SYMPOSIUM: IMPROVING ADOLESCENT IRON STATUS BEFORE CHILDBEARING

PRESENTATION AND PUBLICATION

1999
INTRODUCTION

During the Experimental Biology meetings, held in Washington, D.C. in April, 1999, Kathleen M. Kurz (International Center for Research on Women) and Rae Galloway (World Bank/Micronutrient Initiative) co-chaired a symposium entitled, “Improving Adolescent Iron Status before Childbearing.” The symposium was sponsored by the American Society for Nutritional Sciences and was supported in part by an educational grant from Micronutrient Initiative. Research supported by the MotherCare Project/JSI was presented by five of the panelists, and their papers, collected here, were subsequently published as a supplement to The Journal of Nutrition.

The international health and nutrition community continues to struggle with the persistent failure of public health systems to address iron deficiency and the high prevalence of maternal anemia in many settings. Expanding the target population to include adolescent girls is one possible new approach. In countries with high levels of maternal mortality, it is common to find that girls are anemic well before they become pregnant. And delayed care-seeking during pregnancy means that the time for intervention is often too short to correct pre-existing anemia.

The symposium papers represent research into both biological and applied or operational questions. Looking at the functional impact of reducing anemia among adolescents, Kanani and Poojara ask whether there is an impact on physical growth? In S. Lynch’s paper, questions raised include how long do the benefits of increased iron status last if supplementation or increased dietary iron intake cannot be sustained? Both Lynch and Zavaleta et al. look at the appropriate supplement dosage for the target population, and Creed-Kanashiro investigated the impact of increased dietary iron intake on overall iron status.

Operational questions addressed the types of service delivery channels that are feasible for reaching adolescents (Creed-Kanashiro, Zavaleta, and Kanani and Poojara). The study from Indonesia investigates an approach for reaching women in the year they are likely to conceive (Jus’at et al), as well as the issue of generating demand for dietary or supplemental iron (which must be purchased out of pocket).

K. Kurz and R. Galloway summarized the main findings of the papers (including the five bound here) presented at the symposium in their introduction to the supplement:

- Iron status early in pregnancy appears to have more profound effects on birth outcomes than women’s status later in pregnancy, supporting the importance of intervention before childbearing begins.

- Iron supplementation appears to increase growth among adolescents.

- Adolescent girls can be reached with interventions through a number of channels. Examples include schools, community kitchens, and marriage registration systems.
• It is possible to increase the intake of dietary iron by adolescent girls.

Expanding the target population of iron deficiency and anemia prevention and control programs to include adolescent girls will be an important next step for programs addressing micronutrient deficiencies and other health issues for women. The clear biological rationale, together with optimistic results of operational research, indicate that intervening with adolescents has the potential to improve not only their own health and nutritional well-being, but also that of their future children.
ABSTRACT  Iron deficiency anemia (IDA) during pregnancy is associated with significant morbidity for mothers and infants. Over 50% of pregnant women in developing countries suffer from IDA. It is also prevalent among adolescent girls because the growth spurt and onset of menstruation increase iron requirements. Women who conceive during or shortly after adolescence are likely to enter pregnancy with low or absent iron stores or IDA. Iron supplementation during adolescence is one of the new strategies advocated to improve iron balance in pregnancy. However, iron requirements are highest in the second and third trimesters and the model described here indicates that iron balance at this stage depends more on adequate intakes of bioavailable iron than on the size of the iron stores at conception. Furthermore, although supplementation will correct anemia and increase iron stores in girls, the positive effect on iron status will be temporary if their diets do not contain adequate bioavailable iron. Although iron status in early pregnancy may be improved if the period of supplementation continues up to the time of conception, supplementation before pregnancy should be viewed as an additional strategy to supplementation during the second and third trimesters.  J. Nutr. 130: 448S–451S, 2000.

KEY WORDS: • iron supplementation  • adolescence  • pregnancy

Iron deficiency anemia reduces physical work capacity and the ability to earn income (Dallman 1982, Levin 1986). Verbal learning, memory and physical performance may also be impaired in iron-deficient adolescent girls (Bruner et al. 1996, Nelson 1996). If these young women become pregnant, they are exposed to additional risks. Iron deficiency anemia during pregnancy is associated with premature delivery, low birth weight and increased perinatal mortality (Bothwell et al. 1979, Godfrey et al. 1991, Scholl et al. 1992). Infants born to iron-deficient mothers also have a higher prevalence of anemia in the first 6 mo of life (Preziosi et al. 1997). Maternal mortality is increased in women whose hemoglobin levels fall to below 6–7 g/dL (Bothwell et al. 1979).

The consequences of iron deficiency anemia outlined above are cogent reasons for supporting programs designed to reduce its prevalence in pregnancy. Routine iron supplementation is recommended in the second and third trimesters because most women cannot meet their increased iron requirements from dietary sources alone (Bothwell et al. 1979). However, although efficacious in carefully conducted clinical trials, its effectiveness when implemented on a national scale has been disappointing (Yip 1994). Putative reasons for the discrepancy between efficacy and effectiveness include the cost and logistics of supplying iron tablets, the inadequacy of delivery systems at the primary care level, insufficient counseling about the potential benefits and side effects of iron supplements, and poor compliance among pregnant women. Programmatic alternatives for delivering iron supplements are therefore being sought.

It has been suggested that adolescence may be an optimal time in which to deliver iron supplements to build iron stores before pregnancy. Physiologic needs are high at this stage of life because of increased requirements for the expansion of the blood volume associated with the adolescent growth spurt and the onset of menstruation (Dallman 1992). It is also a time when supervised iron supplementation may be possible, e.g., in school-based programs. However, because iron absorption is closely regulated in the body and because the body limits the size of iron stores, it is questionable whether supplementation during adolescence can in fact build sufficient stores before pregnancy to substitute for the need for supplementation during pregnancy. This analysis is an attempt to predict the potential benefit of such programs for iron balance in subsequent pregnancies. It is based on an examination of the physiologic factors controlling iron balance before and during pregnancy.
Iron requirements in pregnancy

Physiologic iron requirements are three times higher in pregnancy than they are in menstruating women. Approximately 1200 mg must be acquired from the body iron store or from the diet by the end of pregnancy to meet both the requirements of the mother for the expansion of her circulating red cell mass and the demands of the developing fetus. The average requirement for a menstruating woman for the same period of time is ~400 mg. The increased requirement is therefore ~800 mg.

The demand for additional iron is not spread evenly throughout pregnancy. In the first trimester, requirements are actually reduced because menstruation has ceased, the demands of the fetus are still small and the expansion of the maternal red cell mass has not yet started to occur. The need for additional iron commences early in the second trimester and reaches a peak toward the end of the third trimester, when requirements rise to between 4 and 6 mg/d.

Sources of the additional iron required during pregnancy

The relative importance of iron stores on the one hand and increased iron absorption on the other is best illustrated by examining iron balance during pregnancy in women from industrialized countries. They enter pregnancy with adequate stores. The additional iron is derived from both the stores and increased absorption. The serum ferritin level is the best measure of the size of iron stores; 1 µg/L serum ferritin = 8 mg storage iron in an adult (Bothwell et al. 1979). The 50th percentile for serum ferritin concentrations reported in the National Health and Nutrition Examination Survey (NHANES) III for women in the United States aged between 20 and 44 y is 36 µg/L (Looker et al. 1991). This value predicts a mean iron store of ~300 mg. Therefore the average size of iron stores for women entering pregnancy in the United States is ~300 mg. Because the estimated total additional requirement during pregnancy calculated above is 800 mg, the average woman must absorb 500 mg (~2 mg/d) more iron than she required while menstruating to avoid a negative iron balance.

However iron absorption is regulated by the size of body iron stores (Finch 1994). The operation of this important regulatory process is not affected by the advent of pregnancy. Women who enter pregnancy with adequate iron stores absorb relatively little iron during the first trimester. Stores are utilized first as the demand for iron increases in the second trimester. Absorption is accelerated only after there has been a substantial fall in the size of the iron store (Bothwell et al. 1979, Hallberg and Hulten 1996). At the time of the greatest need in late pregnancy, stores are essentially exhausted in most women. Virtually all of the iron is derived from absorption.

A study carried out by Barrett et al. (1994) in a group of women living in the United Kingdom demonstrates the relationship between iron stores and nonheme iron absorption in pregnancy. These women consumed a bioavailable diet that supplied about 12 mg nonheme iron/d. Absorption of the heme iron in the diet was not measured. They received no iron supplements. The relevant observations drawn from the study are summarized in Table 1.

The results show that the women utilized iron stores first. Absorption increased markedly only after most of the storage iron had been used. At the time of highest iron requirement in the third trimester, virtually all of the iron was derived from absorption. The women were able to reach the end of pregnancy without becoming anemic because they entered pregnancy with adequate iron stores and their diets contained a sufficient quantity of highly bioavailable iron to allow absorption to be increased approximately ninefold. The diets of women in developing countries do not contain sufficient bioavailable iron to meet these needs during the second and third trimesters even if iron stores are adequate at the beginning of pregnancy. Supplementation will be necessary in the second and third trimesters of pregnancy even if supplementation before conception improves iron storage status in the first trimester.

Potential benefits of iron supplementation during adolescence

Iron supplementation during adolescence is expected to have significant benefits unrelated to pregnancy, including a reduction in the prevalence of anemia, improved physical performance and better cognitive function. It may also have benefits for pregnancy. A reduction in the burden of anemia for adolescents entering pregnancy would be anticipated. Furthermore, some studies suggest that an adequate iron supply during the first trimester may have a beneficial effect on infant birth weight (Scholl et al. 1992). However it is important to note that the benefit of iron supplementation in terms of

### Table 1

<table>
<thead>
<tr>
<th>Week of gestation (wk)</th>
<th>Hemoglobin (g/L)</th>
<th>Serum ferritin (µg/L)</th>
<th>Iron store (mg)</th>
<th>Absorption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>127</td>
<td>43.8</td>
<td>350</td>
<td>7.2</td>
</tr>
<tr>
<td>24</td>
<td>116</td>
<td>11.1</td>
<td>88</td>
<td>36.3</td>
</tr>
<tr>
<td>36</td>
<td>116</td>
<td>5.4</td>
<td>43</td>
<td>66.1</td>
</tr>
</tbody>
</table>

1 Data from Barrett et al. (1994).
2 Calculated (1 µg/L serum ferritin = 8 mg storage iron).

### Table 2

**Predicted effect of iron supplementation (different doses for ~12 wk) on stores and the percentage of iron absorption**

<table>
<thead>
<tr>
<th>Supplement dose (mg)</th>
<th>Average daily iron intake (mg)</th>
<th>Initial absorption (mg (%))</th>
<th>Final absorption (mg (%))</th>
<th>Initial ferritin (µg/L)</th>
<th>Final ferritin (µg/L)</th>
<th>Final iron store (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12.0</td>
<td>2.0 (16.7)</td>
<td>2.0 (16.7)</td>
<td>10</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>60/wk</td>
<td>20.6</td>
<td>3.4 (16.7)</td>
<td>2.0 (9.7)</td>
<td>10</td>
<td>17.2</td>
<td>138</td>
</tr>
<tr>
<td>120/wk</td>
<td>29.0</td>
<td>4.8 (16.7)</td>
<td>2.0 (6.9)</td>
<td>10</td>
<td>24.2</td>
<td>194</td>
</tr>
<tr>
<td>30/d</td>
<td>42.0</td>
<td>7.0 (16.7)</td>
<td>2.0 (4.7)</td>
<td>10</td>
<td>35.5</td>
<td>279</td>
</tr>
<tr>
<td>60/d</td>
<td>72.0</td>
<td>12.0 (16.7)</td>
<td>2.0 (2.8)</td>
<td>10</td>
<td>60.0</td>
<td>480</td>
</tr>
</tbody>
</table>
The percentage of iron absorption can be calculated from the well-established relationship between the size of iron stores and the percentage of iron absorption (Cook 1990, Hulten et al. 1995).

Table 2 shows the predicted changes in absorption and the size of the iron store in teenage women with relatively high menstrual losses (70th percentile for healthy Western teenagers, Hallberg and Rossander-Hulten 1991) who are given various supplements. This example was chosen because women with high menstrual losses are at greatest risk for iron deficiency.

The predicted increase in iron stores ranges from 58 mg (138 – 80) for women receiving a weekly supplement of 60 mg to 400 (480 – 80) in those receiving a daily 60-mg supplement. Iron stores will be accumulated initially at a rate ranging between 1.4 mg/d for the 60 mg/wk supplement (absorption 3.4 mg/d, excretion 2 mg/d) and 10 mg/d for the 60 mg/d supplement (absorption 12 mg/d, excretion 2 mg/d). The rate falls exponentially as the stores increase, eventually returning to the balanced state with a daily absorption equivalent to the daily loss (2 mg in this example). The average rate of storage iron accumulation over the whole period of adaptation to the higher iron intake will therefore equal one half of the initial rate, ranging from 0.7 mg/d for the 60 mg/wk supplement to 5 mg/d for the 60 mg/d supplement. In all cases, the new steady state will be reached in about 80 d. The illustration is for an individual with a normal hemoglobin level. Anemic women will take a longer period of time to reach the new steady state because of the iron requirement for correcting the anemia.

If the supplement is withdrawn, the percentage of iron absorption from the diet will be too low initially to maintain iron balance because the store regulator has been set for the higher iron intake during the period of supplementation. Iron will be withdrawn initially from the store to make up the shortfall. The initial rate of loss from stores will equal the difference between the requirement and the rate of absorption at the time the supplement is withdrawn. As the stores are used up, the rate of absorption will increase proportionately until it again matches requirements. The average rate of consumption of storage iron will therefore equal half the initial rate. The period of time between removal of the supplement and reestablishment of the presupplementation steady state is expected to be between 5 and 16 mo (Table 3). It is important to note, however, that iron will be derived initially primarily from the store. Absorption will rise in an exponential fashion in concert with reduction in iron storage size. As a consequence, half of the iron store will be lost over a period considerably less than half the time required to return to the original steady state. The amount of storage iron available for pregnancy will therefore be relatively small if the supplement is discontinued several months before conception.

The results of a recent study by Angeles-Agdeppa et al. (1997) provide some support for the validity of the model presented. They reported the serum ferritin levels in adolescent women given various supplemental regimens for 12 wk. The highest values (63.4 µg/L) were achieved by the women given 60 mg/d. In all cases, serum ferritin levels were again close to the baseline levels 6 mo after the supplements had been discontinued. It is therefore evident that the improvement in storage iron status in early pregnancy that can be achieved by supplementation during adolescence is modest if more than a few months separate the end of the supplementation period from the time of conception.

**LITERATURE CITED**


An Innovative Approach for Anemia Control

Reaching Young Indonesian Women through Marriage Registries:
problems in Indonesia. Studies have found more than one half of pregnant women in the country are suffering from nutritional anemia (Demographic and Health Survey 1991). Aware of the decrease the prevalence of anemia during the last decade is the Ministry of Health (MOH) (MOH 1993). The main program to provision of no cost iron-folate (IFA) tablets (60 mg elemental iron and 0.25 mg folic acid) to women throughout the country via health providers and facilities. The United States Agency for International Development (USAID)-funded MotherCare project has been working in collaboration with the Ministry of Health, Indonesia, in three districts (Hulu Sungai Selatan, Banjar and Barito Kuala) of the South Kalimantan province of Indonesia since 1994. The project has implemented a comprehensive program to improve maternal and neonatal health, including decreasing the prevalence of maternal anemia. Initially, the anemia control program focused on increasing the demand for and consumption of IFA tablets by pregnant and postpartum women. To ensure that the demand is supported by adequate supplies of IFA tablets, MotherCare initiated discussions with the Ministry of Health and three pharmaceutical companies to produce an affordable package of IFA tablets. These companies now produce low cost IFA tablets, which are distributed through private sector channels including pharmaceutical warehouses, small shops and the Indonesia Midwifery Organization, at the district and subdistrict levels. At the beginning of the program in South Kalimantan, a baseline study conducted in the three districts showed that 45.2% of pregnant women were suffering from anemia. Because of this high prevalence, it was assumed that many women enter pregnancy with either anemia or iron deficiency. In addition to strengthening the existing antenatal iron program, it is necessary to improve iron status before pregnancy (Achadi et al. 1997). This is confirmed by the MOH policy to alleviate nutritional anemia not only in pregnant women but during the last decade is the Ministry of Health (MOH) (MOH 1993). The main program to provision of no cost iron-folate (IFA) tablets (60 mg elemental iron and 0.25 mg folic acid) to women throughout the country via health providers and facilities. The United States Agency for International Development (USAID)-funded MotherCare project has been working in collaboration with the Ministry of Health, Indonesia, in three districts (Hulu Sungai Selatan, Banjar and Barito Kuala) of the South Kalimantan province of Indonesia since 1994. The project has implemented a comprehensive program to improve maternal and neonatal health, including decreasing the prevalence of maternal anemia. 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In addition to strengthening the existing antenatal iron program, it is necessary to improve iron status before pregnancy (Achadi et al. 1997). This is confirmed by the MOH policy to alleviate nutritional anemia not only in pregnant women but
also in women before their first pregnancies. As part of that policy, the MOH is promoting IFA supplements for female workers and school girls.

The government has been implementing a tetanus toxoid (TT) immunization program targeted to all women registering for marriage. This program is conducted collaboratively between the MOH and Ministry of Religious Affairs (MOR). Because all couples register for marriage with the subdistrict Religious Office and receive marriage counseling, it is also a convenient time to give them health messages. Under the TT program, at the time of registration, women must obtain a TT immunization from the subdistrict health center before couples can obtain their marriage registration certificate.

Given this existing health program and the availability of IFA tablets through private sector channels, MotherCare and the MOH initiated a program to introduce IFA supplements to newly wed women and improve iron status before pregnancy through the MOR dissemination system.

SUBJECTS AND METHODS

The program was implemented in the three districts of South Kalimantan beginning July 23, 1998 and used an information, education and communications (IEC) approach to improve knowledge of anemia and to increase demand for IFA tablets. IEC messages on why and how to take IFA tablets were developed through qualitative research with women of reproductive age. Specific messages for marriage-age women were developed in a separate qualitative study using interviews and focus group discussions with marriage-age women, couples preparing to marry and newlywed couples. The IEC activity, including radio spots, was launched in late July, 1998. At that time and thereafter, all couples registering at the subdistrict Religious Office were counseled on the causes and consequences of anemia and the importance of taking IFA tablets. The couple was given a pocket-sized booklet and a calendar containing messages on anemia and taking IFA tablets; the woman was strongly encouraged to obtain a TT shot and buy and consume 30–60 IFA tablets before becoming pregnant. Women also were counseled that once they have conceived, they should follow the IFA supplementation protocol for pregnant women, which advises them to take at least 90 IFA tablets during pregnancy. Information about where to purchase IFA tablets was reinforced by health care providers at the subdistrict health center when the women came for the TT shot. A radio spot on anemia and IFA tablets was aired at the same time through the five most popular private radio stations in South Kalimantan.

To assess the effectiveness of this program, a cohort of women to be married in Banjar district was followed. All women registering at the subdistrict Religious Office between July 27 and August 22, 1998 were enrolled. The women were asked to go to the subdistrict health center to obtain a TT shot, a finger prick of blood for a hemoglobin (Hb) measurement using the Hemocue and mid-upper-arm circumference (MUAC) measurement using a tape produced by Ross laboratory. A Hb of <120 g/L was used as the cut-off for anemia and 23.5 cm was used as the cut-off for MUAC. Women were also interviewed about IFA tablet consumption and their knowledge about anemia and any IEC materials they might have seen. All data were collected by health center nurse-midwives who had been trained in assessment techniques.

One month after registration, women were asked to return to the subdistrict health center to obtain the second TT shot and Hb and MUAC measurements. The women were asked about the number of IFA tablets consumed, the number of packages (30 IFA tablets each) purchased, and the number of IFA tablets left in the packages. The women were also asked whether they received IEC materials from subdistrict religious officials. Those who did not come to the health center were visited by the nurse midwives at their home. A second follow-up monitoring was conducted 3–4 mo later when the health center nurse-midwives visited all newly wed women in their homes to assess Hb and reinterview study participants about IFA tablet consumption.

RESULTS

The prevalence of anemia at baseline was 23.8%; at the first monitoring, it was 14.2%, and at second monitoring, it was 14.0%, giving a 40% decrease in anemia prevalence over the course of the program. This was a significant decrease (P < 0.05). By the second monitoring, 23% of women reported that they were pregnant. A cut-off of <110 g/L was used for Hb determination in these women. At first monitoring (1 mo after baseline), the average number of IFA tablets consumed was 26.3 ± 8.8 of 35 possible tablets; at the second monitoring (3–4 mo after the baseline), the total number of tablets consumed was 53.9 ± 19.9 of 60 possible tablets.

Seventy-six percent (261 out of 344) of the registered newly wed women were available for the first monitoring at 1 mo postbaseline. Those lost to follow-up migrated to new work locations with their husbands. At the second monitoring, among those 261 women visited, 15% (40 women) had left the research area for the same reason. Those lost to follow-up were similar to those who participated in the first monitoring in baseline age, MUAC, and Hb, but had slightly higher educational levels (45% of those lost to follow-up had some secondary school vs. 30% of those who participated in the first monitoring).

The majority of the women at baseline had received a TT shot at the subdistrict health center and had not received any information on anemia and IFA tablets before the time of the IEC program-launching. One month after the baseline, most of the newly wed women returned to the health center for the second TT shot. All women had heard about IFA tablets and more than two thirds of the newly wed women had received the IEC materials (booklet and calendar) from the Religious Affairs official.

At the first monitoring, the majority (98%) of the newly wed women reported that they had taken IFA tablets, 59.1% of subjects consumed IFA tablets every day and 56% of the entire sample of women had taken ≥30 of 35 possible tablets. Only those who said they consumed IFA tablets everyday, 35.8% experienced side effects. Among those who did not take IFA tablets everyday, 65.7% stated they forgot to take the tablets and about three fourths took <30 IFA tablets. As shown in Figure 1, the Hb levels of newly wed women who consumed <30 (mean 19.4 ± 7.9) and ≥30 (mean 31.6 ± 3.9) IFA tablets were 128.9 (+11.8) and 131.3 g/L (+11.3), respectively, giving a mean change in Hb at the first monitoring of Hb of 2 g/L; this difference was not significant.

However, the effect of the number of IFA tablets consumed is significant for the anemic group. As depicted in Figure 2, the increase in Hb among the anemic newly wed women who consumed ≥30 (mean 31.6 ± 3.34) IFA tablets was 15.9 g/L compared with 8.5 g/L among those who consumed <30
(mean 18.4 ± 8.72) IFA tablets. This resulted in a significant difference ($P = 0.046$) of 7.4 g/L in Hb increase between the two groups.

**DISCUSSION**

This study found that reaching Indonesian women with an educational intervention before pregnancy through the marriage registration system and making low cost IFA tablets available in the community were effective ways in which to decrease anemia and improve their iron status. There was a 40% decrease in anemia prevalence between baseline and the first monitoring (1 mo after the baseline). Among women anemic at baseline, the increase in hemoglobin was significant.

Women were receptive to the intervention, probably because almost 70% of them received IEC materials. However, >30% of the women in the study did not receive IEC materials. Although the program recommended that the MOR officer give the IEC materials to the couple, in many cases it was the parents who went to the subdistrict MOR office to register the couple instead of the couple themselves. To reach all women, it would have been prudent to inform the MOR Officers to counsel parents when they came to register the couple. In addition, interviews with women revealed that in one subdistrict, health center staff rather than MOR staff counseled women, but the materials were distributed by both the health center and the MOR office. The possibility exists that there was a shortage of materials in either site.

Despite the fact that not all women received IEC materials, 98% of them consumed IFA tablets. These results parallel the findings from interviews with women that more women consumed IFA tablets than received educational materials. The high level of compliance with the purchase and consumption of IFA tablets can be explained by the fact that it was strongly recommended by a respected and influential member of the community. However, the behavior of newly wed women also was influenced by information they had heard from radio spots (source of information on IFA tablets for 36.3%), from the health center and community midwives who counseled them to buy and consume iron, or even from their parents who registered them for marriage and may have seen the IEC materials or been told about the program. Another reason for their high level of participation might be that these women are more receptive to behavior change than their older counterparts.

About 7% of the study population had already received the IEC materials at baseline. Some women came to the subdistrict MOR office and received IEC materials before being enrolled in the program and going to the Health Center where they were interviewed. This was interesting because it suggested that girls heard radio spots and responded by going directly to the MOR office to obtain more information about what they thought was an important subject.

One problematic result of the study was that there was no difference in the prevalence of anemia between the first monitoring and the second monitoring. This result may be a function of the sample size not being large enough because as anemia prevalence decreases, a larger sample size would have been required to detect a change. Another explanation is the time lag of ~3 mo between the last IFA consumption (the 60th tablet) and the Hb measurement at the 2nd monitoring. It is probable that taking 60 tablets will help to improve iron status, but reverting back to the same environment (i.e., poor dietary intake) will mean that iron stores will be called upon to make up for inadequate dietary intakes. The period was not long enough to fully deplete stores and cause an increase in anemia prevalence, but anemia prevalence could not be expected to decrease further without continued additional iron intake or addressing other causes of anemia (e.g., malaria). This result has raised some concern that the women in this population have marginal iron stores and therefore are sensitive to any change. Short-term interventions before the first pregnancy may help build iron stores but will not be adequate to avert iron deficiency during pregnancy. Continuing iron supplementation during pregnancy is still required to address total iron deficiency in pregnancy.

Although a marriage registration program such as this may be limited to Indonesia, the use of respected members of the community could be a way in which to counsel young women about important health issues before they marry. In addition to improving maternal iron status before pregnancy, this approach to anemia prevention lays the foundation for expectant mothers' heightened awareness of the importance of iron during pregnancy. More follow-up is required with the women involved in this type of program to confirm whether they were more likely to obtain and take IFA tablets when they were pregnant.

**ACKNOWLEDGMENTS**

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**LITERATURE CITED**

Iron deficiency anemia (IDA) is considered the most prevalent nutritional deficiency in the world (ACC/SCN 1992), and small children and women of reproductive age are most affected (WHO 1992). Global estimates suggest that 47% of nonpregnant women and 60% of pregnant women are anemic (Royston 1982). A recent survey in Peru found that 57% of children <5 y of age and 36% of women were anemic (INEI 1997). IDA reduces physical activity and affects behavior, psychomotor development and school performance (Lozoff et al. 1991, Soemantri et al. 1985, Soewondo et al. 1989). In pregnancy, IDA is associated with increased risk of preterm delivery, low birth weight and higher maternal mortality (Murphy et al. 1986, Scholl et al. 1992, Viteri 1994).

Iron supplementation is one of the recommended strategies to improve iron status in the vulnerable groups. In many countries such as Peru, iron supplements are given to pregnant women who receive checkups at the health centers. However, iron deficiency anemia remains high, affecting 54% of Peruvian pregnant women (Zavaleta et al. 1993). Additional strategies to prevent and treat anemia must be considered to reduce the high prevalence of IDA in women before they become pregnant. One important option, as yet untested, is to give iron supplementation to adolescent girls who are attending school.

The effectiveness of daily iron supplementation programs has been questioned because of the low efficiency of health services and the lack of compliance of the target groups (Schultink et al. 1995). The use of intermittent supplementation schedules has been suggested as a way in which to improve compliance by reducing side effects. Several studies conducted in anemic preschool and school-aged children have shown that the efficacy of an intermittent iron supplementation schedule is similar to that of daily dosing (Schultink et al. 1995). This study aimed to assess the feasibility, efficacy and acceptability of reducing anemia in adolescent girls attending public school in Lima, Peru using daily or intermittent iron supplementation.

SUBJECTS AND METHODS

The study was conducted from August to December 1996 in a public secondary school in Villa El Salvador, a periurban shantytown in Lima, Peru. Subjects were adolescent girls, 12-18 y old, who met the following criteria: living in the community for at least 6 mo before...
the study, healthy, nulliparous, menstruating regularly in the last 3 mo, had not taken any multivitamin-mineral supplement in the last 6 mo and a hemoglobin (Hb) > 80 g/L. Adolescent girls and their parents or guardians signed the informed consent form. The Ethical Committee of the IIN approved the protocol.

This was a double-blind, placebo-controlled study with 312 subjects assigned at random to one of the following groups: 1) 60 mg iron as ferrous sulfate, daily from Monday to Friday; 2) 60 mg iron as ferrous sulfate/d, two times per week (intermittent) and 3) placebo, daily from Monday to Friday. The supplements were given for 17 wk. All tablets had the same brick color and shape and were produced for this study by a local pharmaceutical company (Instituto Quimioterapico S.A Lima, Peru) and distributed in coded blister packages. Supplements were administered daily at school, between meals, together with a sweetened flavored drink without ascorbic acid and under the close supervision of a field worker who also recorded acceptability and side effects. To ensure participation, girls received counseling on the benefits of taking iron tablets and about the possibility of side effects.

At entry, general socioeconomic information, weight, height and midupper-arm circumference were recorded. At the beginning and end of the trial, a blood sample was obtained by venipuncture for analysis of Hb, serum ferritin (SF) and free erythrocyte protoporphyrin (FEP). Hb was analyzed by the cyanometahemoglobin method, SF by ELISA using human antiferritin and antiferritin peroxidase antibodies from DAKO, and FEP by a hematofluoremeter. The cut-offs were defined as follows: for anemia, Hb < 120 g/L; for iron deficiency, SF < 12 µg/L; and for FEP, < 80 µg/L. At the beginning and end of the study, a digital scale (SECA, UK) measured weight to the nearest 0.1 kg and a portable wooden stadiometer measured height to the nearest 0.1 cm.

A total of 312 girls started the trial and 16 dropped out the study. Of these 16, eight girls moved to another school, two girls disliked the tablets, four girls claimed that side effects (constipation, gastric discomfort, headache) were the reason for withdrawal and two girls were absent at the time of final evaluation, although they took the tablets. Girls who withdrew and girls who concluded the study had the same age, weight and Hb.

Data analysis was done using the SPSS/PC Statistical Program V.7.5 (SPSS, Chicago, IL). Data analysis included descriptive statistics, paired t test, chi-square test, nonparametric tests and analysis of covariance with initial Hb as a covariate. Hb values were normally distributed; SF and FEP were not normally distributed and were normalized by using a natural logarithm transformation.

RESULTS

Adolescent girls participating in the three supplement groups were similar in weight, height, body mass index (BMI) and iron indicators. They were also similar in indicators of socioeconomic status, such as parents’ education, housing materials and home services. Girls took 94% of the expected dose of 85 pills, and the median consumption was 80 tablets in the three groups. Few girls in the three groups reported side effects (e.g., gastrointestinal problems or headache) during the intervention, and there was no significant difference in the frequency of side effects reported by any group.

Changes of iron status in the subjects are presented in Table 1. Final Hb values in both iron-supplemented groups (daily and intermittent) were significantly higher than those in the placebo group (P < 0.05), and the daily supplementation group had significantly higher Hb than the intermittent group (P < 0.05). There were no differences in SF and FEP between daily and intermittent groups at the end of the study. SF did not change in the two iron-supplemented groups, but decreased significantly in the placebo group (P < 0.05). FEP decreased in the daily and intermittent groups (P < 0.05) but remained the same in the placebo group. The proportion of anemic subjects was similar in the three groups at entry into the trial, i.e., 19.8% in the daily, 18.4% in the intermittent and 15.5% in the placebo group. At the end of the trial the proportion of anemic subjects in the daily group (10.9%) was lower compared with the intermittent (17.3%) and the placebo (22.7%) groups (P < 0.05).

Results were more pronounced among the anemic subjects than in the entire group. At postintervention, the final Hb concentrations were higher in the iron-supplemented groups than in the placebo group (P < 0.05) (Fig. 1). The response in Hb concentration was correlated with initial Hb values and did not change in the placebo group (P < 0.05). For the anemic subjects in all groups, the gains in Hb were 11.1 g/L (daily), 6.8 g/L (intermittent) and 1.6 g/L (placebo). Hb concentrations among the nonanemic subjects did not change during the time of supplementation in the daily group. However, Hb concentrations declined in the placebo and the intermittent groups (P < 0.05) in nonanemic girls.

DISCUSSION

Iron supplementation given at school improved iron indicators in adolescent girls. The response in subjects receiving daily iron was most efficacious at increasing Hb concentration and reducing the proportion of anemic subjects.

These results are different from the findings in other studies comparing intermittent and daily doses of iron in Indonesian preschool children (Schultink et al. 1995). In animal experiments, a similar effect on Hb for daily and intermittent doses has been observed, and it has been argued that the intermittent dose allows time for the turnover of the intestinal cells that have better absorptive capacity than cells that have recently absorbed iron (Viteri 1996). However, similar levels of absorption between the daily and weekly doses have been reported in humans (Cook and Reddy 1995). The better Hb response and a significant reduction in anemia prevalence observed in girls taking iron supplements daily in this study are explained by the greater amount of iron delivered. The intermittent dose was effective in improving the iron status of this population, although not as effective as the daily dose.

Acceptability of the iron supplements in this study was excellent because girls received information before and during the trial about benefits of taking iron, the possibility of side effects and that side effects or taking iron did not cause adverse
FIGURE 1 Changes in hemoglobin levels by initial anemia status in adolescent girls in Lima, Peru. NS, not significant.

health effects. Side effects were not a serious problem in any of the groups whether supplemented or not with iron, and the dose of iron (from no iron to 60 mg/d) had no significant effect. As a result, compliance was high.

In conclusion, iron supplementation given through the school system could be an intervention to improve iron status and prevent anemia in adolescent girls. It might also reduce the risk of iron deficiency and anemia before pregnancy, particularly among girls who marry and begin childbearing shortly after they finish school. Daily supplementation is more effective than intermittent supplementation in increasing Hb concentrations; however, the intermittent supplementation dose was also effective and could be used if given over a longer period than in this study. Targeting anemic girls might also be considered because the increase in Hb was highest in anemic girls, although this must be weighed against the cost and acceptability of screening girls.

ACKNOWLEDGMENTS

The authors would like to thank the adolescent girls from the Francisco Bolognesi School in Villa El Salvador, Lima, Peru for their participation in this study. We also appreciate the collaboration of the parents and teachers and the excellent fieldwork of Frida Sanchez and Amelia Rodriguez.

LITERATURE CITED


Supplementation with Iron and Folic Acid Enhances Growth in Adolescent Indian Girls

Shubhada J. Kanani and Rashmi H. Poojara

Department of Foods and Nutrition, M. S. University of Baroda, Vadodara, India

ABSTRACT The prevalence of anemia is high in adolescent girls in India, with over 70% anemic. Iron-folic acid (IFA) supplements have been shown to enhance adolescent growth elsewhere in the world. To confirm these results in India, a study was conducted in urban areas of Vadodara, India to investigate the effect of IFA supplements on hemoglobin, hunger and growth in adolescent girls 10-18 y of age. Results show that there was a high demand for IFA supplements and >90% of the girls consumed 85 out of 90 tablets provided. There was an increment of 17.3 g/L hemoglobin in the group of girls receiving IFA supplements, whereas hemoglobin decreased slightly in girls in the control group. Girls and parents reported that girls increased their food intake. A significant weight gain of 0.83 kg was seen in the intervention group, whereas girls in the control group showed little weight gain. The growth increment was greater in the 10- to 14-y-old age group than in the 15- to 18-y-old group, as expected, due to rapid growth during the adolescent spurt. IFA supplementation is recommended for growth promotion among adolescents who are underweight. J. Nutr. 130: 452S–455S, 2000.

KEY WORDS: adolescent girls growth iron folic acid India

Iron deficiency anemia is a widespread deficiency in adolescents of developing countries. In an 11-country study >40% of adolescents were anemic (hemoglobin [Hb]< 115 g/L) in the Asian countries including Nepal and India (Kurz 1996). A review of Indian studies on anemia in adolescent girls revealed that >70% of adolescent girls in low income communities had Hb levels <110 g/L. When the WHO cutoff of 120 g/L was applied, the prevalence was even higher (80–90%) (Kanani and Ghanekar 1997).

Iron requirements are increased during adolescence, reaching a maximum at peak growth, and remaining almost as high in girls after menarche to replace menstrual losses. Adolescent iron requirements are even higher in developing countries because of infectious diseases and parasitic infestations that cause iron loss, and because of low bioavailability of iron from diets limited in heme iron. Low iron status among adolescents may limit their growth spur (Brabin and Brabin 1992). Adolescent girls are at risk of compromised physical and mental functions, and they may also be at increased obstetric risk, once pregnant. In India, to combat the pervasive problem of anemia, initiation of iron supplementation early in the adolescent years has been recommended (Gopalan 1989), but is not yet being implemented.

According to Gillespie (1998), iron and folic acid supplementation is one of the most important nutritional interventions for adolescent girls. Folic acid is included within the iron supplement to prevent folate deficiency, which is implicated in the etiology of anemia and associated with neural tube defects of the newborn. Supplementation with folic acid before pregnancy offers a better chance of preventing neural tube defects than if given during pregnancy (Gillespie 1997).

Iron-folic acid (IFA) supplementation has been shown to enhance adolescent growth. In Kenya, Lawless et al. (1994) supplemented 87 primary school children with 55 mg elemental iron per day for 14 wk and reported a positive effect on growth and appetite that was significantly better than that in children receiving the placebo. The positive effect of iron supplementation on growth of their subjects was likely due to their improved appetite and increased food intake. If iron does enhance growth, it can be promoted in programs instead of food supplementation, which is more expensive and less feasible.

To confirm the results of Lawless et al. (1994) in the South Asian context, we undertook an intervention study to investigate the feasibility, compliance and effect of giving daily IFA supplements for 3 mo on Hb levels, perceived hunger and growth of unmarried, urban, low income adolescent girls in Vadodara (Baroda), Gujrat, India.
SUBJECTS AND METHODS

Sample. This study was conducted in three low income communities of Vadodara, a community in which the first author has worked closely with adolescent girls for 7 y on community-based youth projects implemented by a voluntary organization, the Baroda Citizens Council. Because many girls marry before the age of 18, and this study enrolled only unmarried girls, the sample of 15- to 18-y-old girls was considerably smaller than the sample of 10- to 14-y-old girls. For feasibility reasons and to ensure similar sample sizes, the two smaller communities were combined with respect to the intervention. Through random allocation, the larger community became the experimental group and the two smaller ones became the control group.

All unmarried girls 10-18 y of age, residing in the three communities, were considered eligible for the study and agreed to participate (n = 210). Pre- and postintervention data were available for 203 girls for the girls before and after intervention (see Fig. 1). Methodological development of the scales was based on the visual analog scale for the perception of pain (Mottola 1993, Stratton et al. 1998). Data for the two scales were as follows: a checklist of questions regarding hunger, from which the answers were scored and added into a composite score; and a rating scale (1-10) of the degree of hunger as perceived by the subject, i.e., the lower the score, the lower the feeling of hunger (Fig. 1).

RESULTS

Baseline socioeconomic status, housing conditions, water supply and sanitation, and health facilities were similar in both communities. Similarly, baseline Hb and BMI did not differ (Table 1).

A high level of compliance with the supplements was achieved, i.e., 90% of the girls consumed >85 of the 90 tablets provided. Contributing factors could include the rapport with the girls through previous programs and the semimonthly monitoring. After the intervention, the girls requested that the tablets be continued, saying they felt an improved sense of well-being and were hungrier and more energetic. Baroda Citizens Council complied with this request by continuing to implement the supplementation program for girls who continued to be anemic.

Table 2 summarizes the effect of the intervention on Hb levels, hunger scores, weight gains and BMI in the experimen-

### TABLE 1

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Experimental group (A)</th>
<th>Control group (B)</th>
<th>Chi-square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age range, y</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Mothers literate</td>
<td>10-18</td>
<td>101</td>
<td>101</td>
</tr>
<tr>
<td>House has individual toilet</td>
<td>10-18</td>
<td>101</td>
<td>102</td>
</tr>
<tr>
<td>Age of girls</td>
<td>10-18</td>
<td>101</td>
<td>102</td>
</tr>
<tr>
<td>Family size</td>
<td>10-18</td>
<td>101</td>
<td>102</td>
</tr>
<tr>
<td>Hemoglobin, g/DL</td>
<td>10-14</td>
<td>75</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Body mass index</td>
<td>10-14</td>
<td>81</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>15-18</td>
<td>20</td>
<td>13</td>
</tr>
</tbody>
</table>

1 NS, values are nonsignificant (P > 0.05).
tal compared with the control group. There was an increment of 17.3 g/L Hb in the group that received IFA supplementation, whereas the controls showed a slight decrease in Hb levels. Increase in perceived level of hunger was consistently higher in the experimental group after intervention compared with the control group. Spontaneous responses from several experimental group subjects as well as their parents indicated that the food intake of the girls had increased during the study period. Some girls specifically stated that they ate more food than before the study. A significant weight gain of 0.83 kg was seen in the experimental group, whereas the controls showed little weight gain. The experimental group also had a significantly better BMI response to supplementation than the control group. In the case of BMI, however, the experimental group exhibited no change, whereas the control showed a decrease. This may have occurred because the m² term (denominator of BMI) was increasing at a faster rate than weight (numerator). Differences in the change in height-for-age were not analyzed because they were more pronounced in the younger than in the older girls, and they were also significantly higher than the increments of the controls. In addition, at postintervention, there was a more pronounced increase in the hunger scores in the younger girls by the checklist compared with the older girls (+0.92 vs. +0.75). This is perhaps because the younger girls were more anemic and were less hungry than the older girls before the intervention (Hb 108 vs. 112 g/L, respectively). Among the older girls, although Hb levels and hunger scores improved significantly compared with the controls, the weight and BMI changes were not significantly higher than controls. This could also be because of the smaller sample size of the older girls. Thus, the effect on growth in the overall group was explained by the significant difference seen in the younger age group. The age-related trends in Hb levels, perceived hunger and weight-for-age were not seen in the control group, with the initial and final values being similar in both age groups.

**DISCUSSION**

This study demonstrated that daily iron supplements of 60 mg elemental iron and 0.5 mg folic acid for 3 mo improved growth significantly among adolescent girls compared with...

<table>
<thead>
<tr>
<th>TABLE 2</th>
</tr>
</thead>
</table>

**Changes in hemoglobin levels, perceived hunger scores, weight and body mass index BMI after the iron-folic acid intervention (10–18 y)**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Experimental group¹</th>
<th>Control group¹</th>
<th>Students t value A vs. B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin, g/dL</td>
<td>91</td>
<td>10.87 ± 0.11</td>
<td>12.61 ± 0.08</td>
</tr>
<tr>
<td>Hunger score</td>
<td>101</td>
<td>6.01 ± 0.11</td>
<td>6.90 ± 0.06</td>
</tr>
<tr>
<td>Checklist Rating scale</td>
<td>101</td>
<td>4.47 ± 0.20</td>
<td>6.03 ± 0.14</td>
</tr>
<tr>
<td>Weight kg</td>
<td>101</td>
<td>28.54 ± 0.77</td>
<td>29.39 ± 0.77</td>
</tr>
<tr>
<td>BMI</td>
<td>101</td>
<td>14.69 ± 0.22</td>
<td>14.70 ± 0.23</td>
</tr>
</tbody>
</table>

¹ Values are means ± SEM; significant at P < 0.001.

| TABLE 3 |

**Comparative impact of Iron-Folic Acid Intervention on the Nutritional Status of the younger and the older adolescent girls (10–14 years versus 15–18 years)**

<table>
<thead>
<tr>
<th>Mean change</th>
<th>Age groups (y)</th>
<th>n</th>
<th>Experimental group¹ (A)</th>
<th>Control group¹ (B)</th>
<th>Student’s t value A vs. B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemoglobin, g/dL</td>
<td>10–14</td>
<td>75</td>
<td>1.84 ± 0.11</td>
<td>78</td>
<td>-0.08 ± 0.03</td>
</tr>
<tr>
<td>15–18</td>
<td>16</td>
<td>1.23 ± 0.05</td>
<td>11</td>
<td>-0.15 ± 0.11</td>
<td>9.16</td>
</tr>
<tr>
<td>Hunger score</td>
<td>10–14</td>
<td>81</td>
<td>0.93 ± 0.13</td>
<td>89</td>
<td>0.34 ± 0.08</td>
</tr>
<tr>
<td>15–18</td>
<td>20</td>
<td>0.75 ± 0.24</td>
<td>13</td>
<td>0.23 ± 0.19</td>
<td>1.67</td>
</tr>
<tr>
<td>Checklist Rating scale</td>
<td>10–14</td>
<td>81</td>
<td>1.56 ± 0.13</td>
<td>89</td>
<td>0.48 ± 0.09</td>
</tr>
<tr>
<td>15–18</td>
<td>20</td>
<td>1.55 ± 0.31</td>
<td>13</td>
<td>0.54 ± 0.21</td>
<td>2.71**</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>10–14</td>
<td>81</td>
<td>0.90 ± 0.09</td>
<td>89</td>
<td>0.05 ± 0.07</td>
</tr>
<tr>
<td>15–18</td>
<td>20</td>
<td>0.53 ± 0.21</td>
<td>13</td>
<td>-0.23 ± 0.22</td>
<td>0.97 (NS)</td>
</tr>
<tr>
<td>BMI</td>
<td>10–14</td>
<td>81</td>
<td>-0.03 ± 0.06</td>
<td>89</td>
<td>-0.40 ± 0.04</td>
</tr>
<tr>
<td>15–18</td>
<td>20</td>
<td>0.14 ± 0.11</td>
<td>13</td>
<td>-0.08 ± 0.06</td>
<td>0.42 (NS)</td>
</tr>
</tbody>
</table>

¹ Values are means ± SEM; *significant at P < 0.001; NS, not significant.
controls. A subsequent study showed similar results among 9- to 16-y-old school girls (Kanani et al., unpublished data).

The mechanism by which supplemental iron and folic acid improve growth has not been clearly delineated. Improved appetite and subsequent improvement in food intake could be a factor as suggested by Lawless et al. (1994) and in this study. Although appetite was not assessed (as was done by Lawless and co-workers) with ad libitum intake of food, the indirect measures of improved appetite used in this study, i.e., perceived hunger scores and the feedback from the girls and parents that they consumed greater amounts of food than they had earlier, suggest that appetite had improved after the IFA supplementation.

The younger age group (10–14 y) experienced greater increases in growth in weight and BMI than did the older group (15–18 y). This was expected because the younger ages correspond with the adolescent growth spurt and the highest iron needs (Brabin and Brabin 1992, Srikantha 1989). In addition, the younger adolescents are easier to reach than the older ones because more of them will still be in primary school. IFA supplementation is recommended for girls throughout schools in India, especially for its growth-promoting benefits. It appears to have the potential for maximum benefit at minimum cost.

In addition to improving hematimc status and growth, IFA supplementation to adolescent girls has other added benefits such as improved cognition. This was observed in a study among American adolescent girls who were iron deficient yet not anemic (Bruner et al. 1996). Even in the absence of anemia, oral ferrous sulfate (650 mg twice daily) for 8 wk improved some aspects of cognitive functioning compared with placebo controls. Improved cognition may lead to better academic performance, which may be an incentive for girls to remain in school.

The strong association between anemia and reproductive health is well known and it is being realized increasingly that it is usually too late to begin to address anemia in pregnancy, given the large prepregnancy iron deficits and the added demands of pregnancy for iron. Thus, as Gopalan (1989) suggests, opportunities provided by the precious years of adolescence before marriage and the childbearing that usually follows soon thereafter should not be wasted by the health system. Adolescent girls should be supplied regularly with IFA supplements so that they can enter pregnancy with no serious iron deficiency handicaps.

What about compliance? Our experience with adolescent girls and our compliance data clearly reveal that most adolescent girls are enthusiastic about consuming iron tablets and continue until the necessary supplementation duration, provided they are counseled about the benefits of IFA, are reassured in case of side effects and parental support is sought. Compared with pregnant women, girls are usually less anxious about tablets being “hot” or having deleterious effects, and they are also more willing to consume the tablets.

Thus, iron-folate interventions hold the potential for not only improving Hb levels, but also enhancing growth among disadvantaged adolescent girls. Further epidemiologic and programmatic research is called for to gain understanding of the iron-growth relationships in adolescence and the mechanisms by which iron improves growth.

**LITERATURE CITED**


Iron deficiency anemia is a common nutritional problem world-wide, particularly for women of reproductive age in developing countries. In pregnant women, severe anemia increases the risk of maternal and fetal morbidity and mortality, and the risk of premature delivery and low birth weight for the infant (Garn et al. 1981, Murphy et al. 1986). In adolescent girls, it can have an adverse effect on educational performance, productivity and well-being. Preventing iron deficiency and increasing iron stores in adolescent girls can improve their iron status in preparation for pregnancy and benefit their current health and well-being.

Peru has high rates of iron deficiency anemia. From a 1996 national survey, the prevalence in nonpregnant women of fertile age is 35% (Demographic and Health Surveys 1997). A study by Zavaleta (personal communication) found that 24.7% of adolescent girls from low income families participating in community kitchens in periurban Lima were anemic. In a second study (Zavaleta et al., 2000), the prevalence ranged from 9.9–12% in girls from four schools in Lima of different socioeconomic levels.

The major cause of anemia in this population is low dietary iron intake. Strategies for reducing anemia include supplementation, fortification and improving the diet. Stoltzfus (1993) postulated that improving iron bioavailability of diets may have a greater effect than increasing the total quantity of dietary iron consumed. In many developing countries, access to iron-rich foods and/or iron absorption-enhancing foods such as fruits and vegetables is limited and other strategies are necessary. Although Peruvian diets are typically low in bioavailable iron, in periurban Lima, less expensive heme sources of iron (e.g., chicken offal, blood and fish), beans and sources of vitamin C are available throughout the year. Thus dietary modifications to improve iron status using locally available foods (Layrisse and García-Casal 1997) are possible.

This paper reports on a community-based, randomized behavioral and dietary intervention trial to improve dietary iron intake, iron bioavailability and iron status among adolescent girls in Lima, Peru. The intervention was conducted through local community kitchens (CK) in control and intervention periurban populations of Lima. Formative research assessment formed the basis of the intervention, which consisted of an educational campaign to improve the menus of the community kitchens to provide low cost heme iron sources and the promotion of dietary enhancers (i.e., vitamin C with the meal). The strategy also included motivating adolescent girls to understand their nutritional vulnerability and to improve their diets to benefit their health and well-being.

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1 Presented at the symposium entitled “Improving Adolescent Iron Status before Childbearing” as part of the Experimental Biology 99 meeting held April 17–21 in Washington, DC. This symposium was sponsored by the American Society for Nutritional Sciences and was supported in part by an educational grant from Micronutrient Initiative. The proceedings of this symposium are published as a supplement to The Journal of Nutrition. Guest editors for the symposium were Kathleen Kurz, International Center for Research on Women and Rae Galloway, World Bank/Micronutrient Initiative.

2 This publication was made possible in part through support provided by the Office of Health and Nutrition, USAID, under terms of contract no. HRN-C-00-98-00038-00, and the MotherCare Project, John Snow, Incorporated (JSI). The contents and opinions expressed herein are those of the authors and do not necessarily reflect the view of USAID or JSI.

3 The project was approved by the Ethics committee of the Instituto de Investigación Nutricional, number 081–95/CEI.

4 To whom correspondence should be addressed.
RESEARCH DESIGN AND METHODS

The study was a pre/post-comparison between intervention and control communities with similar demographic and socioeconomic characteristics, but geographically separated to prevent contamination of education messages. Eight communities were randomly selected and one CK randomly selected within each community. Adolescent girls were randomly selected from the lists of members and beneficiaries from each of the selected CK. Six adolescents were enrolled in each CK. Criteria for participation included being nonpregnant, nonlactating girls aged 12–17.9 y. Signed consent was given by each participant. Six girls were enrolled initially for the baseline evaluation in the intervention group and 66 in the control; of these, 71 and 50, respectively, accepted having their blood taken and were included in the cohort. In the final evaluation, six girls were lost to follow-up in the intervention group and eight from the control group.

In the formative research stage, in-depth interviews were conducted with 16 girls (two randomly selected from each of the CK) on topics relating to their perceptions of food and nutrition, health and anemia. The interviews were recorded and the expanded notes analyzed by topic using dtSearch Software (Arlington VA).

On the basis of the results of the formative research, an educational campaign was designed and implemented for a period of 9 mo; the intervention consisted of participatory training sessions with the adolescent girls and the CK leaders. Iron-rich menus were developed with the CK members. During this period, increased accessibility to less expensive sources of heme iron (chicken liver and blood) was facilitated at cost price from a commercial chicken producer. Educational materials included an attractive school folder, pencil case and T-shirt for the adolescents, promoting the relationship between consuming iron-rich foods and iron enhancers and school performance. Posters, recipe booklets and a mobile promoting iron-rich foods were materials used in the CK.

The effect of the intervention was evaluated by estimating dietary intake before and after the education intervention using a quantitative dietary 24-h recall methodology conducted on two successive days by trained nutritionists. The evaluation was conducted during the months of June to August 1996 before the intervention and in the same months in 1997 after the intervention to ensure similar seasonal food availability. Food intake was converted to nutrients using Peruvian food composition tables (Instituto de Investigación Nutricional 1998) and including food composition data from other Latin American and United States tables where necessary. Mean intakes were calculated by averaging the nutrient intake for two consecutive days for each girl and then calculating the mean for all girls in each study group.

Bioavailable dietary iron was calculated using the algorithm of Tseng et al. (1997) in which absorbable iron is calculated for each meal. Heme iron absorption was assumed to be 25%, due to the presence of iron deficiency in this population. An adaptation of the formula of Tseng et al. (1997) was used for calculating the bioavailability of nonheme iron, including enhancer factors, ascorbic acid and flesh food protein, and tea and infusions as an inhibitor factor. The inhibiting potential of phytate was not included in the calculation because of the lack of available data from local food tables.

Iron status was evaluated by blood hemoglobin (Hb) and serum ferritin (SF). Hb was analyzed using the cyanomet-hemoglobin method. SF was measured according to the RIA method (double antibody Ferritin 125I RIA) using a commercial kit. The use of this method for serum was compared with ELISA from a subsample of nine adolescent girls, yielding a correlation of $R^2 = 0.997$. Anemia in girls was defined as Hb<120 g/L and iron deficiency as SF levels <12.0 μg/L.

Socioeconomic characteristics, knowledge and exposure to the campaign were evaluated by questionnaire. Heights and weights were obtained before and after the intervention.

Descriptive statistics were calculated for each variable for baseline and postintervention data, and comparisons made between study groups. Paired comparisons were made between pre- and postintervention data for each study group. The Mann-Whitney nonparametric test was used to test the hypothesis that the medians of the variables of interest between independent groups were different. The Wilcoxon test was used for paired comparisons in which the variables did not have a normal distribution.

RESULTS

A majority of the girls stated that anemia is associated with (9 girls) a poor diet (9), poor quality of diet or lack of vitamins (1), inadequate amounts consumed and not keeping to meals (3). Symptoms of anemia are not clearly identified by the girls. "Paleness" was most mentioned, although other girls associated anemia with "weakness," tiredness, thirst, vomiting, excessive perspiration and body aches. Anemia was not mentioned as being related specifically to blood, but rather to a general state of the body. The principal treatment of anemia was to improve the diet by eating good foods "containing vitamins," keeping to mealtimes, and eating foods considered specifically "good for anemia" such as liver, spleen and beetroot (the red color was associated with the blood). Diet, considered a "natural" treatment, was perceived to be "better" than the clinical treatments such as use of vitamins or tonics. Foods were selected for promotion on the basis of availability, accessibility, acceptability, and cost-nutritional benefits. The "best buys" for iron included blood, spleen, beans and liver. For vitamin C, the "best buys" included oranges, papaya, cabbage, mandarin orange and lemon.

As a result of a behavioral analysis, in which each behavior was evaluated for potential nutritional effect and feasibility of adoption, the primary dietary recommendations selected for the intervention were to increase heme iron food sources in stews prepared in the CK and increase consumption of vitamin C-rich salads and/or drinks with meals containing nonheme iron sources (mostly beans).

No differences were found between the intervention and control groups at baseline on sociodemographic characteristics or dietary intake. Knowledge regarding what foods to eat to improve iron status was higher in the intervention group, particularly with respect to key messages referring to the timely preparation of vitamin C-containing drinks and salads and their consumption with beans at meal times.

Total daily iron intake increased significantly in the intervention group ($P < 0.01$) from 7.75 ± 3.5 to 9.42 ± 5.0 mg/d after the campaign, whereas in the control group there was no change (Fig. 1). Interestingly, intake of heme iron tripled in the intervention group, from 0.21 ± 0.17 to 0.66 ± 1.35 mg/d, and was significantly higher than that of the control group after the campaign (Fig. 2). There was also a significant increase in total ascorbic acid intake from 44 ± 39.6 to 67 ± 45 mg/d in the intervention group, with no change in the control group (41 ± 34.6 pre and 40 ± 27.6 mg/d post). There was a small but significant increase in absorbable iron intake (Fig. 3) in the intervention group, from 0.33 ± 0.16 pre to
0.43 ± 0.41 mg/d post, with no change in the control group: 0.35 ± 0.13 pre to 0.37 ± 0.22 mg/d post.

There was no significant change in anemia prevalence among the girls in the intervention group (pre 14.1%, post 12.3%), although there was a large and significant (P < 0.01) increase in the control group between baseline and final evaluations (pre 14%, post 37.5%). A similar effect in iron deficiency as measured by SF was also demonstrated, in which a small but nonsignificant reduction was observed in the intervention community (pre 21.1%, post 18.5%) and a tendency to increase in the control community (pre 14%, post 25%).

DISCUSSION

As a result of this intervention, there was a marked change in knowledge and perceptions with respect to improving the quality of iron in the diet of adolescent girls participating in the education intervention. Changes in perceptions about anemia in adolescent girls have been reported in other populations (Kanani 1994). The change in knowledge had a positive effect on behavior; dietary iron intake improved, whereas it did not in the control community. Although the behavioral change was significant, it was small; iron intakes were still low, and absorbable iron, even without adjusting for phytate, was still well below recommended intakes after the intervention. However, the results showed an encouraging trend in the adoption of the recommended practices.

The 9-mo intervention period was not sufficient to improve hemoglobin levels significantly. Nevertheless, there appeared to be a protective effect from the intervention in maintaining the iron status of the girls in comparison with the control group.

This study shows that dietary change to improve iron intake is possible in this sample of adolescent girls. A multidietary strategy using an educational campaign combined with identifying and promoting best buys for iron is required to increase consumption of animal sources of iron and vegetable sources with iron absorption enhancers such as vitamin C. These strategies are potentially applicable in urban populations such as Lima where 70% of the country's population is located and access to a variety of cheaper sources of these nutrients is possible. The results from this study with the adolescent girls was extremely encouraging. The education campaign and materials used captured the girls' interest and stimulated their motivation to influence their health, nutrition and diet. The potential of applying this experience through schools and other organizations reaching adolescent girls provides an exciting and feasible opportunity.

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LITERATURE CITED


