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Original Communication
Socio-economic status and puberty are the main factors determining anaemia in adolescent girls and boys in East Java, Indonesia

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Objective: To determine prevalence and contributing factors of anaemia in adolescents.
Design: Cross-sectional study of anaemia prevalence, socio-economic status and puberty.
Setting: Schools in East Java, Indonesia.
Subjects: Male and female adolescent pupils (age 12–15 y; $n = 6486$).
Results: Anaemia prevalence was 25.8% among girls ($n = 3486$), 24.5% among pre-pubertal boys ($n = 821$), and 12.1% among pubertal boys ($n = 2179$). Socio-economic status, indicated by type of school attended, was an important factor determining the risk of anaemia. Girls had a higher risk when they attended a poor school (OR poorest school, 1.00; other schools, 0.67–0.87), had reached puberty (OR, 1.25), had lower retinol intake (OR 1st–4th quartiles—1.00, 0.97, 0.89, 0.77) and higher vitamin A intake from plant sources (OR 1st–4th quartiles—1.00, 1.10, 1.31, 1.04). Boys had a higher risk of anaemia when they attended a poor school (OR poorest school 1.00, other schools 0.54–0.63), were younger (OR per year = 0.79), had not yet reached puberty (OR not yet, 1.00; already, 0.78), were shorter (OR per cm 0.95), had smaller mid-upper-arm circumference (MUAC) (OR per mm 0.99) and lower retinol intake (OR 1st–4th quartile 1.00, 0.67, 0.74, 0.68).
Conclusions: Anaemia in adolescents should be reported separately for pre-pubertal and pubertal subjects and for different ages, and the population's socio-economic status should be specified. The results of this survey call for treatment of anaemia in adolescents. Given Indonesia's current situation, micronutrient intake of adolescents should be increased using supplements for all girls and for pre-pubertal boys.
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Descriptors: iron deficiency anaemia; adolescents; socio-economic status; puberty; Indonesia
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Introduction

Iron deficiency anaemia is still a major public health problem in large parts of the world, including Indonesia. Iron deficiency has detrimental effects on physical and mental development of young children and is irreversible when iron therapy is started after the critical period for development has elapsed (Kretchmer *et al*, 1996). In older children and adolescents, iron deficiency, with or without anaemia, interferes with learning capacity and school achievement (Bruner *et al*, 1996; Seshadri & Gopaldas, 1989) as well as with growth (Chwang *et al*, 1988; Lawless *et al*, 1994) and appetite (Lawless *et al*, 1994). In pregnancy, anaemia can lead to reduced intrauterine growth and thus to low birth weight and peri-natal mortality (Scholl & Hediger, 1994). In addition, anaemia reduces work performance (Basta *et al*, 1979; Scholz *et al*, 1997), and impairs immune function (Hershko, 1993). Through all these effects, anaemia is a major hampering factor in the economic growth of many developing countries, which have the highest anaemia prevalences in the world. The necessity to treat iron deficiency anaemia is therefore both a health and an economic issue.

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The main cause of iron deficiency anaemia is inadequate intake of bio-available iron from the diet, although additional causes also play a role, such as excessive blood loss, infections, especially by intestinal parasites, and deficiencies of vitamins A and C. Rapid growth increases the need for iron to such an extent (Brabin & Brabin, 1992; Antilla & Siimes, 1996) that a positive iron balance is difficult to maintain (Yip, 1994). This makes young children, pregnant women and adolescents especially vulnerable to iron deficiency anaemia. Because of very high iron requirements in pregnancy and the fact that most women have a borderline iron status before pregnancy (Brabin & Brabin, 1992), treatment of anaemia is best started in adolescence.

Few data are available on the prevalence of iron deficiency anaemia in adolescents (DeMaeyer & Adiels-Tegman, 1985), but the prevalence seems to be high, especially among girls (Dallman & Siimes, 1979; Angeles-Agdeppa *et al*, 1997; Ahmed *et al*, 1996; Fairweather-Tait, 1996). Because of the changing nutritional needs of adolescent boys and girls, and the start of menstruation in girls, there may well be differences in haemoglobin concentrations between the sexes, between different ages and between pre-pubertal and pubertal adolescents. However, very few data are available on the relationship between puberty and haemoglobin levels in either boys or girls (Antilla & Siimes, 1996; Greger *et al*, 1978; ACC/SCN, 1997).

In order to identify appropriate interventions for specific groups of adolescents, a survey was undertaken among adolescent boys and girls aged 12–15 y in East Java, Indonesia. The aim of the survey was two-fold: determine anaemia prevalence in adolescent girls and boys of different ages; and analyse the factors associated with iron deficiency anaemia.

Methods

Subjects

The data presented in this paper were collected during a survey between October 1996 and January 1997. The survey was conducted in 34 schools in urban and rural East Java, Indonesia. In Surabaya, capital of East Java, 16 schools were randomly selected. Nine of these schools were general Junior High Schools (SMP = Sekolah Menengah Pertama), whereas the other seven were Islamic Junior High Schools (MTs = Madrasah Tsanawiyah). The rural area consisted of two districts (Bangkalan and Sampang) of Madura, an island off the coast of Surabaya. In the rural area 18 schools were selected, 10 Islamic boarding schools (PP = Pondok pesantren) and eight general Junior High Schools (SMP), equally distributed over the two districts.

The SMPs and MTs were randomly selected, but for the PPs a special approach was necessary to ensure maximal cooperation, as this survey was part of a longitudinal study. Pupils in the selected schools were of middle and low socio-economic class, of Javanese or Madurese ethnicity, and Muslim, except for one school in Surabaya, where most pupils were Chinese and Christian. Data were collected from all pupils in these schools aged 12 to 15-y-old, whose parents gave written informed consent (91.4%).

The study was conducted in collaboration with the Indonesian Ministries of Health and Education and was approved by the Medical Ethical Committee of the Ministry of Health, Indonesia.

Fieldworkers

Data were collected by 15 trained fieldworkers, who had all graduated from Indonesian Schools of Dietetics. Three medical doctors supervised the data collection and re-measured a subsample for quality control.

Questionnaire

A standard questionnaire was used to collect data on the schools as well as on socio-economic background and health of the pupils. Educational level of both parents was recorded as a proxy for socio-economic status. Pubertal status was assessed by the status quo method (Cameron, 1993): each respondent was asked whether she or he had experienced menarche or nocturnal emissions, respectively.

Haemoglobin

Haemoglobin was determined with the Hemocue device (HemoCue, Angelholm, Sweden) in peripheral blood obtained from the fingertip.

Anthropometry

Anthropometric measurements consisted of height (using microtoise to the next 0.1 cm), weight with light clothing and without shoes (using Soehnle digital weighing scales, accuracy 0.1 kg), and mid upper-arm circumference (MUAC; using a special measuring tape developed by the Indonesian Department of Health).

Vitamin A intake

Vitamin A intake was assessed with the 24-VASQ method, which can be described as follows. A 24-h recall questionnaire was administered that included all food and drink consumed during the previous day. All vitamin A-containing ingredients were then assigned a food code and a vitamin A content code. The food code defines whether the ingredient is a vegetable, fruit, animal food or fortified food. Vitamin A content codes were assigned for the amount of vitamin A in the individual ingredient consumed, and were <20; 20–100; 100–250; 250–500; 500–1000 and >1000 RE. Vitamin A intake was calculated per food code using the midpoints of the vitamin A content categories (De Pee *et al*, 1999).

Statistical methods

Values are expressed as mean ± s.d. or as proportions. Statistical tests used included χ^2 test, analysis of variance (ANOVA) and logistic regression analysis. The computer program SPSS (SPSS 7.5 for Windows, SPSS Inc., Chicago, IL) was used for all statistical analyses.

Results

Data were collected from 3075 boys and 3537 girls. Of these, 31 boys (1%) and 21 girls (0.6%) refused to have their haemoglobin determined. In this paper the data are presented of the 3000 boys and 3486 girls on whom complete data are available (at least age, pubertal status and haemoglobin concentration).

Tables 1 and 2 show the characteristics of the study population per type of school, for girls and boys, respectively. The mean age in boys and girls was 14.2 y, and the proportion that had already reached puberty was higher in the girls (82.5%) than in the boys (72.6%).

As the initial focus in the selection process of the boarding schools was on girls, the sex distribution shown in the tables does not represent the actual composition of

Table 1 Characteristics of the girls of the study population per school type ($n = 3486$)[a]

	Madura (n = 1598)		*Surabaya* (n = 1888)	
	PP (n = 1025)[b]	*SMP* (n = 573)[b]	*MTs* (n = 1012)[b]	*SMP* (n = 876)[b]
Proportion within type of school (%)[c]	77.7	35.4	57.9	48.7
Age (y)	14.3 ± 0.9^{B}	14.1 ± 0.9^{A}	14.3 ± 0.9^{B}	14.1 ± 1.0^{A}
Height (cm)[d]	146.1 ± 5.3^{A}	147.4 ± 5.8^{B}	148.0 ± 5.6^{B}	149.6 ± 5.8^{C}
Weight (kg)[d]	41.0 ± 6.2^{C}	39.0 ± 7.2^{A}	40.1 ± 7.7^{B}	40.8 ± 7.9^{BC}
Already reached puberty (%)	82.2^{B}	76.3^{A}	83.7^{B}	85.5^{B}
Maternal formal education (y)[e]	3.4 ± 2.8^{A}	5.5 ± 3.6^{B}	5.3 ± 2.9^{B}	7.6 ± 3.4^{C}
Paternal formal education (y)[f]	4.3 ± 3.2^{A}	7.2 ± 3.9^{C}	6.7 ± 3.4^{B}	9.3 ± 3.5^{D}
Total fees paid in 3 y (×Rp 1000)[g]	202.7 ± 94.6^{B}	170.8 ± 47.1^{A}	790.9 ± 156.8^{D}	602.7 ± 330.9^{C}
Hb (g/l); pre-pubertal ($n = 610$)	126 ± 12	128 ± 11	127 ± 11	128 ± 11
Hb (g/l); pubertal[h] ($n = 2875$)	125 ± 13^{A}	126 ± 11^{AB}	127 ± 12^{B}	126 ± 13^{AB}
Hb < 120 g/l (% (n)); pre-pubertal ($n = 610$)	26.4 (48)	19.9 (27)	23.6 (39)	18.1 (23)
Hb < 120 g/l (%, (n)); pubertal[i] ($n = 2876$)	31.1 $(262)^{B}$	22.2 $(97)^{A}$	23.7 $(201)^{A}$	27.4 $(205)^{AB}$

[a]mean ± s.d. or proportion (n).
[b]PP = religious boarding school; SMP = general Junior High School; MTs = religious Junior High School.
[c]The choice of boarding schools (PP) determined the girl/boy ratio because they are usually for either sex only. The boy/girl ratio at the other schools represents real difference in boy/girl attendance of these schools.
[d]$n = 3485$. [e]$n = 3287$. [f]$n = 3111$. [g]$n = 3400$.
[h]No difference of haemoglobin concentration between pre-pubertal and pubertal subjects per school type.
[i]Difference of anaemia prevalence between pre-pubertal and pubertal subjects for SMP in Surabaya (χ^2, $P < 0.05$). No difference at other schools.
[A,B,C]Groups in one row with a different letter are significantly different from each other ($P < 0.01$, χ^2 or ANOVA with Bonferroni correction for *post-hoc* multiple comparisons).

Table 2 Characteristics of boys of study population per school type ($n = 3000$)[a]

	Madura (n = 1399)		*Surabaya* (n = 1661)	
	PP (n = 295)[b]	*SMP* (n = 1044)[b]	*MTs* (n = 736)[b]	*SMP* (n = 925)[b]
Proportion within type school (%)[c]	22.3	64.6	42.1	51.3
Age (y)	14.3 ± 1.0	14.2 ± 1.0	14.2 ± 1.0	14.2 ± 1.0
Height (cm)	149.6 ± 8.1^{A}	150.2 ± 9.2^{A}	151.6 ± 9.2^{B}	154.2 ± 9.0^{C}
Weight (kg)	39.5 ± 6.8^{AB}	38.8 ± 7.9^{A}	40.4 ± 9.2^{B}	42.8 ± 10.8^{C}
Already reached puberty (%)	87.1^{C}	79.4^{B}	65.8^{A}	65.8^{A}
Maternal formal education (y)[d]	3.3 ± 3.0^{A}	4.4 ± 3.5^{B}	5.5 ± 2.9^{C}	7.7 ± 3.4^{D}
Paternal formal education (y)[e]	3.7 ± 3.5^{A}	5.9 ± 3.9^{B}	6.3 ± 3.1^{B}	9.2 ± 3.7^{C}
Total fees paid in 3 y (×Rp 1000)[f]	235.1 ± 165.7^{B}	166.6 ± 45.4^{A}	793.6 ± 159.5^{D}	603.3 ± 333.6^{C}
Hb (g/l); pre-pubertal ($n = 821$)	126 ± 12^{AB}	125 ± 12^{A}	129 ± 12^{B}	131 ± 14^{B}
Hb (g/l); pubertal[g] ($n = 2178$)	132 ± 15^{A}	133 ± 13^{A}	138 ± 14^{B}	138 ± 14^{B}
Hb < 120 g/l (% (n)); pre-pubertal ($n = 821$)	23.7 $(9)^{AB}$	34.4 $(74)^{B}$	21.4 $(54)^{A}$	20.3 $(64)^{A}$
Hb < 120 g/l (% (n)); pubertal[h] ($n = 2178$)	22.6 $(58)^{B}$	11.9 $(99)^{A}$	10.7 $(52)^{A}$	8.9 $(54)^{A}$

[a]mean ± s.d. or proportion (n).
[b]PP = religious boarding school; SMP = general Junior High School; MTs = religious Junior High School.
[c]The choice of boarding schools (PP) determined the girl/boy ratio because they are usually for either sex only. The boy/girl ratio at the other schools represents real difference in boy/girl attendance of these schools.
[d]$n = 2723$. [e]$n = 2595$. [f]$n = 2956$.
[g]Haemoglobin concentration of pre-pubertal and pubertal subjects was significantly different for each school type (t-test, $P < 0.05$ for PP and $P < 0.001$ for other schools).
[h]Anaemia prevalence among pre-pubertal and pubertal subjects was significantly different for all school types (χ^2, $P < 0.001$), except for PP.
[A,B,C]Groups in one row with a different letter are significantly different from each other ($P < 0.01$, χ^2 or ANOVA with Bonferroni correction for *post-hoc* multiple comparisons).

the student population in these schools. The sex distribution at the other schools shows that parents choose different schools for their sons and daughters: girls tend to go to religious schools more than to general schools. In addition, girls stop attending school at an earlier age. This gender difference in school attendance is a socio-economically determined phenomenon, as can be derived from the differences in the level of parental education, especially of the fathers, between boys and girls attending the same schools. For both boys and girls, father's education was higher in Surabaya than in Madura, and it was higher in general schools than in religious schools. This indicates that parents with a higher education are more likely to send their children to a general school.

The fees in the table are the mean of the total of all fees paid during 3 y at school. They were calculated from school fees and additional fees for necessities such as uniforms and books. The higher school fees encountered in Surabaya are influenced by the selection of the schools. While in Madura all Junior High Schools were state-owned schools without school fees, in Surabaya the majority of the state-run schools were too large to participate in the study of which this survey formed the baseline. For this reason, in Surabaya, privately run schools, which ask fees from their pupils, were enrolled together with one state-run school. This raised the mean of fees paid. Thus, both educational level of the parents and the type of school reflect socio-economic status. Therefore, data are presented per type of school.

Among girls, there was a trend of lower haemoglobin concentrations and higher anaemia prevalence in the religious schools in Madura compared to the other school types. There was a trend, within school types, for a lower haemoglobin concentration, and a higher anaemia prevalence, among pubertal girls than among pre-pubertal girls.

Among pre-pubertal boys, haemoglobin concentrations were lower in the general schools in Madura compared to both Surabaya school types ($P < 0.001$). Among pubertal boys, they were lower in both school types in Madura than in both Surabaya school types ($P < 0.001$). Haemoglobin concentrations were higher, and anaemia prevalences lower, among pubertal than among pre-pubertal boys in all school types.

The relationship of haemoglobin concentration and anaemia with age and puberty for girls and boys are shown in Figures 1 and 2, respectively. Figure 1 shows the trend of lower haemoglobin concentrations and higher anaemia among pubertal girls as compared to pre-pubertal

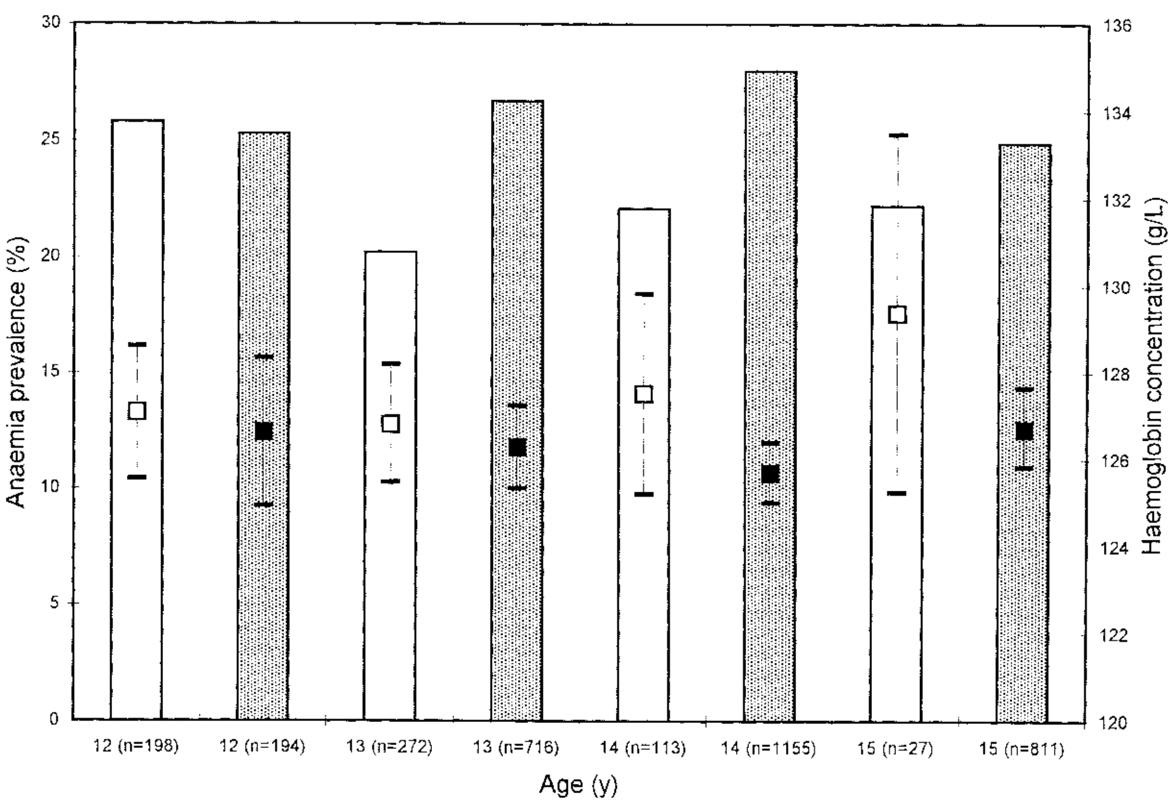

Figure 1 Relationship of haemoglobin concentration (mean ± 95% CI) and anaemia prevalence with age and pubertal status in girls ($n = 3486$). (white block) Pre-pubertal anaemia prevalence; (grey block) pubertal anaemia prevalence; (open square) pre-pubertal haemoglobin concentration (mean ± 95% CI); (filled square) pubertal haemoglobin concentration (mean ± 95% CI).

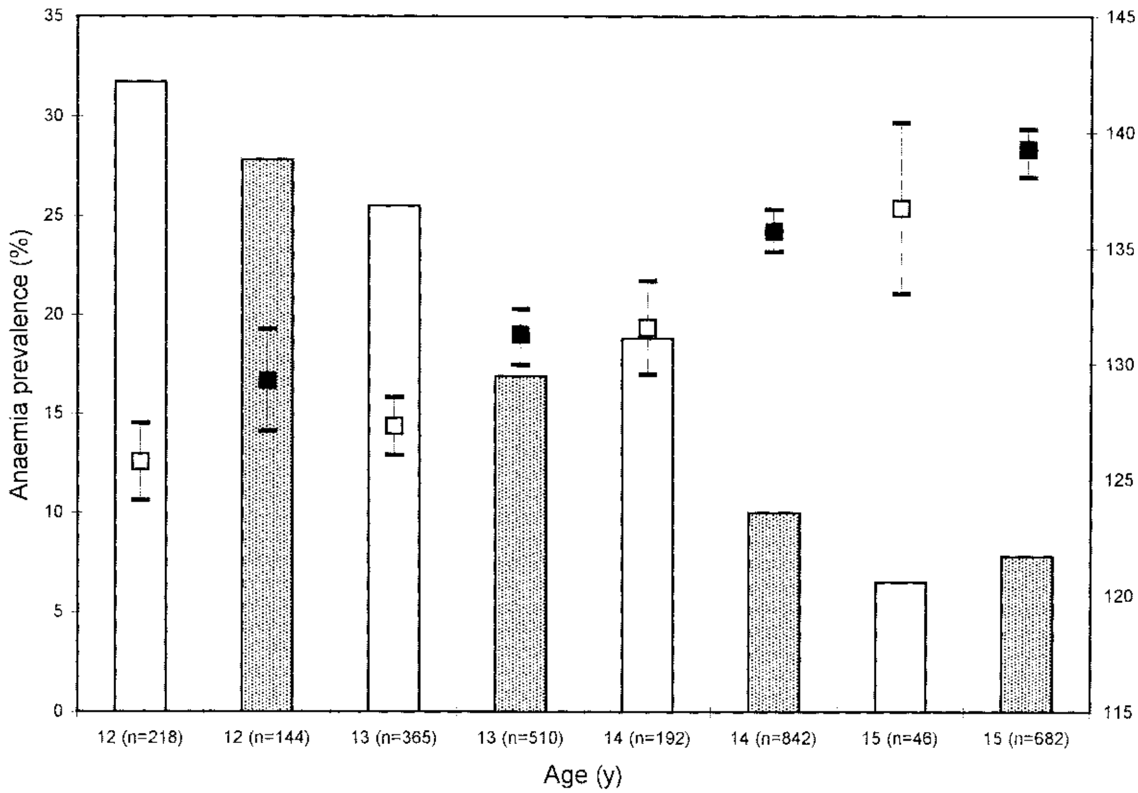

Figure 2 Relationship of haemoglobin concentration (mean ± 95% CI) and anaemia prevalence with age and pubertal status in boys ($n = 3000$). (open square) Pre-pubertal anaemia prevalence; (filled square) pubertal anaemia prevalence; (white block) pre-pubertal haemoglobin concentration (mean ± 95% CI); (grey block) pubertal haemoglobin concentration (mean ± 95% CI).

girls. Haemoglobin concentration in boys was higher in each consecutive age group, and within any given age group, it was higher for pubertal than for pre-pubertal subjects ($P < 0.01$). In pre-pubertal boys, mean haemoglobin concentration was 126 g/l at age 12 and 137 g/l at age 15, while among pubertal boys it was 129 g/l at age 12 and 139 g/l at age 15.

Multiple logistic regression analysis was performed to analyse the chance to be anaemic (Tables 3 and 4). Lower socio-economic status, as reflected by the type of school attended, was an important factor determining anaemia in both boys and girls. In addition, for girls the risk was higher when they had reached puberty, had lower intakes of retinol, and higher intakes of vitamin A from vegetables and fruit. Boys had a lower chance of being anaemic when, in addition to having a higher socio-economic status, they were older, taller, had a larger MUAC, had reached puberty and had a retinol intake >50 RE.

The relationships between intake of vitamin A from animal and fortified sources (retinol), as well as from vegetables and fruit, and indicators of socio-economic status are shown in Table 5. Maternal education is not shown in the table, as it showed a similar relationship to vitamin A intake as paternal education. No relationship was found between intake of vitamin A from plant sources and socio-economic status. In both girls and boys, retinol intake was positively related to socio-economic status, as indicated by type of school attended and by paternal education.

Discussion

This survey among 12 to 15-y-old adolescents enrolled at different urban/rural and public/religious schools in East Java found an anaemia prevalence of 25.8% among girls, of 24.5% among pre-pubertal boys and of 12.1% among pubertal boys. The chance of being anaemic was determined by socio-economic status, as indicated by type of school attended, and by physiological factors. Girls had a lower chance of being anaemic when they had a higher socio-economic status, had not yet reached puberty, had a higher retinol intake, and a lower vitamin A intake from plant foods. Boys had a lower chance of being anaemic when they had a higher socio-economic status, were older, had reached puberty, were taller, had a larger MUAC, and had a higher retinol intake.

The higher anaemia prevalence among subjects of a lower socio-economic status, as found in this survey, is

Table 3 Odds ratios (95% CI) for having a haemoglobin concentration < 120 g/l—girls ($n = 3483$)[a,b]

		OR	*95% CI*	P-*value*
Puberty	No	1.00		
	Yes	1.25	1.02–1.55	< 0.05
Type of school[c]	PP	1.00		
	SMP-M	0.67	0.52–0.85	< 0.005
	MTs-S	0.74	0.60–0.90	< 0.005
	SMP-S	0.87	0.71–1.07	NS
Retinol intake quartiles (RE)[d]	≤20	1.00		
	21–130	0.97	0.79–1.20	NS
	131–295	0.89	0.72–1.10	NS
	>295	0.77	0.61–0.96	< 0.05
VA intake from plant sources (RE)[e]	≤20	1.00		
	21–80	1.10	0.89–1.37	NS
	81–275	1.31	1.06–1.62	< 0.05
	>275	1.04	0.84–1.30	NS

[a]The multiple logistic regression analysis was first run for stepwise entrance into the model ($n = 3009$). *P*-value for entrance in the model was < 0.10. Because the interaction terms of retinol intake with VA intake from plant sources, and of puberty with type of school entered the model, the analysis was re-run with 'forced entrance' of the variables that had entered the model upon stepwise entrance ($n = 3483$).
[b]Variables that did not enter the logistic regression model were age, height, MUAC, weight, BMI, consumption of eggs and educational level of parents.
[c]Overall *P*-value < 0.005.
[d]Overall *P*-value < 0.10.
[e]Overall *P*-value < 0.10.

Table 4 Odds ratios (95% CI) for having a haemoglobin concentration < 120 g/l—boys ($n = 2998$)[a,b]

		OR	*95% CI*	P-*value*
Puberty	No	1.00		
	Yes	0.78	0.61–1.00	< 0.05
Type of school[c]	PP	1.00		
	SMP-M	0.63	0.45–0.88	< 0.01
	MTs-S	0.54	0.37–0.78	< 0.005
	SMP-S	0.56	0.39–0.82	< 0.005
Retinol intake quartiles (RE)[d]	≤50	1.00		
	51-175	0.67	0.51–0.88	< 0.005
	176-320	0.74	0.54–1.00	< 0.05
	>320	0.68	0.51–0.91	< 0.01
Age (y)		0.79	0.69–0.90	< 0.0005
BMI (kg/m^2)		1.04	0.94–1.14	NS
Height (cm)		0.95	0.94–0.97	< 0.0001
MUAC (mm)		0.99	0.98–1.00	< 0.10

[a]The multiple logistic regression analysis was first run for stepwise entrance into the model ($n = 2473$). *P*-value for entrance was < 0.10. Because the interaction terms of school type with puberty, and of retinol intake with BMI entered the model, the analysis was re-run with 'forced entrance' of the variables that had entered the model upon stepwise entrance ($n = 2998$).
[b]Variables that did not enter the logistic regression model were weight, consumption of eggs and educational level of parents.
[c]Overall *P*-value < 0.01.
[d]Overall *P*-value < 0.05.

analogous to the fact that anaemia is most prevalent in developing countries, and among the poorer segments of all societies. A lower socio-economic status reflects a lower intake of iron-rich foods, especially sources of haem-iron, and higher infection rates. While infections, such as intestinal parasites and malaria, generally play a role in the occurrence of anaemia, the study area is not endemic for malaria, and intestinal helminths were not a major factor in the study population. Analysis of a subsample ($n = 1084$) showed that the prevalence of hookworm infection was

Table 5 Vitamin A intake from plant foods (vegetables and fruit) and retinol-rich foods (animal foods and fortified foods; median (25–75 percentile)), by indicators of socio-economic status

		Girls	n	*Boys*	n
VA from plant foods (RE/day)[a]					
Schools	PP	80 (20–245)[A]	900	40 (10–215)[A]	244
	SMP-M	180 (20–455)[B]	492	100 (10–415)[C]	867
	MTs	60 (20–215)[A]	844	70 (20–210)[A]	587
	SMP-S	70 (20–285)[A]	775	80 (20–285)[B]	776
Father's education[b]	None	80 (20–350)	322	60 (10–350)	293
	Primary	80 (20–270)	1621	70 (10–360)	1253
	Junior High	80 (20–245)	435	90 (20–370)	363
	Senior High	110 (20–365)	518	120 (20–370)	464
	>12 y	130 (20–265)	115	80 (10–420)	101
VA from retinol-rich foods (RE/day)[a]					
Schools	PP	60 (10–180)[A]	900	70 (10–185)[A]	244
	SMP-M	120 (20–295)[B]	492	150 (40–295)[B]	867
	MTs	150 (20–255)[B,C]	844	175 (50–320)[B]	587
	SMP-S	195 (70–410)[C]	775	185 (60–395)[C]	776
Father's education[b]	None	30 (10–180)[A]	322	120 (10–235)[A]	293
	Primary	120 (10–240)[B]	1621	150 (30–305)[B]	1253
	Junior High	180 (60–375)[C]	435	180 (60–355)[C]	363
	Senior High	180 (60–365)[C]	518	205 (80–395)[D]	464
	>12 y	235 (65–405)[C]	115	185 (60–375)[C,D]	101

[A,B,C]Groups in one set with a different letter are significantly different from each other ($P < 0.001$, Kruskal–Wallis *H*-test).
[a]$P < 0.001$ between the types of school for both sexes (χ^2 test).
[b]Girls $n = 3110$; boys $n = 2593$.

only 1.3%. In addition, infection load of any type of worm was very low and no relationship was found between parasitic infection and anaemia (unpublished data). Thus, low iron intake was a major causal factor of anaemia in the study population. This was confirmed in the logistic regression analysis, which showed the positive effect on anaemia of a high consumption of retinol-rich foods. This effect might be because of: (1) increased vitamin A status which in turn leads to improved iron status (Bloem, 1995), (2) the fact that retinol-rich foods generally also contain a considerable amount of haem-iron, and thus that retinol intake reflects haem-iron intake; and/or (3) the fact that a higher retinol intake might reflect a higher socio-economic status. However, because type of school already reflects higher socio-economic status, the first two hypotheses are more likely to explain the negative relationship between retinol intake and anaemia. The higher risk of anaemia that was associated with a higher vitamin A intake from vegetables might be caused by the high fibre content of vegetables, which inhibits absorption of non-haem-iron.

For girls, puberty was the only other major factor, in addition to socio-economic status, that was related to the occurrence of anaemia. As menarche occurs 1–2 y after the physical changes of puberty, the use of menarche as indicator of puberty might have led to lower proportions of pubertal subjects than if physical examination had been used. However, in the setting of this study, physical examination was not appropriate, and menarche is the most relevant parameter in relation to haemoglobin concentration.

The data on puberty in boys, however, should be interpreted with caution, because the question about nocturnal emissions, the parameter used for puberty, might have caused shyness among respondents, influencing the results. Although we expect delayed onset of puberty in Madura compared to Surabaya, due to poorer socio-economic conditions, our results show the opposite, in particular in the boarding schools. This might have been due to a difference in frankness between rural and urban boys, further enhanced by the fact that, in contrast to the other school types, pupils in the boarding schools were only allowed to be interviewed by field workers of the same sex. Thus, the choice of the parameter is likely to have resulted in more false-negative answers from boys and, consequently, a proportion of pubertal boys will have been classified in the pre-pubertal group. Therefore, this study is likely to have found a smaller difference between pubertal and pre-pubertal boys than actually existed in the study population, and the decrease of the prevalence of anaemia with age may in fact appear stronger than it really is, due to the weakened effect of puberty caused by the false-negative answers to the question on pubertal status. The setting in which the data were collected did not allow for a more precise assessment of pubertal status such as by examining genital and pubic hair status.

This study population is appropriate to study the influence of different factors on haemoglobin concentration and anaemia in adolescents in East Java. Although the subjects were sampled from schools instead of from households, the sampling of the schools was done in such a way that a broad range of socio-economic conditions was included, and all pupils of each school were studied. Analyses were controlled for school type, and the results should be interpreted within this context. Because the study population consisted of school-attending adolescents, prevalences found should not be extrapolated to adolescents in general. Adolescents who have dropped out of school represent the poorest socio-economic status, and are likely to have higher risks of anaemia and other deficiencies than the subjects in the present study.

The differences in anaemia prevalence between boys and girls are consistent with data published by the International Nutritional Anaemia Consultative Group in 1979 (Dallman & Siimes, 1979). Angeles-Agdeppa *et al*, (1997) found an anaemia prevalence of 17.4% among 14 to 18-y-old menstruating girls in Jakarta, Indonesia. The lower anaemia prevalence in their study as compared to our study is partly due to differences in socio-economic status. The girls in their study were still attending school at an age when part of our population would have dropped out of school (State Ministry of Population/National Family Planning Coordinating Board & UNICEF, 1994).

Although not much is known about the prevalence of iron deficiency anaemia among adolescent boys, Anttilla and Siimes (1996) showed similar relationships between age, haemoglobin and pubertal status as the present study. The lower anaemia prevalence among pubertal boys can be explained by the physiological rise in haemoglobin concentration caused by sexual maturation (Dallman, 1992), as well as by decreasing requirements after completion of the growth spurt. In girls, any expected age-related increase in haemoglobin concentration is halted by the occurrence of menarche and the ensuing regular blood loss. This is consistent with the results of the logistic regression analysis, which showed that pubertal girls had a higher chance of being anaemic than pre-pubertal girls. The peak of the growth spurt in girls occurs approximately 1 y before menarche. Therefore, rapid growth is no factor of importance among pubertal girls. It may however be a cause of anaemia in pre-pubertal girls. In a small study among well-nourished non-anaemic girls in the US, haemoglobin concentration was 137 ± 9 g/l in post-menarcheal girls ($n = 46$) and 139 ± 12 g/l in girls who had not yet reached menarche ($n = 44$; Greger *et al*, 1978). To our knowledge, no other data are available that distinguish between pre-pubertal and pubertal girls, nor any reference data from a well-nourished population of pre- and post-pubertal boys.

In conclusion, anaemia in adolescents is related to poor socio-economic status. Among girls, puberty increases the risk of being anaemic, while it decreases the risk among boys. Therefore, data should be reported separately per sex, age and puberty, and sampling frames should take into account differences in socio-economic status.

Because of the strong relationship with socio-economic status, the most appropriate short-term approach to control anaemia is distribution of micronutrient supplements. Our data indicate that boys would benefit most from supplementation before the onset of puberty, while girls would benefit both before and after the onset of puberty.

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