Community and International Nutrition

The High Prevalence of Low Hemoglobin Concentration among Indonesian Infants Aged 3–5 Months Is Related to Maternal Anemia[1]

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ABSTRACT Iron deficiency anemia among young children is a large health problem. However, there is little information about the prevalence of anemia among young infants because it has been assumed that normal, breast-fed infants have adequate iron stores until 4–6 mo of age. We analyzed cross-sectional data from the HKI/GOI Nutrition and Health Surveillance System in rural Java, Indonesia from Sept. 1999 to Feb. 2001 for hemoglobin (Hb) of 3- to 5-mo-old breast-fed infants ($n = 990$) and related factors. The prevalence of Hb < 90 g/L was 13.4%, < 100 g/L, 37%, and < 110 g/L, 71%. Multiple logistic regression analysis revealed that normal birth weight infants (>2500 g) of anemic mothers (Hb < 120 g/L) had an odds ratio (OR) [95% confidence interval (CI)] of 1.81 [1.34–2.43] to have a low Hb (< 100 g/L) compared with infants of nonanemic mothers with a normal birth weight. Infants of nonanemic mothers but with low birth weight had an OR of 1.15 [0.61–2.16], and those with low birth weight and anemic mothers of 3.68 [1.69–8.02]. Other risk factors included stunting (OR 1.70 [0.97–2.95]), a young mother (<20 y, OR 1.54 [0.95–2.49]), lower maternal education and living in West Java or East Java. Considering that maternal postpartum Hb reflects Hb during pregnancy, that anemia among mothers in this population is due mainly to iron deficiency, and that children born to anemic mothers are at higher risk of a low Hb, we hypothesize that low infant Hb in this population is due to iron deficiency. Intervention studies in iron deficient populations should test this hypothesis. J. Nutr. 132: 2215–2221, 2002.

KEY WORDS: • *anemia* • *infants* • *Indonesia* • *birth weight* • *maternal anemia* • *hemoglobin*

Iron deficiency anemia among young children is a large health problem worldwide. In developing countries, 40–45% of children aged 0–4 y old suffer from anemia, and in Southeast Asia this figure is as high as 60–70% (1). The main cause of anemia is iron deficiency. Severe anemia increases mortality; iron deficiency impairs behavioral and cognitive development and reduces fitness and work capacity (2). Although iron deficiency can be corrected at any point in life, its consequences cannot always be corrected because certain developmental opportunities occur only during a particular period of life. Therefore, iron deficiency and severe anemia should be prevented and/or treated at as young an age as possible. However, little is known about the prevalence of these problems before the age of 6 mo.

One reason for the lack of prevalence data is the absence of good cut-off values for infants <6 mo old. Anemia is defined as a low hemoglobin (Hb)[3] concentration; cut-off values have been established for groups of different ages and sex, starting from the age of 6 mo (3). For infants <6 mo old, the cut-off value for children aged 6 mo to 5 y (110 g/L) is sometimes applied. However, this is not appropriate. During the first months of life, Hb declines from the very high level at birth to its lowest level at 6–10 wk of age (4). This decrease is known as the "physiologic anemia of the newborn" because the iron stores of all young infants, except those born with a very low birth weight (<1500 g), are filled as a result of the breakdown of RBC that occurs in the period immediately after birth. Therefore, until 6–10 wk of age, Hb does not reflect iron storage or supply. After Hb has reached its lowest level at ~2 mo of age, it slowly increases again and becomes more or less stable at 6–9 mo of age, unless iron stores have become depleted (4,5). Although no cut-off value has yet been suggested for infants aged 3–5 mo, Saarinen and Siimes (6) reported that mean -2SD for Hb of healthy Finnish infants was 94 g/L at 2 mo of age, 103 at 4 mo and 111 at 6 mo. The last-mentioned value was the basis for the cut-off value of 110 g/L for infants 6 mo to 5 y old. Lonnerdal et al. (7) recently suggested a cut-off value of 100 g/L for infants aged 4–8 mo on the basis of the Hb distribution observed among healthy Swedish infants and among Honduran infants who had received iron supplementation. In both populations, 5% of infants aged 4–8 mo had an Hb < 100 g/L (7).

Another reason for the lack of data on the prevalence of anemia and iron deficiency among young infants is that it has

[1] The data presented in this paper were collected by the HKI/GOI Nutrition and Health Surveillance System, funded by the United States Agency for International Development, Asian Development Bank and United Nations Children's Fund.

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[3] Abbreviations used: CI, confidence interval; Hb, hemoglobin; NSS, Nutrition and Health Surveillance System; OR, odds ratio.

Manuscript received 10 October 2002. Initial review completed 8 November 2001. Revision accepted 30 April 2002.

generally been assumed that infants born at term and with an adequate birth weight have adequate iron stores for the first 4–6 mo of life (8). Thereafter, infants require a good supply of iron either from iron-rich foods, especially iron-fortified complementary foods, or from supplements. Before the age of 6 mo, only preterm infants and infants with low birth weight (<2500 g) are considered at-risk of iron deficiency anemia and are prescribed iron supplements (9). However, evidence has accumulated that infants with adequate birth weight but born to anemic mothers have low iron stores and are more likely to develop anemia (10–15).

Because there is a lack of data on Hb distribution and anemia prevalence among young infants and because the prevalence of anemia among women in South and Southeast Asia (1) including Indonesia (16) is high, we analyzed cross-sectional data from 3- to 5-mo-old Indonesian infants for Hb distribution and its relationship with maternal Hb, birth weight, other physiologic factors and socioeconomic status to identify the most likely causes of a low Hb in this population.

SUBJECTS AND METHODS

Subjects. Data presented in this paper were collected by the HKI/GOI (Helen Keller International/Government of Indonesia) Nutrition and Health Surveillance System (NSS) in West, Central and East Java, Indonesia during five rounds of data collection between Sept. 1999 and Feb. 2001. For each round, a new random sample of households was selected, using a multistage cluster sampling design. Each province was divided into 3–6 ecological zones. From each zone, 30 villages were selected by probability-proportional-to-size sampling. Each village provided a list of households with one or more children <60 mo old. From this list, 40 households were selected by interval sampling, using a random start. West Java was divided into four zones (4800 households per round), Central Java into six (7200 households) and East Java into three (3600 households). In a subsample of 20% of the selected villages, blood was collected from the mother and the children <5 y old of all selected households for measuring Hb. Written informed consent was obtained before blood collection. This procedure was approved by the Medical Ethical Committee of the Indonesian Ministry of Health.

Methods for data collection. A questionnaire was used to collect information on household composition, parental education and occupation, sanitary conditions, land and livestock ownership, nutritional knowledge, food production and consumption, vitamin A capsule receipt, receipt of iron pills, child and maternal morbidity, birth weight of each child and vitamin A intake. For receipt of iron pills, the mother was asked whether she received them at any time during her last pregnancy. Birth weight was known for 90% of the children; for 35%, it was recorded from a written record and for 55% as reported by the mother. In addition, anthropometric measurements were taken from the woman and her youngest child. Weight was measured to the nearest 0.1 kg using an AND UC-300 Precision Health Scale (A&D, Tokyo, Japan). Children's length was measured using a lengthboard, and mothers' height was measured using a microtoise. Precision of length and height measurements was 0.1 cm. Blood samples were collected by fingerprick to measure Hb using the HemoCue device (Angelholm, Sweden), as follows. First, the hand and finger of the subject are rubbed to stimulate blood flow, after which the fingertip is cleaned with alcohol. The fingertip is then dried to the air before being pricked with a sterile lancet. The first drop of blood that appears is wiped away; the second drop is collected into the HemoCue microcuvette. The finger is not squeezed for obtaining blood. When the microcuvette is full, any spilled blood is carefully wiped away from its edges before inserting it into the HemoCue device.

Data collection: quality assurance and quality control. Data were collected by 20–40 enumerators per province, most of whom were graduates from Indonesian schools of dietetics. The enumerators were carefully selected and trained, and every team of four was supervised by one field supervisor. For quality control, a special team reinterviewed 10% of the households that had already been visited by a data collection team. After data entry, the performance of each enumerator was evaluated by comparing his/her data to that of the special team. This was then discussed in the refresher training that was organized before the next round of data collection to maximize enumerators' performance. Enumerators that were found to have knowingly recorded incorrect data were dismissed. Data were entered into a computerized database using SPSS Data Entry Builder for Windows version 1.0 (SPSS, Chicago, IL). The program has a facility to check validity of values as they are being entered. After data entry, further checks on the data were performed.

Data selected for analysis. The purpose of the analysis presented in this paper was to assess the distribution of Hb among infants aged 3–5 mo and assess its relationship with different intermediate, underlying and basic factors, including the following: *1*) child variables: birth weight, birth order, age, sex, stunting and diarrhea in the week preceding the interview; *2*) mother variables: Hb, body mass index, age, receipt of iron pills during pregnancy and receipt of vitamin A capsule receipt within 4 wk after delivery; and *3*) indicators of socioeconomic status and environment: maternal education, province and the period of data-collection. Children's data were included in the analyses when they were 3.0–5.9 mo old, breast-fed and had a complete set of data for the variables analyzed (i.e., the indicators mentioned above). Of the 78,000 households interviewed (five rounds of surveillance among, per round, 4800 households in West Java, 7200 in Central Java and 3600 in East Java), 15,600 (20%) were selected for blood collection. Of these, 990 contributed data on infants aged 3–5 mo that met the criteria given above.

Statistics. A distribution curve was constructed by calculating the proportion of infants within Hb intervals of 10 g/L. The values on the *x*-axis of the curve represent the midpoints of the intervals (Figs. 1, 2). Differences between groups were examined by ANOVA for continuous variables, and by χ^2 test for categorical variables. When ANOVA indicated a significant difference among groups, a post-hoc multiple comparisons test for least significant differences was performed. When the χ^2 test indicated a significant difference among groups, χ^2 tests were performed for each combination of two groups. Univariate analyses (χ^2 tests) were used to determine which of the factors mentioned under "data selected for analysis" above were related to low infant Hb. Low Hb was defined as <100 g/L, based on a review of available literature (5,6) which indicated that this might be the most appropriate cut-off value for anemia among these 3- to 5-mo-old infants (see above also). For factors that were highly correlated, such as child age and breast-feeding status, the relationship with low infant Hb was assessed for all possible combinations (e.g., 3 mo old and exclusively breast-fed, 3 mo not exclusively breast-fed). Factors and combinations of factors that were found to be associated with low infant Hb were then used for multiple logistic regression analysis, which was used to estimate odds ratios (OR) and 95% confidence intervals (CI) for the regression parameters (17). A *P*-value < 0.05 was considered significant, whereas a *P*-value < 0.10 was used to select factors for use in the multivariate analysis and for entry of factors into the multiple logistic regression model. Analyses were conducted using SPSS for Windows version 7.5 (SPSS).

RESULTS

Table 1 shows the characteristics of the infants whose data were included in the analyses and of their households, by province. Differences among the three provinces were small. Hb was slightly higher in Central Java. Length-for-age Z-scores were slightly higher in Central Java, whereas weight-for-length Z-scores were slightly higher in West Java. The proportion of the infants that were exclusively breast-fed was highest in Central Java. Additional analysis revealed that 93% of all infants that were not exclusively breast-fed received solids. The proportion of mothers that had received a vitamin A capsule after delivery was highest in East Java.

As shown in **Figure 1**, 37% of the infants had a Hb concentration < 100 g/L. The distributions were not different

TABLE 1

Characteristics of the infants in each province[1,2]

	West Java (*n* = 314)	Central Java (*n* = 459)	East Java (*n* = 217)
Age, *mo*	4.5 ± 0.9	4.5 ± 0.9	4.6 ± 0.9
Proportion girls, %	42.7	44.2	47.0
Length for age Z-score	−0.62 ± 0.93[b]	−0.23 ± 1.11[a]	−0.44 ± 1.01[b]
Weight for length Z-score	0.41 ± 1.04[a]	0.01 ± 1.01[b]	0.14 ± 1.05[b]
Weight for age Z-score	−0.09 ± 0.96	−0.09 ± 0.94	−0.15 ± 0.89
Hemoglobin (Hb), *g/L*	103 ± 13[b]	104 ± 11[a]	101 ± 12[b]
Birth weight, %			
≤2500 *g*	6.7	8.5	8.8
2501–3000 *g*	30.6	33.8	27.2
>3000 *g*	62.7	57.7	64.1
Proportion exclusively breast-fed, %	10.5[b]	22.4[a]	14.7[b]
Maternal age, *y*	26.9 ± 6.0	26.7 ± 5.7	26.1 ± 5.8
Maternal education, %			
None	1.9	2.8	3.7
Primary	58.6	60.1	53.0
Junior high	20.1	20.0	21.2
Senior high	16.9	15.3	18.9
Tertiary	2.5	1.7	3.2
Maternal Hb, *g/L*	125 ± 14	125 ± 13	125 ± 1.6
Mother received iron pills during pregnancy, %	84.7	88.7	89.4
Mother received vitamin A capsule after delivery, %	13.1[b]	16.3[b]	24.4[a]
Data collection period, %			
Sept.–Nov. 1999	18.2	19.8	23.5
Apr.–June 2000	21.3	22.7	20.7
July–Sept. 2000	18.8	19.8	17.5
Sept.–Nov. 2000	22.6	18.3	21.2
Dec. 2000–Feb. 2001	19.1	19.4	17.1

1 Values are mean ± SD, unless indicated otherwise.

2 Values in a row with different superscripts differ, $P < 0.05$. (ANOVA with post-hoc multiple comparisons test for least significant differences for continuous variables and χ^2 test for categorical variables).

for 3-, 4- or 5-mo-old infants (data not shown). The Hb concentration of infants with an anemic mother was shifted toward lower concentrations and the shift was greatest for those whose mothers were most anemic (Hb < 100 g/L, $P < 0.001$; **Figure 2**).

Univariate analysis revealed that several other factors, in addition to maternal Hb, were related to low infant Hb (χ^2 test, $P < 0.10$). All of these factors are shown in **Table 2**, except diarrhea during the week preceding the interview, because it was not included in the multiple logistic regression model. Because four of the factors were highly correlated, maternal Hb and birth weight, and child age and breast-feeding status, they were included in combination. Two categories were made for maternal Hb because more categories resulted in too few subjects per category when combined with low birth weight. The first data column of Table 2 shows the number of infants in the different categories of each indicator or combination of indicators, and the second shows the proportion of these infants that had a low Hb (<100 g/L). The next three columns show the results of the multiple logistic regression analysis. Compared with infants with a normal birth weight and a nonanemic mother (Hb ≥ 120 g/L), the OR [95% CI] for the infant to have a low Hb was 1.15 [0.61–2.16] when birth weight was low, 1.81 [1.34–2.43] when birth weight was normal but the mother was anemic, and 3.68 [1.69–8.02] when both low birth weight and an anemic mother were present. No synergy was found between the two factors. Other physiologic risk factors included stunting (OR 1.70 [0.97–2.95]), young age of the mother (OR 1.54 [0.95–2.49] for mothers <20 y old), and the combination of age and breast-feeding status. For the latter, the OR was highest for infants aged 3 mo and exclusively breast-fed (1.00), followed by infants aged 5 mo and not exclusively breast-fed (0.65 [0.41–1.05]). Other, nonphysiologic indicators included in the model were maternal education (lower OR for infants of mothers with higher education level) and province (lowest OR for infants from Central Java).

DISCUSSION

The prevalence of a low Hb concentration among breast-fed Indonesian infants 3–5 mo old from Java was very high (37% < 100 g/L), and infants of anemic mothers were more likely to have a low Hb concentration. In fact, the infant's risk of having a low Hb when birth weight was normal (>2500 g) but the mother was anemic (Hb < 120g/L) was greater than that of infants that had a low birth weight but a nonanemic mother. This finding supports the accumulating evidence, largely collected among infants aged 6–12 mo, that children born to anemic mothers have lower iron stores, even when they are born at term and with a normal birth weight (10–15).

Before accepting the reported proportion of infants with a low Hb, we must be sure that although the blood sample was obtained correctly (see methods section), the method used to measure Hb, the HemoCue device, was also appropriate. It has previously been shown among Indonesian women that results obtained with the Hemocue are comparable to those of the cyanmethemoglobin method (18). When using blood obtained by finger stick, the HemoCue assessment had a sensitivity of 70.6% and a specificity of 95.2% (18). Thus, the proportion of infants with a low Hb is more likely to have been slightly underestimated than overestimated.

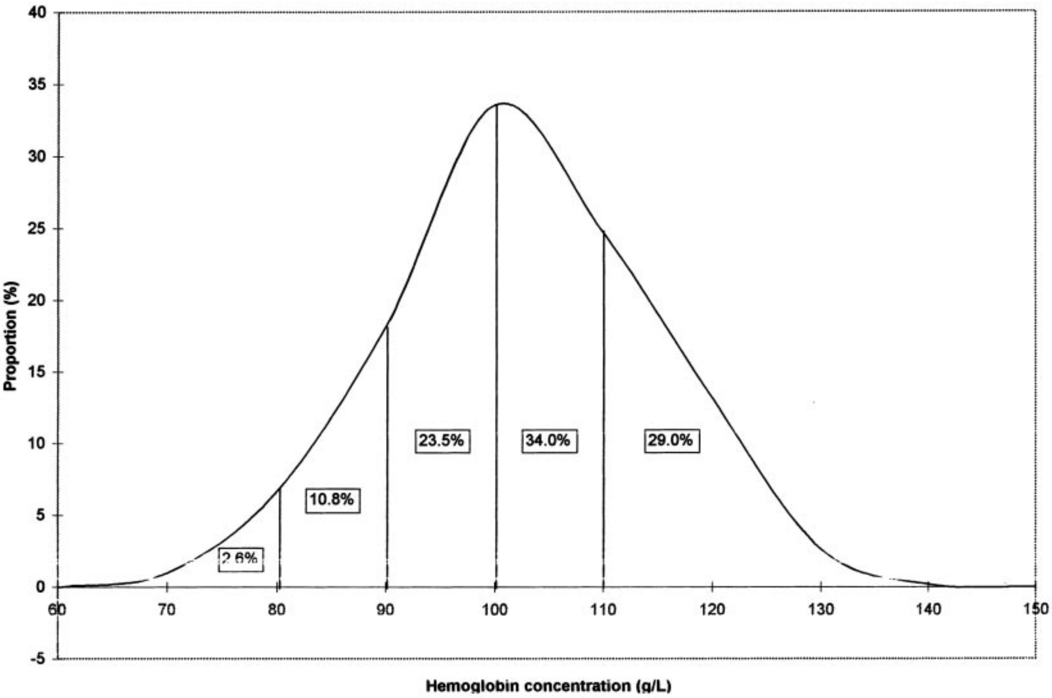

FIGURE 1 Distribution of hemoglobin concentration in Indonesian infants aged 3–5 mo (n = 990).

A high prevalence of a low Hb concentration among infants has previously been reported for infants aged 6 mo, i.e., in Honduras, 32% of exclusively breast-fed infants < 103 g/L, and 24.7% of breast-fed infants consuming iron-fortified solids (19); among Ghanaian infants, 29.5% < 100 g/L (20); and among Inuit infants from northern Quebec, Canada, 47.4% with Hb less than −2 SD of the mean of the reference population (21). Although there is no established cut-off value for anemia among infants 3–6 mo of age, it has recently been suggested that 100 g/L may be the most appropriate for 4- to 8-mo-old infants (7), which would also be consistent with observations among healthy Finnish infants (6), and the Finnish data would support extending that cut-off value to 3 mo of age. Thus, at least 37% of the infants aged 3–5 mo from Java, Indonesia, suffered from a low Hb.

The next question is: what causes these low Hb levels? Because the findings presented in this paper are based on cross-sectional data, we will discuss the most likely causes, based on our findings and what is known about anemia, and then formulate a hypothesis that should be tested in an intervention study. First, we should consider the possibility that these 3- to 5-mo-old infants had adequate iron stores and that

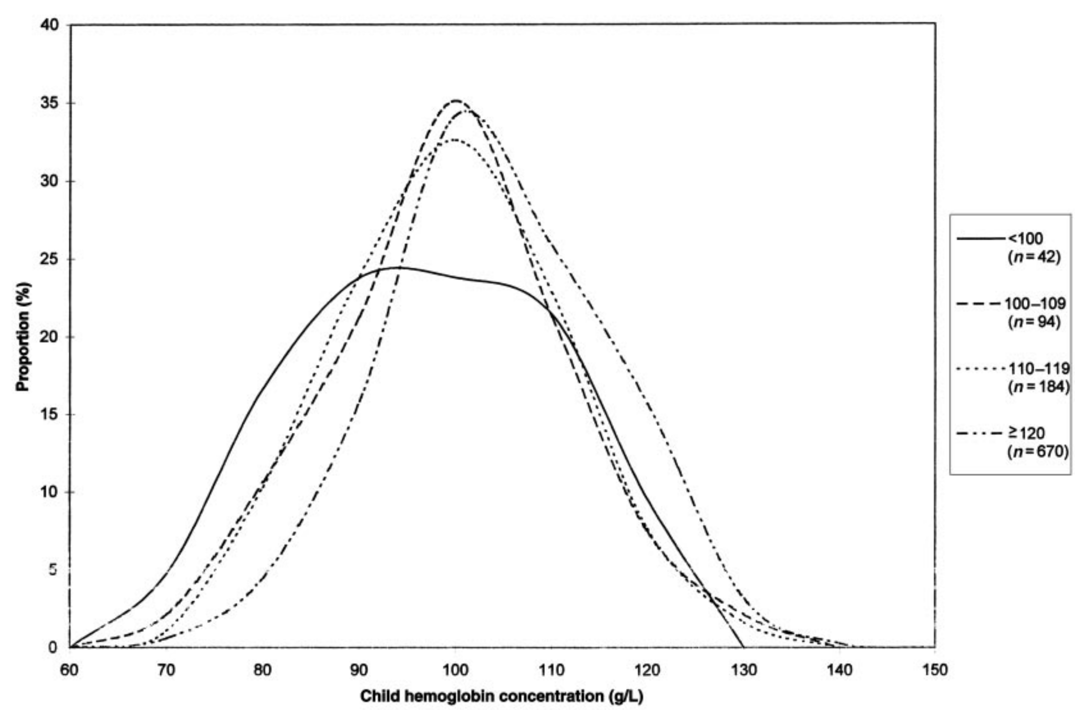

FIGURE 2 Distribution of hemoglobin concentration of infants aged 3–5 mo stratified by Hb concentration of their mothers (g/L). Mean Hb of infants of mothers with Hb < 100 g/L was lower than of infants of mothers with a higher Hb ($P < 0.001$, ANOVA). Proportions of infants with Hb < 100 was highest among infants of mothers with Hb < 100 g/L, lower of infants of mothers with Hb 100–109 or 100–119 g/L, and lowest of infants of mothers with Hb ≥ 120 g/L ($P < 0.001$, χ^2 test).

TABLE 2

Proportion of infants with a low hemoglobin (Hb) (<100 g/L) for categories of different indicators and odds ratios (OR) for a low Hb (<100 g/L) as assessed by multiple logistic regression analysis[1]

Variable	*n*	Hb < 100 g/L, %	OR	95% confidence interval	*P*-value
Maternal Hb and birth weight					<0.0001
≥120 *g/L, >2500 g*	622	31.7	1.00		
≥120 *g/L, ≤2500 g*	48	37.5	1.15	[0.61–2.16]	
<120 *g/L, >2500 g*	289	45.3	1.81	[1.34–2.43]	
<120 *g/L, ≤2500 g*	31	64.5	3.68	[1.69–8.02]	
Child age and breast-feeding					0.03
3 mo, exclusive	97	47.4	1.00		
3 mo, not exclusive	233	36.5	0.54	[0.33–0.89]	
4 mo, exclusive	46	32.6	0.56	[0.27–1.19]	
4 mo, not exclusive	279	31.9	0.44	[0.27–0.72]	
5 mo, exclusive	25	32.0	0.46	[0.18–1.19]	
5 mo, not exclusive	310	39.7	0.65	[0.41–1.05]	
Child stunted (length for age Z-score < −2 SD)					0.06
No	931	36.0	1.00		
Yes	59	52.5	1.70	[0.97–2.95]	
Maternal age					0.08
≥20 y	911	36.0	1.00		
<20 y	79	48.1	1.54	[0.95–2.49]	
Maternal education					0.0004
None + primary	602	42.2	1.00		
Junior high	201	29.9	0.57	[0.40–0.81]	
≥Senior high	187	27.8	0.56	[0.39–0.81]	
Province					0.007
Central Java	459	32.9	1.00		
West Java	314	37.9	1.32	[0.97–1.81]	
East Java	217	44.2	1.72	[1.22–2.43]	

[1] The variable that was not included in the multiple logistic regression model (forward entry, $P < 0.10$) was diarrhea in the week preceding the interview.

their Hb was still increasing to a stable level that would be reached at 6–9 mo of age (4,5). Additional analysis revealed that among infants aged 6–9 mo of the same population and measured in the same rounds of surveillance, 44–48% had an Hb < 100 g/L and 76–80% an Hb < 110 g/L. Thus, the Hb of these infants becomes lower rather than higher as they grow older. The most likely causes of a low Hb are specific morbidity and iron deficiency. Specific morbidity, including malaria, α-thalassemia trait and hemoglobin H disease, is unlikely to have played an important role because their prevalence in Java is very low (22,23). Also, the infants were too young to experience hookworm infestation. General morbidity, which can reduce appetite and increase iron loss in cases in which gastrointestinal problems such as diarrhea are present, may have played a role. However, the prevalence of fever (auxiliary temperature ≥ 37.5°C) was <2%, and <10% of the infants suffered from diarrhea in the week before the interview. Is there other evidence that iron deficiency is the main cause of the low Hb observed?

The analyses revealed that an important factor related to low infant Hb was low maternal Hb. Among mothers in this population, iron deficiency is the main cause of a low Hb (16). The first question is whether the mother's Hb, which was measured at the same time as that of the infant, reflects Hb during a longer period, including pregnancy. Most likely it does because it has been reported that maternal Hb and iron stores tend to approach prepregnancy values during the first few months postpartum (5,24) and that mothers that were anemic during pregnancy had not recovered adequate iron status at 6 mo postpartum (12). Additional analyses of our surveillance data set for Java revealed that the proportion with an Hb < 120 g/L was lower among mothers with an older infant (36.0, 32.3, 30.1 and 27.3% for those with an infant aged 3, 4, 5 and 6–11 mo, respectively). This seems to indicate that mothers' iron stores were still recovering during at least the first 6 mo postpartum. Also, of the mothers whose data are reported in this paper, 31.7% of those that reported having taken iron pills during pregnancy were anemic compared with 36.6% of those that had not ($P = 0.28$). The fact that the difference is small, and also nonsignificant, is most likely due to the variation in the number of iron pills taken. Thus, there appears to be a relationship between iron status during pregnancy and postpartum Hb. The high prevalence of anemia among mothers that reported having taken iron pills may be explained by the fact that the number of pills taken appears to be low, i.e., NSS data collected in Java during later rounds indicated that the median number of pills taken, according to the women, was 60, which is similar to a median of 50 reported from West Java (25). Thus, it is very likely that the women that had a low Hb concentration at 3–5 mo postpartum also had a low Hb during pregnancy, which, in this population, is due mainly to iron deficiency (16,26).

The next question is whether it is possible that normal birth weight babies (>2500 g) of anemic mothers accumulated less iron reserves than normal birth weight babies of nonanemic mothers. A number of studies, conducted largely among infants aged 6–12 mo, found that infants born to anemic mothers had a lower Hb concentration (10–12), and similar findings were reported for the relationship between iron status of mothers and infants (13). Preziosi et al. (14) supplemented pregnant women from Niger with iron and found that the ferritin concentration of infants of the iron-supplemented mothers was higher at 3 and 6 mo of age, but there was no increase in Hb. A study of women who had elective abortions showed that fetal iron status varied linearly with maternal Hb (15). While that study examined very early pregnancy and the other studies focused on 6- to 12-mo-old infants, our data suggest that the Hb concentrations of infants born to anemic mothers may be too low well before the age of 6 mo. Although Preziosi et al. (14) found that the Hb concentration of 3- and 6-mo-old infants had not increased while their ferritin concentrations had, the fact that the Hb concentration of 6- to 9-mo-old infants in our population was lower than that of 3- to 5-mo-old infants makes it very unlikely that their ferritin stores were adequate at 3–5 mo.

We also found a number of other factors that were related to low infant Hb. Because iron stores of newborn infants are proportional to body weight, low-birth-weight infants (<2500 g) have relatively small iron stores and should be supplemented with iron from the age of 2 mo (9). Because our data showed a relationship between birth weight, maternal anemia and infant Hb, the birth weight data are considered to be reliable. This was further confirmed by additional analyses that found that the relationship was strongest among the subgroup that did not have a written record of birth weight (data not shown). The findings concerning the association with age and breast-feeding status are somewhat confusing. Infants at 3 mo of age that were exclusively breast-fed had a higher risk of having a low Hb than infants that already had received complementary foods. Our data do not show a negative consequence of early introduction of complementary foods on iron status possibly because most children already received complementary foods (i.e., little power of the analysis) or that such effects led only to an increased risk of having a low Hb at a later age. The observation that stunted infants had a higher risk of a low Hb most likely reflects poor nutritional status, which affects both Hb and linear growth. The finding that infants of young mothers were more likely to have a low Hb is most likely due to the mothers' inability to meet the high nutritional demands of pregnancy and those for adolescent growth. The observed relationship between maternal education and low infant Hb may well reflect a relationship with socioeconomic status because in Indonesia, maternal education level is a good indicator of socioeconomic status (27). The fact that the risk of infants having a low Hb concentration was lower in Central Java most likely also reflects socioeconomic status. Socioeconomic status can play a role in different ways, including poorer nutritional status of the mother and hence poorer fetal nutrition, lower quality of complementary foods due to their cost, and more contact with germs and therefore higher morbidity.

Others have also reported a relationship between infant Hb, albeit for slightly older infants, and some of the factors that we found. At 6 mo of age [or 8 mo for (28)], Hb and/or serum ferritin concentration were related to low birth weight (19,20,28), sex (20,28), socioeconomic status (20), infection (20) and season (20). At 12 mo, Hb and serum ferritin concentration were related to low birth weight (19,20), sex (20,29), fever (20) and infection (20). Because women of lower socioeconomic status often also have a lower Hb, the observation by Lartey et al. (20) of a relationship between infant Hb and socioeconomic status at 6 mo of age may reflect a relationship between Hb concentrations of mothers and infants.

In conclusion, it was believed until recently that mild maternal iron deficiency and anemia have few repercussions on the iron status of newborns and that they would have adequate stores till 4–6 mo of life (8). However, on the basis of our findings, we hypothesize that the Hb concentration of many infants is too low well before the age of 6 mo due to iron deficiency, as indicated in particular by the increased risk for low Hb among infants of anemic mothers. This hypothesis should be tested by iron or multimicronutrient supplementation studies among young infants of populations with a high prevalence of iron deficiency.

ACKNOWLEDGMENTS

The authors thank the mothers and their infants for their willingness to be interviewed by the NSS and to allow a finger prick for blood collection; the fieldworkers, supervisors and coordinators of the NSS teams in West, Central and East Java for their continuous efforts to collect good-quality data; the NSS collaborators at national, provincial and local level for their continued assistance and interest; the HKI data entry departments in Jakarta and Surabaya for entering all of the data from the questionnaires; and Wouter van Solinge, clinical chemist of Utrecht Medical Center, for looking at our findings from a clinical perspective and sharing additional literature on hematology.

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