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Weekly iron supplements given by teachers sustain the haemoglobin concentration of schoolchildren in the Philippines

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Summary

OBJECTIVES To examine the effectiveness of weekly iron supplements given for 10 weeks by teachers to children in rural schools in the Philippines.

METHODS Forty-nine rural primary schools took part in the study and were randomly assigned to two groups: children in 25 schools received a weekly tablet providing 108 mg iron while children in 24 schools acted as controls. All children were dewormed before the start of the iron supplementation. The haemoglobin concentration of a systematic sample of one in three children in two classes in each school was estimated before and 5–17 weeks after the end of the iron supplementation.

RESULTS A total of 1510 children aged 7–12 years were studied at both surveys. The mean haemoglobin concentration of children in the intervention group did not change significantly; in the untreated group it fell by 3.8 g/l and the prevalence of anaemia rose from 14.3% to 25.6%. The difference between study groups was significantly larger amongst the younger children (7–8 years), and was observed in both anaemic and non-anaemic children.

CONCLUSION Even where anaemia is only a mild public health problem, weekly iron supplements given by teachers may prevent a fall in the haemoglobin concentration, and can benefit both anaemic and non-anaemic children.

keywords Philippines, anaemia, iron supplements, schoolchildren, teachers

Introduction

Iron deficiency is the most common nutritional deficiency worldwide today (WHO 2001) and the effect it has on worker productivity and the outcomes of pregnancy are well documented (Edgerton *et al.* 1979; Murphy *et al.* 1986; Li *et al.* 1994; Schorr & Hediger 1994). In recent years several studies have indicated that iron deficiency may also be associated with poor mental performance in children. For example: iron-deficient children have scores in well-established tests of cognitive function that are about a half a standard deviation lower than non-deficient controls (Pollitt 1993); a study in Indonesia showed improvements in educational tests following iron treatment (Soemantri *et al.* 1985); and a study of non-anaemic but iron-deficient adolescent girls in the US suggested that iron supplementation may have some effects on cognitive function (Bruner *et al.* 1996). These studies provide evidence that an iron deficiency as well as anaemia could impair both the cognitive functions of school-age children and their ability to learn.

In a recent survey of the haemoglobin concentrations of schoolchildren in Africa and Asia, in five of six African countries 40% or more schoolchildren aged 7–11 years were anaemic (Partnership for Child Development 2001), so that almost all were probably iron deficient (WHO 2002). But in the two Asian countries that took part in the survey, Indonesia and Viet Nam, the prevalence of anaemia was lower at 27% and 12% respectively. In Thailand the prevalence of anaemia amongst schoolchildren was 27% and in Indonesia 67% (Soemantri *et al.* 1997; Sungthong *et al.* 2002). The 1998 National Nutrition survey of all 16 regions of the Philippines found anaemia prevalences of 34.8% among boys and 36.5% among girls aged 6–12 years (Food and Nutrition Research Institute 2001).

A recent review of studies which compared daily or intermittent iron supplementation concluded that weekly iron supplementation could be as effective as daily supplementation under supervised conditions, such as in schools (Beaton & McCabe 1999). In Mali, for example, teachers in 30 rural community schools gave weekly iron tablets to their pupils for 10 weeks with 90% coverage that resulted in a 17% difference in the prevalence of anaemia compared with children in 30 schools who did not receive iron tablets (Hall *et al.* 2001). Studies in Bolivia and Malaysia have shown similar benefits of iron supplements for schoolchildren (Tee *et al.* 1999; Aguayo 2000).

The aim of this study was to examine the effectiveness of weekly iron supplementation for 10 weeks delivered by teachers to children in rural schools in the Philippines.

Subjects and methods

The study took place on the islands of Iloilo and Guimaras in the West Visayas region of the Philippines. It was part of a school health and nutrition program launched in 1999 by Save the Children (USA), the Department of Education, and the local government of the islands, which aims to improve schoolchildren's educational performance by means of behaviour change and simple school health services given by teachers.

Approval for the study was given by the National and Regional offices of the Department of Education through the School Health and Nutrition Center. The study design was explained to the Division Superintendents, District Supervisors and School Heads, who also gave their approval. The school nurses then informed the teachers, parents and children about the purpose of the study and the parents of each subject voluntarily signed a consent form.

All 51 primary schools on both islands were included in the study: 20 in Iloilo and 31 in Guimaras. Fourteen of these schools had recently joined a programme receiving iron fortified rice and had benefited for up to 2 months before the present study began. All 51 schools were assigned to two groups using a random number table.

Children in two school grades were chosen for the study: pupils in grade 2 aged 7–8 years and pupils in grade 4 aged 10–12 years. These grades were selected to represent pre-adolescent and young adolescent children. Children in higher grades were not included because they are more likely to drop out of school.

No data were available on the haemoglobin concentration of Filipino children for a power calculation, so data were used from a study conducted by Save the Children in Mali with the same design. In Mali a difference in final haemoglobin concentration of 4.5 g/l was achieved (Hall *et al.* 2001), but the initial mean haemoglobin concentration was thought likely to be higher in the Philipppines so a smaller difference might be expected. For this reason 50% of this value (2.25 g/l) was applied in a power calculation using a formula for the comparison of two mean values given by Kirkwood and Sterne (2003) with a power of 90% and at the 5% level of significance. This gave a sample size of 670 which was increased to allow for 30% drop out and then rounded up to 900 per study group.

To obtain this sample it was estimated that a third of all children currently enrolled in grades 2 and 4 in the 51 schools were required for the study. Because written consent had to be obtained from parents prior to the arrival of the survey team, the teachers were taught how to select the children for the study using simple instructions, as follows. The teacher asked a child to pick any number between 1 and the total number of children in the class. The pupil whose number had been selected was then used as the starting point on the class register. Every third child on the register was then selected for study. When the end of the register was reached, the teacher returned to the beginning and continued selecting every third child until the first chosen child had been reached. This provided a systematic 33% sample of all children in each class. The teachers then obtained written consent using a form provided by Save the Children from the parents of the children selected for study.

The baseline survey was conducted over a period of a month in July 2001, at the start of the school year. The date of birth of the child was recorded from the school register, information that had been provided by the parents. A finger-prick blood sample was taken from each child by one of eight school nurses, each of whom was responsible for about six schools, and the haemoglobin concentration was estimated using a Hemocue haemoglobinometer (Hemocue, Sweden). The nurses had been trained to take blood samples and to use the Hemocue, which they calibrated each day using the internal cuvette.

All children in both groups of schools were dewormed at the start of the study using a single dose of 400 mg albendazole (Medpharm, Washington, DC, USA) because surveys in the same schools had found that 67% of children were infected with one or more intestinal worms. The species identified were *Trichuris trichiura* in 48%, *Ascaris lumbricoides* in 40% and hookworm in 15% (Belizario *et al.* 2001).

All children in the intervention schools were then given a single iron tablet by their teacher every week for 10 weeks, starting between 1 and 7 weeks after the baseline survey. Each iron tablet contained 325 mg ferrous sulphate (United Laboratories, Philippines) and provided 108 mg of elemental iron. The consumption of each tablet was recorded by the teachers who were trained by the school nurses on the causes and consequences of anaemia and the potential impact and side-effects of the iron supplements. Data on side-effects were not recorded as there was no placebo group to be able to assess whether any problems were real or not. Information sheets were also provided for children to take home to their parents.

Between 5 and 18 weeks after the end of the iron supplementation, a capillary blood sample was taken again by a finger-prick from the same children in each school and the haemoglobin concentration was estimated using a Hemocue haemoglobinometer. The range in number of weeks occurred because there were only two Hemocue haemoglobinometers for use by eight school nurses, each of whom had to return to schools to follow up children who were absent on their first visit, so the re-survey took considerably longer than the baseline survey.

Children were classified as anaemic using thresholds recommended by the WHO (2001): children aged 5–11.9 years, 115 g/l and children aged 12.0–14.9 years, 120 g/l.

Data were entered into a computer and analysed using EpiInfo version 6.04 and SPSS version 9.0. Differences between mean values were tested for statistical significance using Student's t-test, and differences between proportions were tested using the chi-square test. Multiple regression models were developed to examine factors associated with the baseline haemoglobin concentration and the change in haemoglobin over the study.

Results

A total of 51 schools took part in the study, 25 in the intervention group and 26 in the control group. Two schools were dropped from the study, both from the control group, because they were unable to collect the baseline measurements within the month allotted. There was no significant difference at baseline in the mean haemoglobin concentration and age of children in these two schools compared with the rest of the sample.

Blood samples were collected from 1785 children at the baseline survey and from 1510 of the same children an average of 22.6 weeks later. The mean period in days between the baseline and follow-up surveys did not differ significantly between the intervention and control group and the mean haemoglobin concentrations of the 275 children (15.4%) who were not present at the final survey was not significantly different at baseline to the 1510 who remained in the study (125.4 g/l *vs.* 125.4 g/l, $P = 0.98$). All 10 iron tablets were taken by 93.4% of children.

Table 1 The characteristics of study groups at the baseline survey

Characteristic	Intervention group ($n = 708$)	Control group ($n = 802$)	P
Sex (%)			
Boys	51.8	49.3	0.33
Girls	48.2	50.7	
Grade (%)			
Grade 2	53.0	51.9	0.68
Grade 4	47.0	48.1	
Island (%)			
Iloilo	55.9	64.1	0.001
Guimaras	44.1	35.9	
Mean age (months)	109.6	110.3	0.4

Table 1 shows the characteristics of the 1510 children studied on both occasions. Table 2 shows the mean haemoglobin concentration of children in both study groups at baseline and follow-up, and the percentage of children who were classified as anaemic. At the baseline survey, the control group had a slightly but significantly higher mean haemoglobin concentration and a lower percentage of children were anaemic compared with the intervention group.

Fourteen of the 49 schools in the study had participated for about 2 months in the fortified rice programme: six in the intervention group and eight in the control group. The mean haemoglobin concentration of children in the 14 schools that had participated in the programme was slightly but significantly higher than that of children in the other 25 schools (126.4 g/l *vs.* 125.0 g/l, $P = 0.031$). But participation by schools in the iron fortified rice programme did not have a significant effect on the present study. A multiple regression model in which baseline haemoglobin concentration was the dependent variable showed no significant association with study group, sex, island or whether children had or had not received iron fortified rice. Age was the only variable that was significantly associated with baseline haemoglobin concentration

	Mean (SD)			Percentage anaemic, n (%)		
	Intervention ($N = 708$)	Control ($N = 802$)	P	Intervention ($N = 708$)	Control ($N = 802$)	P
Baseline	124.7 (12.2)	126.1 (11.1)	0.015	138 (19.5)	115 (14.3)	0.009
Resurvey	124.5 (11.6)	122.3 (12.8)	<0.001	125 (17.7)	205 (25.6)	<0.001
Difference	−0.16 (13.0)	−3.84 (13.6)	<0.001	−13 (−1.6)	94 (10.7)	
P	0.7	<0.001		<0.001	<0.001	

Table 2 The mean and SD of haemoglobin concentrations in g/l and the number and percentage of children classified as anaemic in the intervention group (weekly iron supplements for up to 10 weeks) and comparison group (no iron supplements) at the baseline and resurvey. The statistical significance of differences in mean values and proportions between study groups is shown in rows, and between surveys is shown in columns

($P < 0.001$). Young children (<10 years) had a lower mean haemoglobin concentration than older children (≥10 years) (125.0 *vs.* 126.6, $P = 0.015$).

At the follow-up survey, which was conducted an average of 158 days (S.D. 21.4) after the baseline and 10 weeks of iron supplementation, the haemoglobin concentration of the intervention group had not changed significantly. However there was a statistically significant fall of 3.8 g/l in the haemoglobin concentration of the control group (−0.2 g/l *vs.* −3.8 g/l, $P < 0.001$). When expressed in terms of the percentage of children classified as anaemic, the prevalence rose from 14% to 26% in the control group and fell slightly from 20% to 18% in the intervention group ($P < 0.001$).

Figure 1 shows the mean change in haemoglobin concentration for both study groups according to the children's age. The differences between the intervention and comparison group was significantly larger in the younger (7–8 years) than the older children (9–11 years). The net difference in haemoglobin change between the study groups was 5.9 g/l in the 7–8-year age group *($P < 0.001$)*, but only 1.8 g/l in the 9–11-year age group, a difference which was not statistically significant ($P = 0.5$).

Table 3 shows the results of a multiple regression model in which the dependent variable was the change in haemoglobin concentration between the baseline and final surveys. Because the period between surveys had a wide range from 122 to 222 days due to the practical problems of only having two Hemocue machines and trying to find all the study children again, the number of days between surveys for each child was entered into the model. Table 3 shows that the treatment with iron, the baseline haemoglobin concentration and the number of days between surveys were all statistically significant ($P < 0.001$ and <0.01).

Figure 2 shows the mean change in haemoglobin concentration by study group according to the baseline haemoglobin concentration. It reveals that over the study period low haemoglobin concentrations tended to rise while high haemoglobin concentrations tended to fall, a phenomenon called regression to the mean. But, regardless of the initial haemoglobin concentration, children in the control group experienced a greater change in haemoglobin concentration, which on average went down, than children in the treatment group.

During the course of the study the haemoglobin concentrations of children in the control group who were not initially anaemic fell significantly more than among

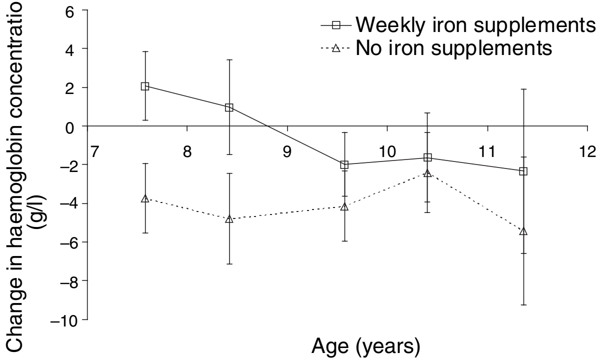

Figure 1 The mean change in haemoglobin concentration of Filipino schoolchildren with 95% confidence intervals according to age for each study group ($n = 1473$). Children aged 12 years and older were excluded from this analysis because there were insufficient numbers.

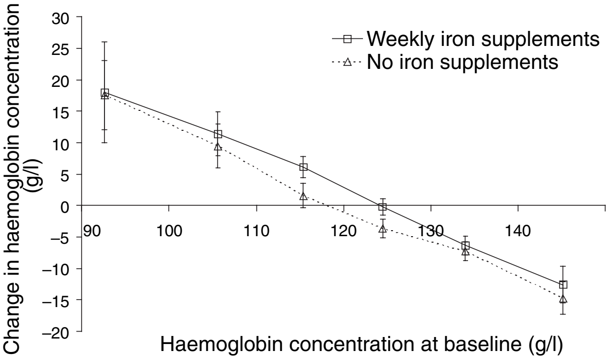

Figure 2 The mean change in haemoglobin concentration of Filipino schoolchildren plotted against their initial haemoglobin concentration.

Table 3 The results of a multiple regression model in which the dependent variable was the change in haemoglobin concentration in g/l between baseline and follow-up

Variable	Coefficient (*B*)	SE	*t*	*P*
Treatment	−0.252	0.060	−4.202	<0.001
Sex	−0.029	0.059	−0.487	0.627
Age (years)	0.003	0.002	1.791	0.074
Island	−0.063	0.068	−0.938	0.348
Baseline haemoglobin (g/l)	−0.608	0.025	−23.919	<0.001
Time between surveys (days)	0.004	0.002	2.563	0.010

non-anaemic children in the intervention group (−5.9 g/l *vs.* −2.8 g/l, $P < 0.001$).

Discussion

During this study the haemoglobin concentration of the children given weekly iron supplements did not change significantly, while the mean haemoglobin concentration of the control group, which was significantly higher at baseline, fell by an average of 3.8 g/l. This indicates that the weekly iron supplementation helped to prevent a fall in haemoglobin concentration and avert a rise in the prevalence of anaemia during the period of the study. This occurred although the initial prevalence of anaemia was classified as only of mild public health significance (WHO 2001). The prevalence of anaemia at baseline was 14% in the control group and rose to 26% approximately 23 weeks later, while in the intervention group the prevalence fell slightly from 20% to 18% over the period of the study. This indicates that there may be seasonal fluctuations in haemoglobin concentrations, perhaps related to food availability; the period between the baseline and follow-up coincided with the lean season between harvests in the Philippines.

Two factors could have affected the results of this study. First was the fact that some schools had been enrolled in a programme to receive rice fortified with iron. This did not have an effect on the study as the schools which had received the iron fortified rice were distributed roughly equally between the two groups and, despite the difference between the baseline haemoglobin of children who had participated in the iron fortified rice programme and those who had not, participation in the programme was not associated with baseline haemoglobin concentrations in the study groups.

The second factor that could have affected the outcome of the study was the relatively short period of supplementation and the sometimes long interval between the baseline and final surveys. The regression analysis showed that the interval between surveys was statistically significant and a slightly bigger effect of treatment might have been found had the re-survey been conducted soon after the end of treatment. Nevertheless the study suggests that relatively small amounts of iron given to Filipino children may have quite long-lasting effects even where anaemia is only a mild public health problem.

Teachers were able to give children the iron tablets with a high level of compliance. As there was no placebo group it was not possible to assess reliably the prevalence of side-effects. A randomized placebo controlled trial of anthelminthic treatments in the Philippines had reported that children given a placebo reported as many side-effects as children given an anthelminthic (Olds *et al.* 1999) . The authors concluded that this might have been due to the high prevalence of pre-existing conditions in schoolchildren.

Figure 1 shows that the younger children, who tended to be more anaemic than older children, benefited more from the iron tablets. The net difference in the haemoglobin concentrations between the two study groups was three times higher in the younger age group (7–8 years) compared with the older age group (9–11 years) (5.9 g/l *vs.* 1.8 g/l).

This study and one in Bolivia, which also found that a weekly iron tablet helped to prevent a fall in the haemoglobin concentrations among supplemented children (Aguayo 2000), show how important it is to have a control group. This is not such an absurd conclusion as it may seem because many school health programmes are considering giving iron supplements to school children but, because they are programmes rather than studies, do not have an untreated comparison group when they evaluate the impact. Without a control group the present study and any programme evaluation could have concluded that the iron supplements had had no effect. For this reason, we recommend having a control group when evaluating programmes as well as undertaking research studies.

Other studies in Asia have shown that even mildly anaemic children may benefit from weekly iron supplements. Twelve weeks of iron supplements given to Malaysian children improved the haemoglobin concentrations of both anaemic and borderline anaemic schoolchildren, but the difference between borderline children and the control group was not statistically significant, probably because the sample size was too small (Tee *et al.* 1999). A recent study in Thailand also found that weekly iron supplements significantly improved haemoglobin concentrations compared with a control group, but that daily supplements did not have a bigger effect than a single weekly dose of ferrous sulphate (Sungthong *et al.* 2002).

As well as deworming children before giving iron supplements, it may also be important to give a large dose of vitamin A beforehand in some circumstances. Studies in Bangladesh and Tanzania have shown that a proportion of anaemia can be attributed to a vitamin A deficiency (Mwanri *et al.* 2000; Ahmed *et al.* 2001).

There is now considerable scientific evidence from South America, Africa and Asia and covering a wide range in the prevalence of anaemia, that there is a good case for giving schoolchildren short courses of weekly iron tablets, especially if there are annual periods of food shortage. These studies have only used anaemia as an outcome measure and if the prevalence of iron deficiency is typically 2.5 times the prevalence of anaemia (WHO 2001), then many more will have benefited from the supplements. Deworming is becoming a routine exercise in schools in many developing countries because guidelines have been provided when mass treatment can be given (WHO 2002). WHO has recently proposed that if >40% of school-age children are anaemic then iron tablets should be given daily for 3 months (WHO 2001) although who is to give the treatment is not indicated. No recommendations were made for circumstances in which the prevalence is lower than 40% but the present study and others suggest that most rural children would benefit from receiving a weekly iron tablet for 10–16 weeks if 20% or more were anaemic, and that teachers can give the pills.

References

Aguayo VM (2000) School-administered weekly iron supplementation – effect on the growth and hemoglobin status of non-anemic Bolivian school-age children. A randomized placebo-controlled trial. *European Journal of Nutrition* **39**, 263–269.

Ahmed F, Khan MR & Jackson AA (2001) Concomitant supplemental vitamin A enhances the response to weekly supplemental iron and folic acid in anemic teenagers in urban Bangladesh. *American Journal of Clinical Nutrition* **74**, 108–115.

Beaton, GH & McCabe GP (1999) *Efficacy of Intermittent Iron Supplementation in the Control of Iron Deficiency Anaemia in Developing Countries. An Analysis of Experience to Date: Final Report to the Micronutrient Initiative*. The Micronutrient Initiative, Ottawa.

Belizario V, Baylon MA, Bugayong MP *et al.* (2001) *Baseline Parasitologic Assessment of Selected Public Elementary Schools in Guimaras, Iloilo and Metro Manila, Philippines*. The College of Public Health, University of the Philippines, Manila.

Bruner AB, Joffe A, Duggan AK *et al.* (1996) Randomised study of cognitive effects of iron supplementation in non-anaemic iron-deficient adolescent girls. *Lancet* **348**, 992–996.

Edgerton VR, Gardner GW, Ohira Y *et al.* (1979) Iron deficiency anaemia and its effect on worker productivity and activity patterns. *British Medical Journal* **2**, 1546–1549.

Food and Nutrition Research Institute (2001) *Philippine Nutrition Facts and Figures*. Food and Nutrition Research Institute, Department of Science and Technology, Metro Manila, Philippines.

Hall A, Roschnik N, Ouattara F *et al.* (2001) A randomised trial in Mali of the effectiveness of weekly iron supplements given by teachers on the haemoglobin concentrations of schoolchildren. *Public Health Nutrition* **5**, 413–418.

Kirkwood, BR & Sterne AC (2003) *Essential Medical Statistics*, Blackwell Science, Oxford.

Li R, Chen X, Yan H *et al.* (1994) Functional consequences of iron supplementation in iron-deficient female cotton mill workers in Beijing, China. *American Journal of Clinical Nutrition* **59**, 908–913.

Murphy JF, O'Riordan J, Newcombe RG *et al.* (1986) Relation of haemoglobin levels in first and second trimesters to outcome of pregnancy. *Lancet* **1**, 992–995.

Mwanri L, Worsley A, Ryan P *et al.* (2000) Supplemental vitamin A improves anemia and growth in anemic school children in Tanzania. *Journal of Nutrition* **130**, 2691–2696.

Olds GR, King C, Hewlett J *et al.* (1999) Double-blind placebo-controlled study of concurrent administration of albendazole and praziquantel in schoolchildren with schistosomiasis and geohelminths. *The Journal of Infectious Diseases* **179**, 996–1003.

Partnership for Child Development (2001) Anaemia in schoolchildren in eight countries in Africa and Asia. *Public Health Nutrition* **4**, 749–756.

Pollitt E (1993) Iron deficiency and cognitive function. *Annual Review of Nutrition* **13**, 521–537.

Scholl TO & Hediger ML (1994) Anemia and iron-deficiency anemia: compilation of data on pregnancy outcome. *American Journal of Clinical Nutrition* **59**, 492S–500S.

Soemantri AG, Pollitt E & Kim I (1985) Iron deficiency anemia and educational achievement. *American Journal of Clinical Nutrition* **42**, 1221–1228.

Soemantri AG, Hapsari DE, Susanto JC *et al.* (1997) Daily and weekly iron supplementation and physical growth of school age Indonesian children. *Southeast Asian Journal of Tropical Medicine and Public Health* **28** (Suppl. 2), 69–74.

Sungthong R, Mo-suwan L, Chongsuvivatwong V *et al.* (2002) Once weekly is superior to daily iron supplementation on height gain but not on hematological improvement among schoolchildren in Thailand. *Journal of Nutrition* **132**, 418–422.

Tee ES, Kandiah M, Awin N *et al.* (1999) School-administered weekly iron-folate supplements improve hemoglobin and ferritin concentrations in Malaysian adolescent girls. *American Journal of Clinical Nutrition* **69**, 1249–1256.

WHO (2001) *Iron Deficiency Anaemia. Assessment, Prevention and Control. Guidelines for Program Managers*. WHO/NHD/01.3. World Health Organization, Geneva.

WHO (2002) *Helminth Control in School-Age Children. A Guide for Managers of Control Programmes*. World Health Organization, Geneva.

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