1976) with some modification (Chen, 1981). The reproducibility of the determination was found to be 4% and the day-to-day variation was found to be from 4 to 8%.

Anthropometry

Body weight and height were measured to the nearest 0·1 kg and 1 mm respectively using a beam weighing scale and measuring system (Model 220; Seca, Hamburg, Germany). The weight of the patient's clothing was measured separately and subtracted from the total weight.

Bioelectrical impedance analyses (RJL Systems, Detroit, USA) were performed in duplicate after voiding, at the right side of the body as described by Lukaski *et al.* (1986) and Deurenberg *et al.* (1988). Empirically derived formulas provided by the manufacturer of the instrument were used to calculate estimated FFM.

Statistical analysis

All statistical analyses were done using the SPSS/PC$^+$ (1988) program. The results of Hb, SF and FEP after intervention were compared with the pretreatment results by two-tailed paired Student's *t* test. The straight-line regression of the change of Hb value *v.* initial Hb value was specified with regard to different treatments, using the multiple-regression SPSS/PC$^-$ program with treatment as the dummy variable (placebo group = 0, Fe-treated group = 1). Parallelism of the two lines was tested by the interaction effect as described by Kleinbaum & Kupper (1978). Comparisons between cases and controls were done using two-tailed two sample Student's *t* test and chi-square test where appropriate. The dietary history survey was analysed by the China-prj software designed by the Chinese Academy of Preventive Medicine, Beijing in 1987, which is based on the Chinese Food Composition Table published in 1982.

RESULTS

Table 1 describes some haematological, anthropometric and demographic variables for the total study population, for anaemic subjects and for controls. The mean value of Hb among 447 subjects was 123 (SD 15) g/l. Of the 447 Hb values 150 were below 120 g/l, accounting for 34% of the total population; of them, 78% were in the range 100–120 g/l, 20% between 70 and 100 g/l and 2% below 70 g/l. The mean FEP value was 419 (SD 215) μg/l; 55% of the FEP values were higher than 350 μg/l in the total population but 72% in the anaemic subjects with Hb below 120 g/l. SF was mainly examined in women with Hb below 120 g/l. The mean SF value in the total sample was 23·2 (SD 28·2) μg/l, but the mean values of SF among the subjects with Hb at or above 120 g/l and among the subjects with Hb below 120 g/l were 38·7 (SD 35·3) μg/l and 11·1 (SD 10·7) μg/l respectively. Of the anaemic subjects 71% had SF values below 12·0 μg/l and 83% below 15·0 μg/l.

The findings of the double-blind intervention trial are given in Fig. 1 and Table 2. Fig. 1 shows that one of the Fe-treated subjects with Hb < 120 g/l fell below the regression line for the change in Hb levels relative to the initial Hb levels for the placebo group. Since the non-responders in the Fe-treated group must be assumed to the symmetrically distributed around the placebo regression line, the total numbers of non-responders in the Fe-treated subjects with Hb < 120 g/l may be $1 \times 2 = 2$ subjects (Garby *et al.* 1969). Consequently a high response rate in Fe-treated subjects with Hb < 120 g/l was obtained, i.e. 22/24 = 92%. Similarly the response rate of 90% is calculated for the whole Fe-treated group. The regression analysis showed that the relationship between the change in Hb level and the initial Hb level was significantly different between the Fe-treated group and the placebo group ($P = 0{\cdot}013$), the improvement was much more pronounced in the Fe-treated group.

Differences in some socio-demographic variables between anaemic subjects and controls are shown in Table 1. The results indicate that the level of education and average family income were significantly lower for the anaemic subjects. In the present study population,

Table 1. *Profiles of the biochemical, anthropometric and demographic values for female cotton mill workers in Beijing, China*

(Mean values and standard deviations)

	Total population			Anaemic subjects (*n* 80)		Control subjects (*n* 80)	
	Mean	SD	*n*	Mean	SD	Mean	SD
Age (years)	29·2	7·9	447	29·9	6·0	30·6	5·5
Working duration (years)	7·7	6·6	447	10·6	6·5	11·1	5·6
Hb (g/l)	123	15	447	115	14	130	7*
FEP (μg/l)	419	215	447	535	246	389	157*
SF (μg/l)†	23·2	28·2	268	10·0	8·7	42·7	28·9*
Height (m)	—	—	—	1·61	0·05	1·60	0·05
Weight (kg)	—	—	—	54·6	6·9	56·7	6·7
Fat-free mass (kg)	—	—	—	39·8	4·0	38·3	3·4
Education level (years)	—	—	—	9·5	1·3	10·1	1·2*
Family income (Yuan/month)‡	—	—	—	404·4	70·8	465·3	43·9*
Menstruration duration (d)	—	—	—	6·6	2·9	6·0	2·4
Duration of using intra-uterine devices (years)	—	—	—	3·4	3·1	4·6	4·1

Hb, haemoglobin; SF, serum ferritin; FEP, free erythrocyte protoporphyrin.

Mean values for Fe-deficient subjects were significantly different from those for controls: * $P < 0{\cdot}01$.

† SF was tested only in all the subjects with Hb value less than 120 g/l (*n* 150) and in 118 subjects with Hb value higher than 120 g/l.

‡ One US dollar was equivalent to 5·4 Chinese yuan.

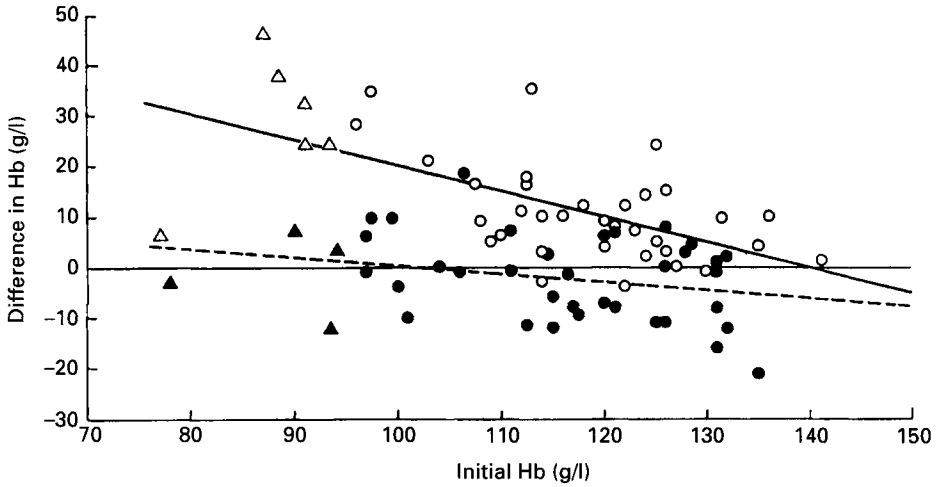

Fig. 1. The relationship between response in haemoglobin (Hb) and initial Hb levels of female cotton mill workers in Beijing, China. (○, △), Fe-treated subjects receiving one (○) or two (△) pills daily respectively; (●, ▲), control subjects receiving placebos one (●) or two (▲) pills daily respectively).

forty-six of sixty-four women in the ID group and forty-eight of fifty-eight women in the normal control group practising contraception were using IUD. The analysis did not show that use of IUD was a contributing factor for ID compared with other contraceptive practices such as pills and condoms (χ^2 1·87, df 1, $P > 0{\cdot}05$). However, a significant

Table 2. *Evaluation of haematological status of female cotton mill workers in Beijing, China before and after 12 weeks treatment with iron or a placebo*

(Mean values and standard deviations)

Treatment group...	Fe (*n* 40)		Placebo (*n* 40)	
	Mean	SD	Mean	SD
Haemoglobin (g/l)				
Before treatment	114	15	115	14
After treatment	127	12	113	14
Difference (95% CI)	13***	12 (9,17)	−2†††	8 (−5,1)
Serum ferritin (μg/l)				
Before treatment	9·7	5·6	10·6	10·9
After treatment	30·0	20·8	18·8	17·9
Difference (95% CI)	20·3***	18·9 (14·3, 26·3)	8·2*††	19·4 (2·1, 14·3)
Free erythrocyte protoporphyrin (μg/l)				
Before treatment	570	308	525	168
After treatment	277	113	372	150
Difference (95% CI)	−296***	264 (−379, −213)	−153***††	144 (−199, −107)

95% CI, 95% confidential interval.

The values after treatment were significantly different from pretreatment values (paired *t* test): * $P < 0{\cdot}05$, *** $P < 0{\cdot}001$.

The values for the two groups were significantly different (group *t* test): †† $P < 0{\cdot}01$, ††† $P < 0{\cdot}001$.

Table 3. *The comparison of daily nutrients intake and sources of energy between anaemic and control Chinese female cotton mill workers*

(Mean values and standard deviations)

	Anaemic subjects (*n* 80)			Control subjects (*n* 80)		
	Mean	SD	RDA(%)†	Mean	SD	RDA(%)
Energy (kJ)	8995	2755	80	8903	2345	79
Protein						
g	75	29	94	75	26	94
Energy (%)	14	5	—	14	3	—
Animal source (%)	34	12	—	33	13	—
Fat						
g	87	35	—	84	35	—
Energy (%)	36	9	—	35	9	—
Carbohydrate						
g	269	89	—	270	77	—
Energy (%)	50	10	—	51	9	—
Fe (mg)	17	6	94	22	5	122**
Vitamin A (μg retinol equivalents)	797	278	100	1137	466	142**
Thiamin (mg)	1·1	0·6	79	1·1	0·4	79
Riboflavin (mg)	0·9	0·4	64	0·9	0·4	64
Ascorbic acid (mg)	111	59	185	136	52	277**

RDA, recommended daily allowance.

Mean values for Fe-deficient subjects were significantly different from those for controls: ** $P < 0{\cdot}01$.

† Values established by Chinese Nutrition Society (Jian, 1990).

difference in the severity of ID was found between subjects using IUD for more than 2 years and for less than 2 years. In ID subjects having IUD, only nine of twenty-two subjects used them for less than 2 years; but in mild and moderate IDA subjects having IUD, seventeen of the twenty-four used them for less than 2 years (χ^2 4·18, df 1, $P < 0·05$). Women using IUD for less than 2 years showed more severe ID.

Table 3 shows the daily nutrient intake and sources of energy for anaemic and control groups.

DISCUSSION

Prevalence of anaemia

A mean Hb value of 123 g/l and a mean FEP value of 419 μg/l were found in the 447 female menstruating cotton mill workers examined. The World Health Organization (1968) has proposed an Hb value of 120 g/l as the lower limit of the normal range for adult non-pregnant females. In the present study sample of 447 female cotton mill workers, 34% of all the subjects had Hb values below the limit of 120 g/l. This result is similar to the value reported for the region in the Second National Dietary Survey in 1982 and much higher than the anaemic prevalence among adult males, which was found to be 14% on average (Institute of Nutrition and Food Hygiene, 1985).

Although specific data for female workers are not available in China, the prevalence of anaemia in the present study population is within the range for fertile women (21–55%) reported by the regional health organization (Institute of Nutrition and Food Hygiene, 1985). Furthermore, the average age, height and weight in the present study sample were comparable to those studied in female workers (29 years, 1·60 m, 56 kg *v.* 27 years, 1·58 m, 53 kg respectively; Yu, 1982). On the other hand, the energy expenditure at work measured in the present study (R. Li, unpublished results) is similar to the data obtained from another population of female cotton mill workers by the Health Institute, Chinese Academy of Preventive Medicine (9·7 KJ/min *v.* 11·0 KJ/min; Yu, 1982). Therefore, one might assume that the present study population could at least represent Chinese female cotton mill workers, who play a very important role in state economy.

The type of anaemia

Initially an SF value of 12·0 μg/l was proposed as the lower cut-off value for ID. More recent studies propose a SF value of 15·0 μg/l to be indicative of ID (Hallberg & Rossander-Hultén, 1991). By these definitions, 71 or 83% respectively of the anaemic subjects in this population were ID type. Based on an FEP value of 350 μg/l as a cut-off value for ID, 72% of the anaemic subjects were regarded as Fe deficient. Therefore, it was assumed that ID was the major type of anaemia in this population. However, it is known that the cut-off values for haematological variables for diagnosing ID and IDA are arbitrary and may not be appropriate for all given geographic areas and populations; therefore, the Fe supplementation trial constitutes an important step toward defining the nature and extent of nutritional deficiency (World Health Organization, 1975). The evidence that the anaemia in this population was of the ID type was actually derived from the high response to Fe supplementation in the Fe-treated subjects with Hb < 120 g/l.

The diagnosing boundary line between ID and IDA could be both indefinite and shifting; therefore, both ID and IDA subjects were selected for the intervention trial. Since the analysis results were not significantly influenced when omitting the subjects receiving two tablets daily, the data from the subjects receiving one or two tablets were combined in Table 2. Table 2 shows that the initial values for all the haematological variables were identical for the Fe-treated and the placebo group. The increase in Hb value in the Fe-treated subjects was statistically significant, while the Hb value in the placebo group

remained almost constant. Although the changes in SF and FEP in the group receiving placebo were also significant, the subjects receiving Fe treatment showed a significantly greater increase in SF and decrease in FEP. The regression analysis of the change in Hb relative to the initial Hb level also showed that the rise in the Hb value was significantly attributable to the Fe treatment. These findings indicate that not only IDA subjects but also ID subjects diagnosed on the basis of the haematological cut-off values were indeed lacking in Fe. Therefore, the assumption that ID was the major type of anaemia in this population based on the cut-off values may be considered as correct. The reason for the change in SF and FEP in the placebo group could be due to the fact that a programme on nutrition education given in combination with the project may have influenced the subjects to pay more attention to their food intake. In the placebo-treated group the increase in SF and the fall in FEP levels were significant, with no corresponding increase in Hb values. For SF this could be due to the relatively high variability from day-to-day. For FEP this remains unclear. FEP has a relatively high stability. Although seasonal variation could have had an effect, it was under control in the present study as placebo and Fe-treated groups were studied simultaneously. In the Fe-treated group at least one haematological variable was improved to the normal level in all the subjects, but still approximately 10% of the subjects failed to reach the normal limits of all three haematological variables after treatment with Fe for 12 weeks. The dropout rate was small in the present study (3·6%) and appeared unrelated to side effects of Fe treatment. There were only four spontaneous complaints concerning side effects and these tended to disappear after a couple of days.

Contributing factors for iron deficiency

The causes of ID for menstruating women are multiple and can be due to low Fe intake, poor Fe absorption, increased Fe losses and poor Fe utilization.

Based on the physiological Fe losses and bioavailability of dietary Fe consumed from the general Chinese diet, the Chinese Nutrition Society established 18 mg as the RDA for Fe intake for menstruating adult females (Jian, 1990). In the present study the calculated Fe intake for both ID subjects and for normal controls meets the Chinese RDA (see Table 3). Previous studies had the same findings (Wang *et al.* 1983). The apparent paradox of a high prevalence of nutritional Fe deficiency in women with 'high' Fe intake could be due to poor bioavailability of Fe in the diet, higher Fe requirement in women using IUD (Hallberg & Rossander-Hultén, 1991) or due to an overestimation of Fe contents in the Chinese food composition table used (Chinese Academy of Preventive Medicine, 1990). It has been reported that the Fe contents of foods analysed by a colorimetric method, as used in making the Chinese food composition table, were higher than those being analysed using atomic absorption spectrophotometry (Hong *et al.* 1983). Although the food consumption data in the present study were not validated, a comparison of the dietary intake between the different groups using the same method may indicate real differences.

Blood losses have a profound effect on Fe balance. The major cause of blood loss in Chinese fertile women may be the menstrual blood loss. In developing countries IUD are widely used among married women, which increases menstrual blood loss by between 35 and 146% depending on the type of device (Hefnawi, 1974; Guillebaud *et al.* 1976). Stainless-steel IUD are the most common type used in China. It has been reported that such devices increase mean menstrual blood loss by 54% within 1 year after inserting them (Yuan *et al.* 1987). In the present study no relationship was found between ID and different contraceptive practices. One major reason could be that IUD were fitted in most of the women practising contraception in our study, which was 83% on average. However, the severeness of ID was found to be related to the duration of using IUD. The complaints of our subjects were also in accordance with this finding, i.e. menstrual blood loss was

increased by using an IUD especially during the first 2 years. This implies that the longer the practice of using IUD lasts, the more readily the women adapt. Therefore, it is suggested that Fe supplementation should be given to IUD users suffering from menorrhagia, especially during the first few years.

In summary, a high prevalence of anaemia (34%) was found in Chinese female menstruating cotton mill workers and the major type of anaemia in this population was ID. Low availability or utilization of Fe and excessive blood loss in IUD users may be the most common factors leading to ID and IDA in this population. Although the causes of ID in this population could not be determined from the present study, oral Fe treatment was found to be efficient and Fe supplementation in IUD users suffering from menorrhagia may well be beneficial.

The authors are very grateful to Dr B. Schürch (Lausanne, Switzerland) for his invaluable contribution to this project. They would also like to thank Huang Lei, Wang Jing-Zhong, Wang Jie, Anne and the nurses in the factory hospital for their help with the practical work and the subjects for their excellent cooperation. This research was sponsored by the Nestlé Foundation, Switzerland.

REFERENCES

Chen, C. L. (1981). A micromethod for testing free erythrocyte porphyrins. *Chinese Journal of Preventive Medicine* **6**, 362–363 (In Chinese).

Chinese Academy of Preventive Medicine (1990). Table of Food consumption in Beijing. Beijing: Light Industry Publishing House.

Cook, J. D. (1982). Clinical evaluation of iron deficiency. *Seminars in Haematology* **19**, 6–18.

DeMaeyer, E. M. (1989). *Preventing and Controlling Iron Deficiency Anaemia Through Primary Health Care.* Geneva: WHO.

Deurenberg, P., Weststrate, J. A. & Paymans, I. (1988). Factors affecting bioelectrical impedance measurements in humans. *European Journal of Clinical Nutrition* **42**, 1017–1022.

Garby, L., Irnell, L. & Werner, I. (1969). Iron deficiency in women of fertile age in a Swedish community: III. Estimation of prevalence based on response to iron supplementation. *Acta Medica Scandinavica* **185**, 113–117.

Guillebaud, J., Bonner, J., Morehead, J. & Matthews, A. (1976). Menstrual blood loss with intrauterine devices. *Lancet* **i**, 387–390.

Hallberg, L. & Rossander-Hultén, R. (1991). Iron requirements in menstruating women. *American Journal of Clinical Nutrition* **54**, 1047–1058.

Haraldsdottir, J. (1988). Dietary history. In *Manual on Methodology for Food Composition Studies*, pp. 88–92 [M. E. Cameron and W. A. Staveren, editors]. New York: Oxford University Press.

Hong, S., Guo, D., Zhou, J. & Chen, J. (1983). Iron content analyzed by the methods of colorimetry and atomic absorption. *Acta Nutrimenta Sinica* **5**, 271–274.

Hefnawi, F. (1974). Menstrual blood loss with copper intrauterine devices. *Contraception* **9**, 133–137.

Institute of Nutrition and Food Hygiene (1985). *National Nutrition Survey in 1982.* Beijing: Institute of Nutrition and Food Hygiene (In Chinese).

International Nutritional Anaemia Consultative Group (1984). *Iron Deficiency in Women.* Washington, DC; The Nutrition Foundation.

Jian, D. (1990). *Comment on the Recommended Dietary Allowance of Chinese Nutrition Society.* Beijing: China Science and Technology Publishing House (In Chinese).

Kleinbaum, D. G. & Kupper, L. L. (1978). *Applied Regression Analysis and Other Multivariable Methods.* North Scituate, Massachusetts: Duxbury Press.

Laifer, S. A., Kuller, J. A. & Hill, L. M. (1990). Rapid assessment of fetal haemoglobin concentration with the HemoCue system. *Obstetrics and Gynaecology* **76**, 723–724.

Li, P. K., Humbert, J. R. & Cheng, C. (1978). Evaluation of commercially obtainable ferritin test kit in relation to the high dose parabolic phenomenon. *Clinical Chemistry* **24**, 1650–1656.

Lukaski, H. C., Bolonchuk, W. W., Hall, C. B. & Siders, W. A. (1986). Validation of tetrapolar bioelectrical method to assess human body composition. *Journal of Applied Physiology* **60**, 1327–1332.

Piomelli, S., Brickman, A. & Carlos, E. (1976). Rapid diagnosis of iron deficiency by measurement of free erythrocyte porphyrins and haemoglobin: the FEP/haemoglobin ratio. *Paediatrics* **57**, 136–141.

SPSS/PC$^+$ (1988). *Base Manual SPSS/PC+ V 2.0.* Chicago, Illinois: SPSS Inc.

United Nations Children's Fund (1989). *Children and Women of China – A UNICEF Situation Analysis.* Beijing: United Nations Children's Fund.

Wang, W. G., Yan, H. C., Dai, J. & Chen, X. C. (1983). Studies on iron deficiency anaemia of pregnant women in Beijing. *Acta Nutrimenta Sinica* **5**, 73–77.
World Health Organization (1968). *Nutritional Anaemia. Technical Report Series* no. 455. Geneva: WHO.
World Health Organization (1975). *Control of Nutritional Anaemia With Special Reference to Iron Deficiency. Technical Report Series* no. 580. Geneva: WHO.
World Health Organization (1992). *Intrauterine Devices–One Hurdle Less*. Geneva: WHO.
Yu, Yong-Zhong (1982). *The Manual of Energy Expenditure of Occupational Activities*. Beijing: Health Institute (In Chinese).
Yuan, M., Cai, G. & Zhang, J. (1987). The effects on menstrual flow by five kinds of intrauterine device. *Shanghai Medicine* **10**, 261–264.

Printed in Great Britain