Follow-up studies on the distribution of haemoglobin levels in female farm workers

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SUMMARY Haemoglobin concentrations in about 1000 women agricultural workers in Japan were measured every year, except in 1972, during the period 1967–77. Improvements were noted in the course of this investigation, and these were predominantly associated with the fact that those in the study community began to pay attention to the problem of low haemoglobin levels and to improve their diets, with an increase in daily food intake, particularly of animal protein and iron. In addition, a marked decrease in anaemia caused by hookworm also played an important role. In this paper, the changes in haemoglobin concentration during the period of study are described and the aetiology is discussed.

Since 1965, haemoglobin (Hb) concentration among populations of various social classes has been studied in this laboratory. Attention has been focused on the analysis of anaemia and its aetiology in female farm workers, who generally show relatively low Hb concentrations (Takamatsu et al., 1969; Futatsuka et al., 1973a; Futatsuka et al., 1973b). During the period 1967 to 1977, using the methods described below, we investigated the Hb concentration among the female population engaged in agriculture each year, except for 1972.

Materials and methods

Those examined were women aged 20 to 59 working in the central farming area in Kumamoto prefecture. Five to 10 of the 47 regions in the area were chosen at random for the study, and about 100 to 150 farm women were chosen at random for investigation in each region—that is, 500 to 1000 persons were investigated annually with sampling rates of 5% to 10%.

Blood properties may be changed by ageing or medication in the case of protracted follow-up studies of the same subjects. Therefore, another population with the same age distribution was sampled annually in the same area.

This is the main agricultural area in Kumamoto prefecture. Incomes are derived from production of rice (29%), green vegetables (6%), industrial crops, such as rush for mats (8%), fruit, such as oranges (5%), and livestock products (10%) to make about 0.1 million yen per 10 ares of cultivated field, or about 1.2 million yen* per family, about the average for a Japanese farmer.

In July or August, just after the busiest summer farming season, blood samples were taken from the cubital vein between 10:00 and 12:00, three hours after breakfast. The Hb concentration was determined by the cyanmethaemoglobin method immediately, together with the specific gravity and the haematocrit value. Serum iron and unsaturated iron binding capacity were occasionally measured. Haematological examinations were carried out by the same method for 10 years. Haematological studies, including examination of the precision of Hb determination, were carried out. Most of the measurements were conducted as part of the multiple mass health examination.

Results

Changes in the mean Hb concentration during the study years are shown in Fig. 1, where means for each two-year period are plotted. The means were 12.04 ± 1.33 g/dl (n = 1198) for 1967–68; 12.13 ± 1.35 g/dl (n = 852) for 1969–70; 12.58 ± 1.30 g/dl (n = 1173) for 1971–73; 12.82 ± 1.22 g/dl (n = 1620) for 1974–75; and 12.85 ± 1.23 g/dl (n = 2292) for 1976–77. The average for 1971–73 is significantly higher than the

* ¥1 = approximately 360 yen.
Follow-up studies on the distribution of haemoglobin levels in female farm workers

Fig. 1  Trends of mean levels of haemoglobin in female farm workers 1967-77.

The incidence of Hb concentration below 11 g/dl revealed no significant change in the period after 1971.

All the annual frequency curves shown in Fig. 3 appear to fit a normal distribution with skewing to the left (that is, towards lower values). The log-normal

The prevalence of low Hb concentrations is tabulated below and plotted in Fig. 2.

<table>
<thead>
<tr>
<th></th>
<th>Less than 12 g/dl*</th>
<th>Less than 11 g/dl</th>
</tr>
</thead>
<tbody>
<tr>
<td>1967-68</td>
<td>43.8%</td>
<td>14.1%</td>
</tr>
<tr>
<td>1969-70</td>
<td>36.6%</td>
<td>13.9%</td>
</tr>
<tr>
<td>1971-73</td>
<td>26.3%</td>
<td>8.9%</td>
</tr>
<tr>
<td>1974-75</td>
<td>19.6%</td>
<td>5.6%</td>
</tr>
<tr>
<td>1976-77</td>
<td>16.1%</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

* The value recommended by WHO as the lower limit of the normal value for adult women.

The incidence of Hb concentrations below 12 g/dl and below 11 g/dl in 1971-73 was significantly lower than that in 1967-70 (P <0.05). The incidence of Hb concentrations below 12 g/dl in 1976-77 was significantly lower than that in 1971-73 (P <0.05).

The log-normal plots of the accumulated frequency curves for Hb concentration consist of two linear lines with an inflection point between about the fifth and fifteenth percentiles, as shown in Fig. 4, indicating that the distribution of Hb concentration for the female farming population may be divided into two subgroups, one with relatively low Hb concentration and the other with normal concentration. The frequency curves for each of the two subgroups reveal normal distribution. The inflection point of the accumulated frequency curve moves towards the right and downwards: namely, towards the area of high Hb concentration coupled with a low percentile, reflecting the increase in concentration in recent years. The annual 5th, 25th, 50th, 75th, and 95th percentiles are shown in Table 1. The annual average

Fig. 2  Prevalence rates of low haemoglobin concentrations 1967-77.

Table 1  Trends of haemoglobin levels of female farm workers 1967-77

<table>
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<tr>
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<tbody>
<tr>
<td>5th percentile</td>
<td>9-90</td>
<td>10-25</td>
<td>10-71</td>
<td>11-27</td>
<td>11-09</td>
</tr>
<tr>
<td>25th percentile</td>
<td>11-68</td>
<td>11-66</td>
<td>12-16</td>
<td>12-41</td>
<td>12-49</td>
</tr>
<tr>
<td>Mean</td>
<td>12-04</td>
<td>12-13</td>
<td>12-58</td>
<td>12-82</td>
<td>12-85</td>
</tr>
<tr>
<td>Mode</td>
<td>12-18</td>
<td>12-32</td>
<td>12-68</td>
<td>12-89</td>
<td>12-99</td>
</tr>
<tr>
<td>75th percentile</td>
<td>12-73</td>
<td>12-84</td>
<td>13-27</td>
<td>13-42</td>
<td>13-46</td>
</tr>
<tr>
<td>95th percentile</td>
<td>13-42</td>
<td>13-73</td>
<td>14-33</td>
<td>14-44</td>
<td>14-32</td>
</tr>
</tbody>
</table>

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Hb concentrations were expressed in index numbers taking the 1967–68 mean concentration as normal. The Hb level at the 5th percentile began to increase first, followed by the 95th percentile. Then, the 25th, 50th, and 75th percentiles gradually increased at almost the same rate. The increases in the 5th and 95th percentiles remained at about 11·1 to 11·3 g/dl and 14·3 to 14·5 g/dl respectively. The trend was especially remarkable in the 95th percentile. Compared with 1967–68, the 5th percentile for 1976–77 is higher by 12·0% and the 25th, 50th, 75th, and 95th percentiles for 1976–77 are higher by 6% to 7%. These results suggest that the size of the subgroup with relatively low Hb concentration at the early stages of the investigation was largely responsible for the marked increase in mean Hb concentration.

In addition to this, the mean Hb concentrations of the male population of the same age engaged in agriculture in the same area was 15·0 ± 1·2 g/dl in 1970 (Fig. 5). The cases with Hb concentration below 13 g/dl were five out of 241 (2·1%). In 1977, mean concentration was 15·0 ± 1·2 g/dl, and the number of cases with Hb concentration below 13 g/dl was 30 out of 870 (3·5%). Compared with the results observed in the female population, the Hb concentrations of the male population were consistently high and no change was observed during the period investigated.

**Discussion**

The area studied is a farming area in central Kyushu, the south-eastern part of Japan. The Hb concentrations of women farm workers in this area used to be relatively low compared with the national average. In the latter half of the 1960s, the Research Group of Rural Anaemia in the Japanese Society of Public Health (Group Leader: Professor Rikio Yanagisawa) measured Hb concentrations in 14 areas of the country. (Experts Committee on Nutritional Anaemia of Women in Rural Areas, 1970). The mean Hb concentration throughout the country was about 12·5 g/dl and the incidence of Hb concentration below 12 g/dl was about 25%. Thereafter, a similar investigation was conducted by a research group of the Japanese Association of Rural Medicine (Group Leader: Professor Akio Uchida) in 10 areas throughout the country in about 1975 (Experts Committee on Nutritional Anaemia of Women in Rural Areas, 1977). The mean Hb concentration was about 12·6 g/dl and the incidence of Hb concentration below 12 g/dl was about 25%. Although these two investigations covered different areas, no remarkable difference was observed between the two results. In or about 1970, the Hb concentrations of adult women engaged in agriculture were apparently lower than those of women engaged in other occupations, as shown in Fig. 6 (Matsushita, 1972). Another
Follow-up studies on the distribution of haemoglobin levels in female farm workers

Follow-up study of Hb concentration, in fixed areas in Akita, Nagano, and Ehime prefectures, covered relatively long periods. According to the reports from Akita, the mean Hb concentration was 11.7 ± 1.1 g/dl in 1968, but had increased by 1.0 g/dl to 12.7 g/dl in 1974 (Miyahara et al., 1975). The incidence of those below 12 g/dl was reduced from 56.1% to 20.0% during the same period. Furthermore, from 1974 to 1976, neither the mean Hb concentration nor the incidence revealed marked fluctuation. These results agree well with our observation. On the other hand, no marked fluctuation was observed during the study period in either Nagano or Ehime prefectures. In Nagano prefecture, the mean Hb concentration was 13.9 g/dl and the incidence of those below 12 g/dl was 7.0% in 1970 (Matsushima, 1977). The Hb concentration was much higher than that found in the present report. The corresponding values in 1975 were 13.1 g/dl and 13.0% indicating a trend towards a decrease in Hb concentration thereafter.

Thus, as these investigations differ in population, method of sampling, and environmental factors, the results do not necessarily show a common trend. Re-examination of the present data by region and size of farms reveals that there are apparently two subgroups, one with a remarkable increase in the Hb concentration, and the other with no improvement (Fig. 7; Table 2). However, the mean Hb concentration for the whole group increased. These facts are worth noting to elucidate the aetiology of anaemia in farm areas. However, it seems clear that the differences in Hb concentration are being reduced individually as well as among the whole group.

In the group investigated, the mean Hb concentration began to improve, starting with a reduction of those with less than 11 g/dl of Hb, thus minimising the skewness towards low concentration. Therefore, increase in mean and median is preceded by increases in the 5th and the 25th percentiles, and the increments for the latter two values are larger than for the mean and median population. When the mean Hb concentration of the given population came close to 13 g/dl with a variation coefficient less than
Rice and horticulture
Rice and dairy
Rice and fruit
Rice and mat rush
Multiculture

Fig. 7 Mean levels of haemoglobin in various types of agricultural area.

0.1, the mean Hb concentration hardly changed; however, the number of cases below 12 g/dl gradually decreased. Haemoglobin concentration in the male population is being observed in Akita and also in the area of the present investigation. These data will be evaluated in connection with the daily quantity of food and its rate of absorption.

In males, the mean value of Hb was already as high as 15.0 g/dl in 1970. In the male, there are no influences of pregnancy or delivery, and the daily work load of about 3000–3500 cal is not as hard as that of the female. The nutritional condition of males is better than that of females. In Japanese rural areas, anaemia in males has not been important in the past. The stability of the mean Hb concentration in males provides an interesting and important contrast to the pattern in females. Special attention needs to be paid to the ability to saturate the serum iron content. Investigations are currently being carried out on the haematological changes in iron deficiency anaemia for both males and females in this area.

In this connection, the World Health Organisation plans to reduce to 5% the incidence of those below 12 g/dl in the campaign to reduce anaemia. In the present study, while the mean concentration reached 12.9 ± 1.2 g/dl in 1976–77, the 5th percentile was 11.1 g/dl and 16.1% had a concentration less than 12

| Table 2 Mean levels of haemoglobin by area |
| Urban area | Open field area |
| Northern area | 1968 | 1975 |
| 12.5 ± 1.3 | 11.9 ± 1.3 |
| Southern area | 1968 | 1975 |
| 12.5 ± 1.2 | 12.3 ± 1.3 |
| 12.4 ± 1.5 | 12.9 ± 1.2 |

Fig. 8 Trends in average daily food intake in rural areas in Kumamoto prefecture.
Follow-up studies on the distribution of haemoglobin levels in female farm workers

**Fig. 9** Trends in the prevalence rates of hookworm infections.

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### References


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g/dl. In other words, the 5th percentile still remains at the level of 11 g/dl, far below the WHO standard.

In addition to earlier reports presented by Uchida and Owada, this laboratory has been studying the aetiology of anaemia among women engaged in agriculture (Nomura, 1972; Tanaka et al., 1976). The dominant cause of increases in Hb concentration observed during the 10 years of our investigation were related to increases in daily food intake, particularly of animal protein (Yasutake et al., 1975). This animal protein, accompanied by additional animal iron, made changes in the amino-acid composition (Fig. 8). Also, a marked decrease in anaemia caused by hookworm played an important role (Fig. 9) (Koyama, 1971). The details are to be published in the near future.
Follow-up studies on the distribution of haemoglobin levels in female farm workers.

M Futatsuka, W Koyama, Y Arimatsu, A Ueda, T Hitoshi, T Ueda, R Yasutake, S Tanaka, J Misumi and S Nomura

*J Epidemiol Community Health* 1979 33: 286-291
doi: 10.1136/jech.33.4.286

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