References

Some Hematological Findings in Children of Western Samoa

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Although approximately 50 years have passed since the publication of the late Margaret Mead’s celebrated ‘Coming of Age in Samoa’, the people of Upolu in Western Samoa retain many of the beliefs and customs so vividly described by Dr. Mead. The traditional houses without walls (fale) continue to dominate the island’s habitations; all social interactions revolve around the highly structured chief or matai system; family relations and obligations underlie almost every decision-making process; important occasions are marked by mandatory gift exchanges, including the prized fine mats and the ritually-prepared pigs; and every possible happy time (fiafia) finds expression through traditional dancing and singing.

But important changes have taken place. The
grandchildren of the young girls and boys described by Mead share the same island space with a population whose numbers have quadrupled (see Fig. 1). More than half of the population today is younger than 15 years of age. For many of the Samoans a solution to the population explosion has been to leave their tropical homeland and try to carve a niche in economically more rewarding areas such as New Zealand, Australia and the USA.

Although political independence was achieved in 1962, economic independence is still far off. One-half of the gross national product derives from money sent home by the loyal emigrees. For those who have remained in the islands, subsistence depends on agriculture, particularly the prized root crop, taro (Colocasia antiquorum). More and more imported products, particularly tinned beef and fish, are purchased with the little cash derived from the primary export, copra.

The majority of the population live on the two larger volcanic islands, Savai'i (662 square miles) and Upola (433 square miles) with the heaviest concentration of people found on the latter island. As in Mead’s day, the population is primarily Polynesian with a small admixture of Europeans and Asians.

The Samoans live with many of the health problems common to developing tropical nations. Sanitation is rudimentary, and, in the hot, wet climate, the proliferation of microorganisms rivals that of coddled laboratory cultures. The many impinging hallmarks of the external world, introduced by travel, tourists, films, television in the one urban center, and radio throughout the islands, stimulate demands for cash expenditures that tend to emphasize 'prestige' symbols ahead of more basic health priorities.

One of the most frequent reasons given for high fertility levels is the felt need to insure the survival of adequate numbers of children who will survive to care for the parents in their old age. In Western Samoa, this is not an unreasonable concern. In keeping with the strong tradition of family responsibility for all its members as well as the low level of national income, there is no reliable social security or old age pension system. In addition, infant mortality rates, while lower than those of many of the developing nations, nevertheless, hover around 40 deaths per 1000 live births in contrast with the figures of 12-24 per 1000 live births found in many of the industrialized nations.

The health conditions of the children, therefore, have important implications, extending beyond purely humanitarian concerns, particularly as related to interrupting the present population expansion through greater acceptance of family planning. In mid-1978, a hematological study was conducted to gauge the health conditions of children living in seven villages on Upolu as well as in the urban center of Apia. The results are examined in the perspective of cultural and environmental interactions.

**Methods**

Free-flow finger pricks were performed on 266 children assembled at gatherings of five villages' Women’s Committees plus one village’s (Luatuanu'u) kindergarten class and one village’s after-Sunday-services (Salamumu). For hemoglobin determinations, 0.02 milliliters of whole blood were drawn into a calibrated Sahli pipet, then lysed in Drabkin’s Solution. The color intensity of the resulting solution was read at 540 µm and reported in grams per 100 milliliters of whole blood. Hemoglobin determinations were performed twice for approximately every eighth subject.

Packed cell volume (PCV) was determined by filling micro-hematocrit tubes by capillary action. The tubes were plugged, then centrifuged at regulated revolutions per minute for five minutes, read immediately and recorded in per cent of red blood cells per 100 milliliters of whole blood. With occasional exceptions, all PCV determinations were performed in duplicate. Mean corpuscular hemoglobin concentration (MCHC) was calculated using the following formula:

\[
\text{MCHC} = \left( \frac{\text{hemoglobin, grams per 100 ml whole blood} \times 100}{\text{volume packed cells, ml per 100 ml whole blood}} \right) \times \frac{1}{\text{expressed in per cent}}
\]

* Drabkin’s diluent solution: NaHCO₃, 1.0 gm; KCN 50 mg; K₃Fe(CN)₆, 200 mg, and distilled water to 1 liter (Wintrobe, 1962).
Differentials of white blood cells and evaluations of red cell morphology were performed from the same free flow finger prick. Each blood film was air-dried, labeled and stained with Wright’s Stain. Using 1000 × magnification, 100 leucocytes were differentiated and erythrocyte morphology assessed for each child by one of the authors (CSW). Random stool specimens were examined by a parasitology technician of the Western Samoa National Hospital. Weight and age for the children were obtained from the records maintained by the District Nurse assigned to the village.

Results

The children’s ages ranged from two weeks to 15 years; 120 boys were represented and 146 girls. The distribution of age and sex is shown in Table 1. Seven villages plus the urban center of Apia were represented.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>1-2</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>2-3</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>3-4</td>
<td>18</td>
<td>32</td>
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<td>4-5</td>
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<td>5-6</td>
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<td>20</td>
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<tr>
<td>6-11</td>
<td>19</td>
<td>23</td>
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<tr>
<td>12-15</td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>

The mean hemoglobin level was 11.4 g per 100 ml whole blood, with a range of 7.2 to 14.5 g. The mean PCV was 35.4 per cent with a range of 27 to 44. The mean MCHC was 32.1 per cent with a range of 24.0 to 40.6. There were no significant differences between boys and girls in hemoglobin, PCV, and MCHC. Using the values of 12.0 g, 37 per cent, and 32 per cent as minimum levels of normals for hemoglobin, PCV, and MCHC, respectively, 63 per cent of the children were found to be below desirable levels in their hemoglobin content; 64 per cent were below normal in PCV; and 53 per cent were found to have low MCHC.

High rates of red blood cell dyscrasias accompanied these findings. Slight to moderate hypochromia was seen in 61 per cent of the children and marked hypochromia in an additional six per cent. Slight to moderate microcytosis was found in 22 per cent of the children and slight to moderate anisocytosis in 45 per cent. Anisocytosis was found to be significantly higher among boys of all ages (P<0.001). Five per cent of the children revealed poikilocytosis in their erythrocytes and occasional poikilocytes was found in 7.5 per cent. The red cell abnormalities are summarized in Fig. 2.

Eosinophilia was the most common pathological finding in the leucocyte differentials. One to five eosinophils may be encountered in a differential of 100 normal white blood cells. In the differentiated leucocytes of the Samoan children, eosinophils ranged from 0 to 50 per cent, with a mean of 11.2 and a median of 10.2. The distribution of the eosinophils among the children is shown in Figure 3. In addition, 5.7 per cent of the children were found to have elevated numbers of immature white blood cells in the neutrophilic series; these ranged from five to fourteen bands per 100 leucocytes counted.

As might be expected, the morphological patterns, i.e., the hypochromasia, microcytosis, anisocytosis, poikilocytosis and polychromasia, were found to be highly correlated (p<0.001) with abnormally low MCHC.
hemoglobin, PCV, and MCHC levels. On the other hand, it is interesting that there was not a significant correlation with high eosinophil counts.

Every random stool specimen examined revealed multiple helminthic infections; hookworm, trichuris and ascaris were consistently found. Although the children were not tested for the presence of microfilaria, this is a continuing problem on the island and may be responsible for the occasional extremely high eosinophil levels.

There was a highly significant correlation (p < 0.001) between age and practically all the other factors studied. Hemoglobin and PCV were considerably below normal for babies under two years of age with a mean hemoglobin count of 10.2 and PCV of 32.3 per cent for the 48 children in this age group. The values increased gradually beyond this age but did not reach normal levels until the ages of seven or eight years, after which they remained slightly above the minimum normal standards. The prevalence of red cell dyscrasia was greatest in the babies and children up to age three; after this age the erythrocyte morphology improved with only occasional abnormalities.

The age relationship to eosinophilia went in the opposite direction. Only the group of children under one year of age had mean eosinophilic levels lower than six. When the one-year-olds and under are excluded, the eosinophil level is found to be almost 12 with boys having a mean of 13.1 and girls 10.8. Including all of the subjects, the mean number of eosinophils found in the differentials was 11.2, with a range of 0 to 50. Since the distribution of eosinophil levels is clearly skewed the median was also calculated. It turned out that 50 per cent of the children had eosinophil levels above 10.2. There was a significant difference (p < 0.04) between eosinophil rates and the sex of the child with boys of all ages having consistently higher numbers. The mean figure for the boys was 12.1 while for the girls it was 10.3. The age and sex distribution of eosinophilia levels is shown in Figure 4.

The weights of the children up to age seven were recorded as a per cent of normal weight-for-age using the Harvard Standard for normal. The mean per cent of normal weight was 97.2 per cent with a range from 67.3 to 157.3 per cent. There was no difference between boys and girls but there was a strong negative correlation (p < 0.001) between weight and age. The 15 babies under one year of age were significantly over the Harvard Standard. They averaged almost 120 per cent of normal weight while all the rest of the children were below 100 per cent.

Seven villages, plus the urban center, Apia, were included in the study. Analyses of variance showed that the villages where the children lived had a highly significant relationship (p < 0.01) with their hemoglobin and PCV levels. The children’s weights, eosinophil counts, and red blood cell morphology all were significantly affected by their place of residence. The children tested in the urban center of Apia and the prestigious village of Salamumu demonstrated significant differences.

<table>
<thead>
<tr>
<th>Village</th>
<th>(n)</th>
<th>Hemoglobin &lt;12</th>
<th>PCV &lt;37</th>
<th>MCHC &lt;32</th>
<th>Eosinophils &gt;6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apia</td>
<td>(13)</td>
<td>23</td>
<td>31</td>
<td>15</td>
<td>31</td>
</tr>
<tr>
<td>Luatuanuu</td>
<td>(30)</td>
<td>70</td>
<td>67</td>
<td>57</td>
<td>90</td>
</tr>
<tr>
<td>Magiagi</td>
<td>(61)</td>
<td>66</td>
<td>71</td>
<td>53</td>
<td>82</td>
</tr>
<tr>
<td>Salamumu</td>
<td>(6)</td>
<td>50</td>
<td>50</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>Vaigaga</td>
<td>(25)</td>
<td>72</td>
<td>76</td>
<td>64</td>
<td>60</td>
</tr>
<tr>
<td>Vailoa</td>
<td>(75)</td>
<td>53</td>
<td>48</td>
<td>59</td>
<td>76</td>
</tr>
<tr>
<td>Vaimea</td>
<td>(26)</td>
<td>54</td>
<td>77</td>
<td>27</td>
<td>69</td>
</tr>
<tr>
<td>Vaimoso</td>
<td>(30)</td>
<td>93</td>
<td>80</td>
<td>67</td>
<td>57</td>
</tr>
</tbody>
</table>
appreciably higher levels of hematological competency. Unfortunately, these two samples were very small but the pattern holds true when accounting for age and sex.

Discussion

The children examined in this study present a pattern of intestinal parasitosis and anaemia with specific age distributions for each condition. The relationship between the two conditions in Samoa needs more definitive analysis.

Effects of hookworm

Studies of blood loss as a result of hookworm infections are very suggestive. Scrimshaw et al.,1 reported a daily loss of 0.03 milliliters of blood resulting from each hookworm in the body. The joint FAO/WHO Expert Committee on Nutrition12 found that the average blood loss from hookworms amounted to 2.4 milliliters ± 1.06 per gram of feces for a worm load of 1000 ova per gram of feces. They showed that blood loss in some cases could reach 30 milliliters of blood per day.

More recently, Cahill13 reported that blood loss due to hookworm could exceed 200 ml per day with a concurrent iron loss of over 30 milligrams daily. Layrisse and Roche14 found that individuals with severe hookworm infestation developed anaemia because the fecal iron loss could not be met by the absorption of iron from food. They reported that the overwhelming majority of the anemias found by them in rural Venezuela were of the hypochromic, microcytic variety which parallels that reported here for the Western Samoan children. Ghai, et al.15 found similar conditions of hypochromia among children infected with hookworm.

Anemia and nutritional factors

The role of nutrition in the etiology of the anemias found in this study also needs further study. Although the figures reflecting anaemia remain high throughout the age groups examined, the trend appears to be in the direction of improvement as the children advance in age. Here the admonition of Jelliffe and Bennet16 is most pertinent, 'In no other aspect of child health is intimate knowledge of the local culture so absolutely vital for maternal and child health workers as in nutrition...'

Study of the distribution of food as well as any possible differences in types of food given as a function of age or sex might provide some valuable insights to explain these differences. Other studies17 suggest that hematological competency declines for the girls when they enter their reproductive cycles. The traditional Samoan customs that place the young women and children at the lower end of the food distribution ladder, particularly for animal protein foods critical in the hematopoietic process, are likely to be contributing factors to the present finding of widespread anaemia among the young women17 as well as the children represented in this study. Traditional practices related to food given to small children often conflict with scientific knowledge that stresses the relatively high protein requirements of the growing child. Jansen,2 in a study based on 24 hour recall, found that the overwhelming choices of food fed to the children he studied in Samoa were taro, bread, rice and cooked bananas, all high in carbohydrates and low in protein. The protein source cited most frequently was canned fish which is quite expensive and likely to follow the distribution pattern cited above.

Relationship of traditional practices

Traditionally, Samoans eat two meals a day, usually a breakfast in the early morning and one extremely large meal at the end of the day. This practice, to the extent that it is observed among the children, operates against satisfying the nutritional needs of the small, young bodies since they are unable to consume their total requirements in such infrequent feedings.

In addition, unequal food consumption is found between the sexes, even at a very early age. Random observation (CSW) suggests that the male children very early are permitted more freedom than are the females to move greater distances from their homes, thus allowing more access to diverse food intake. Young boys are frequently seen on the beaches and shallow water’s edges hunting for shellfish and other foods. Young girls, on the other hand, are invariably seen near the homes, or fales, burdened with a slightly younger child balanced on their hips. These practices may have the effect of limiting the young girls to food distributed at home. The daily home food is quite likely to revolve around the traditional, low-protein staple, taro, while the young boys have more access to additional supplementary protein and random fruit intake as well as greater quantities of food.

Widespread eosinophilia and related cultural practices

The widespread distribution of elevated levels of eosinophilia suggests that the underlying cause is common to a majority of the children, with interesting differences found among the girls and boys, as well as among the various villages sampled. Random stool specimen examinations revealed the presence of multiple infestations of the intestinal helminths: hookworm, ascaris and trichuris in all of the specimens examined. Barring unlikely contradictory findings, it is valid to assume that these parasitic infections underlie the high rates of eosinophilia. The rare child found with as much as a 50 per cent eosinophilia is likely, in addition, to be demonstrating a hematological response to the mosquito-borne microfilaria, Wuchereria bancrofti, a continuing problem in this area of the world.
An examination of the distribution of elevated eosinophil counts suggests relevant cultural practices as well as biological and micro-environmental factors combining to shape the particular patterns found. Perhaps equally significant would be an investigation of these factors among the children displaying low eosinophil counts.

Eosinophilia and age differences

As shown in Figure 4, the youngest children, aged 0.1 to 1.0 years, have the lowest rates of eosinophilia. This group also appears to have the highest weight gains. These are the infants and the toddlers who have not yet begun to be independently mobile, and, of course, have neither had sufficient time to accumulate large numbers of parasites nor to mount an effective immunological response to those acquired. This corresponds to the pattern noted by Mata, et al. in their study of children in Guatemala where they found, "Weight faltering and weight loss in general were detected after infectious disease became established".

As the children grow older and more mobile, 1.0 to 3.0 years of age, they begin to move about more freely over longer periods of wakefulness and, in the process, they also associate with an expanding group of children. As ages advance, the eosinophil levels are seen to rise until, by ages 3 to 12, the number of children with significant eosinophilic responses reaches approximately 85 per cent.

This fits the predictable pattern in which the children of this age play over a widespread area, visit back and forth extensively in the traditional Samoan manner, and engage in more interactions with a broader circle of other children than do their younger peers. The older children, also, have had a longer period of time in which to accumulate the multiple infections that evoke the demonstrated hematological responses.

Further relevant cultural practices

Further contributing factors to the existing patterns found, particularly for the hookworm and ascaris infections, derive from the traditional cultural practice of delayed toilet training, often not begun until the child approaches four, five or six years of age. An equally important traditional practice among the children displaying low eosinophil counts suggests relevant cultural practices among the children displaying low eosinophil counts.

Village differences

The variations in hematological values found among the children living in the various villages included in this study are deserving of further study. It is unfortunate that the numbers and ages represented in each village do not match, but controlling for the age and sex distributions it is evident that the children of Apia and Salamumu present a better hematological picture. Apia is the nation's capital and the only urban area. It has the only deep sea harbor and virtually the only facilities for foreign tourists. Salamumu, on the southern coast, is one of the villages most frequently used by USA Peace Corps and other outside groups. However, other differences among the villages that might affect the factors studied are not obvious. In total size Upolu is approximately 12 miles wide by 38 miles long and the inhabited area is considerably less than that. Some of the villages, such as Luatuanu'u lie right on the coast while others, for example Magiagi, are somewhat inland. It would appear that subtle differences in such things as nutrition, sanitation and child rearing practices are operating rather than gross differences in the ecological settings.

Threat of artificial feeding

Under the circumstances reported for the children tested, the current threat of intense promotion of artificial feeding looms menacingly for Western Samoa. In a related study performed among pregnant women in Western Samoa, currently in preparation, the present authors found that 42 per cent of the mothers interviewed indicated that they were considering early alternatives to breastfeeding. Similarly, Jansen found that 38.5 per cent of the children he studied in Apia, Western Samoa, had been completely weaned by five months of age and almost 70 per cent by 6-11 months. The well-documented dangers of bottle feeding given the technological deficiencies existent in the villages, with the accompanying likelihood of increased intestinal infection for the already endangered infants could be predicted to exacerbate the reported problems to the point of disaster.

On the other hand, the multinational agencies, such as Glaxo, now promoting bottle formulas in Western Samoa, could perform a valuable service by introducing iron-rich, nutritious, easily-prepared infant feeding supplements, perhaps in the nature of the porridge-type weaning food now being experimentally produced on the island. Supplements for pregnant women, particularly in their third trimester have also been shown to be beneficial in similar developing nations. Should the impressive merchandizing skills now being used to propagate the ill-advised formula feeding be converted to the promulgation of vital supplements, health needs would be well served and multinational profits might continue uninterrupted.

Summary

A hematological study was conducted of 266 children living in several villages of Western Samoa.
More than 60 per cent of the children were found to be below generally accepted normal levels in hemoglobin and packed cell volume accompanied by high rates of red blood cell dyscrasias. Leucocyte differentials disclosed widespread eosinophilia. The various negative findings appear to be related to age, sex, and village of residence. Various cultural practices and environmental factors are seen as contributing to the conditions observed.

Summary and Conclusion

This study indicates that the children in Western Samoa begin to experience problems related to anemia at a very early age. Although weight increments generally are within desirable ranges, other factors are intervening to produce health problems. These problems appear to be related to cultural practices including reliance on a diet which is low in protein and, furthermore, is hierarchically distributed without sufficient attention to the special needs of growing children. Also, as the children grow older, they experience greater exposure to environmental hazards such as the widely prevalent intestinal parasites.

There is little likelihood that eradication of the intestinal parasite problem can become a reality short of the introduction of modern water and sewage treatment throughout village communities. On the other hand, there are indications that modest modifications in certain relevant practices could produce definite improvement in the health of the children.

References