

Maternal HIV status affects the infant hemoglobin level

A comparative cross-sectional study

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Abstract

Children, especially infants, are highly vulnerable to iron-deficiency anemia because of their rapid growth of the brain and the rest of the body. *The objectives of this study were to compare the prevalence of iron-deficiency anemia in infants born from HIV-positive mothers and HIV-negative mothers and to identify the determinants of iron-deficiency anemia in infants.*

A comparative cross-sectional study was conducted in Bahir Dar city. Simple random sampling technique was used to select the study participants. Mothers were interviewed; blood samples were collected from mothers and infants to measure the hemoglobin level and anthropometric indicators were obtained from the infants using world health organization standards. Descriptive statistics were used to estimate the prevalence of infant anemia. Binary logistic regression and multiple linear regressions were used to identify the determinants of infant anemia.

A total of 1459 infants born from HIV-positive and HIV-negative mothers were included. The prevalence of iron-deficiency anemia in infants born from HIV-positive and HIV-negative mothers was 41.9% (95% CI: 39–44). Infantile iron-deficiency anemia was associated with maternal HIV infection (adjusted odds ratio [AOR] 2.54 [95% CI: 1.65–3.9]), stunting (AOR 3.46 [95% CI: 2.41–4.97]), low income (AOR 2.72 [95% CI: 2–3.73]), maternal malaria during pregnancy (AOR 1.81 [95% CI: 1.33–2.47]), use of cow milk before 6 month (AOR 1.82 [95% CI: 1.35–2.45]), residence (AOR 0.09 [95% CI: 0.06–0.13]), history of cough or fever 7 days preceding the survey (AOR 2.71 [95% CI: 1.99–3.69]), maternal hemoglobin (B 0.65 [95% CI: 0.61–0.68]), educational status of mother (B 0.22 [95% CI: 0.2–0.23]), age of the mother (B –0.03 [95% CI: –0.03, –0.02]), and family size (B –0.14 [95% CI: –0.18, –0.11]).

Abbreviations: AOR = adjusted odds ratio, CI = confidence interval, COR = crude odds ratio, Epi Info = epidemiological information, HIV = human immunodeficiency virus, kg = kilogram, mg/dL = milligram per deciliter, mL = milliliter, PMTCT = prevention of mother to child transmission, SD = standard deviation, SPSS = statistical package for social science, WHO = world health organization.

Keywords: anemia, determinants, HIV infection, infants, prevalence

1. Introduction

Red blood cells are one of the formed elements of blood and they perform transportation of nutrients and waste products.^[1] The total numbers of red blood cells present in human beings vary by

genders and age. In children hemoglobin count <11 mg/dL is defined as anemia.^[2–4] Anemia is a condition in which the hemoglobin level of the individual is low and one of the great burdens of the world. Globally >1.5 billion people are affected by anemia.^[5] Children especially infants are highly vulnerable to anemia because of their rapid growth of brain and the rest of the body.^[6–8] In developing country 42% of under 5 years of age children are anemic.^[9]

Iron-deficiency anemia in early childhood has numerous effects that are nonreversible at later age. Anemia in infancy can lead to impairment in brain development, delay in brain maturation, thereby reducing the cognitive function of the child, decrease in the growth of the child, and increase in the risk of infection because of its effect on immunity.^[10–18]

The burden of childhood anemia differs from continent to continent: in North America 17% to 50% of children are anemic.^[19–21] In South America, the prevalence of anemic in children ranges from 13% to 40.9%.^[21–23] In Europe, 6% to 14% of children are anemic.^[21,24] In Asia, 19.7% to 60.8%,^[25–27] in Africa, 12% to 78.6%,^[21,28–30] and in Ethiopia, 25% to 75% of under 5 years of children are anemic.^[31–33]

Different findings across the globe revealed that childhood iron-deficiency anemia is associated with *nutritional status, duration of breast feeding, maternal education, overweight, residence, use of cow milk before 6 months, low birth weight (<3 kg), gender (higher in male), child or maternal age,*

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maternal underweight, family size, income, dietary diversity, HIV infection, serum ferritin level, fever and cough in the preceding 7 days, frequent morbidity and low maternal CD4 count at enrolment, *placental malaria* and maternal anemia.^[20–25,27,28,30,32,34]

Information regarding infantile anemia was scarce and this led to failure to plan effective anemia prevention in infants. Many children suffer from irreversible harm because of improper anemia prevention activities during their infancy period. This study will fill these gaps and will alert decision makers to prioritize infantile anemia prevention and control intervention. This study will also benefit scholars to investigate more into infantile anemia by acting as a baseline document.

The objectives of this study were to compare the prevalence of iron-deficiency anemia in infants born from HIV-positive mothers and HIV-negative mothers and to identify the determinants of iron-deficiency anemia in infants.

2. Methods and materials

A community-based comparative cross-sectional study was conducted in Bahir Dar city, the capital of the Amhara national regional state, located at the geographical coordinates of 11° 38' north latitude and 37° 15' east longitude, which is located ~560 km northwest of Addis Ababa. The city contains 10 governmental health centers. The target population consisted of infants born from HIV-positive and HIV-negative mothers. Mothers who were unable to communicate, absent during house-to-house visit, and of unknown HIV status were excluded from the study. The sample size was calculated using Epi Info software version 7 with the assumption of 95% CI, power of 90%, 50% prevalence of iron-deficiency anemia in infants born from HIV-free mothers, ratio of infants born from HIV-free mothers to HIV-infected mothers of 3:1, odds ratio of 1.5 and 10% nonresponse rate gives 395 infants born from HIV-positive mothers and 1185 infants born from HIV-free mothers.

Infants were selected from the community of Bahir Dar using prevention of mother-to-child transmission of HIV (PMTCT) log book of the health centers as a sampling frame. Simple random sampling technique was used to select these infants. Study participants were traced from the community based on the address written in the PMTCT log book. The data were collected from January 2014 to June 2015. Mothers were interviewed and blood samples were collected both from the mothers and infants to measure the hemoglobin level. Length and weight of the infant were measured using world health organization (WHO) standards. An infant was gently placed on the recumbent board; we have assured that the infant was looking up and that the head, body, and toes were in a straight line; legs held together, with the other hand, slide the footboard against the infants feet until the heels of both feet touch the footboard with toes pointed upward; measurement was taken to the nearest 0.1 cm. The digital weight scale was used to measure the weight of each infant and weight was measured to the nearest 0.1 kg.^[35] Infants who scored <-2 standard deviation on length for age were considered as stunted. For the interview part, first the questionnaire was prepared in English then translated to Amharic language and then back to English to keep its consistency. The interview was conducted by 17 nurse professionals and supervised by 6 health officers. The blood sample was collected by 9 laboratory technologists and close supervision was conducted by 4 second degree holder medical microbiologist. One milliliter (mL) blood sample was collected from each mother and infant following standard

Table 1
Population profile of infants born from HIV-negative mothers (n=1114).

SN	Variables		Frequency	Percentage
1.	Sex	Male	626	56.2
		Female	488	43.8
2.	Stunting	Present	886	79.5
		Absent	228	20.5
3.	Monthly income	≤2000 birr	388	34.8
		>2000 birr	726	65.2
4.	Maternal malaria during pregnancy	Present	345	31
		Absent	769	69
5.	Use of cow milk before 6 months	Used	750	67.3
		Not used	364	32.7
6.	Residence	Urban	350	31.4
		Rural	764	68.6
7.	Cough or fever 7 days preceding the survey	Present	529	47.5
		Absent	585	52.5

HIV=human immunodeficiency virus, SN=serial number.

operational procedures to measure the hemoglobin level of mother and infant using the Mindray hematology analyzer. To maintain the quality of the data, pretest was conducted in 50 mothers, training was given for data collectors and supervisors, and the whole data collection process was closely supervised. The collected data were checked for completeness. The data were entered into the computer using Epi-info software and analyzed using SPSS software version 20 and WHO Antro plus software. Descriptive statistics were used to estimate the prevalence of infantile anemia. Binary logistic regression and multiple linear regressions were used to identify the determinants of infant anemia. A variable with *P*-value <0.05 was declared as determinants of anemia.

This study was ethically approved by Amhara National Regional State Health Bureau ethical committee. Permission was obtained from the respective authorities. Written informed consent was obtained from each mother. The confidentiality of the data was kept at all steps. Study participants having the right to withdraw from the study at any point was respected. Infants or mothers with low hemoglobin counts were referred to the nearby health center for further management.

3. Results

3.1. Population profile of infants born from HIV-negative mothers

A total of 1114 infants were included with a response rate of 94%. The mean age of infants in this group was 8.11 months (SD [standard deviation] 1.80 months). The mean maternal hemoglobin count was 11.07 mg/dL (SD 1.09). The prevalence of iron-deficiency anemia among infants born from HIV-negative mothers was 46.7% (95% CI: 44–50) (Table 1).

3.2. Population profile of infants born from HIV-positive mothers

A total of 345 infants were included for a response rate of 87.34%. The mean age of infants born from HIV-positive mothers was 8.72 months (SD 1.66 months). The mean maternal

Table 2
population profile of infants born from HIV-positive mothers (n = 345).

SN	Variables	Frequency	Percentage
1.	Sex	Male	42.3
		Female	57.7
2.	Stunting	Present	79.4
		Absent	20.6
3.	Monthly income	≤2000 birr	13.6
		>2000 birr	86.4
4.	Maternal malaria during pregnancy	Present	21.7
		Absent	78.3
5.	Use of cow milk before 6 month	Used	55.7
		Not used	44.3
6.	Residence	Urban	94.8
		Rural	5.2
7.	Cough or fever 7 days preceding the survey	Present	42.9
		Absent	57.1

HIV = human immunodeficiency virus, SN = serial number

hemoglobin count was 11.28 mg/dL (SD 0.73 mg/dL). The prevalence of iron-deficiency anemia among infant born from HIV-positive mothers was 26.7% (95% CI: 22–31) (Table 2).

3.3. Anemia in infants born from HIV-positive and HIV-negative mothers

A total of 1459 infants born from HIV-positive and HIV-negative mothers were included for a response rate of 92.34%. The mean age of the infants was 8.26 months (SD 1.79 months). The prevalence of iron-deficiency anemia in infants born from HIV-positive and HIV-negative mothers was 41.9% (95% CI: 39–44).

After adjusting for gender, age of infant, maternal HIV status, stunting, residence, history of maternal malaria during pregnancy, history of cough or fever 7 days preceding the survey, income, use of cow milk before 6 months, family size, age of the mother, educational status, and maternal hemoglobin level, infantile anemia was associated with maternal HIV status, stunting, residence, history of maternal malaria during

Table 4
linear regression output for predictors of hemoglobin level in infants (dependent variable=hemoglobin level in mg/dL).

Variables	B coefficient [95% CI]	t	P-value
Maternal hemoglobin	0.65 [0.61,0.68]	34.81	<0.01
Educational status of mother	0.22 [0.2,0.23]	26.14	<0.01
Age of mother	-0.03 [-0.03,-0.02]	-13.52	<0.01
Family size	-0.14 [-0.18,-0.11]	-7.89	<0.01

CI = confidence interval.

pregnancy, history of cough or fever 7 days preceding the survey, income, use of cow milk before 6 months, family size, age of the mother, educational status of the mother, and maternal hemoglobin level (Tables 3 and 4).

4. Discussion

The prevalence of anemia in infants born from HIV-positive and HIV-negative mothers was 41.9% (95% CI: 39–44). This result was higher than those from Montreal, Estonia, and Sweden,^[23,24,34] similar to those from Nepal,^[27,36] and lower than those from Indonesia.^[25] This is because of the different attention given for prevention and control of infantile anemia in different countries.

The odds of anemia for infants born from HIV-positive mothers were 2.54 times higher than those born from HIV-negative mothers (AOR 2.54 [95% CI: 1.65–3.9]). This finding agrees with those from Zimbabwe and Indonesia.^[25,37] This is because of the fact that maternal HIV decreases her hemoglobin level, thereby decreasing the iron transferred to infants.^[37]

Stunted infants had 3.46 times higher risk of anemia than normal infants (AOR 3.46 [95% CI: 2.41–4.97]). This finding agrees with those from Mexico.^[20] This is because malnourished children lack food diversity and the serum ferritin contents of malnourished children are low.^[36]

Infants born from low-income family had 2.72 higher risks of anemia than those from medium-income family (AOR 2.72 [95% CI: 2 –3.73]). This finding agrees with those from Indonesia and Kenya.^[25,28] This is because low-income families didn't have

Table 3
logistic regression output of determinants of anemia in infants born from HIV-positive and HIV-negative mothers (n = 1459).

Variables		Anemia		COR [95%CI]	AOR [95%CI]	P-value
		Present	Absent			
HIV status of mother	Positive	92	253	0.42 [0.32–0.55]	2.54 [1.65–3.9]	<0.01
	Negative	520	594			
Stunting	Present	192	107	3.16 [2.41–4.16]	3.46 [2.41–4.97]	<0.01
	Absent	420	740			
Income	≤2000 birr	303	132	5.31 [4.13–6.83]	2.72 [2–3.73]	<0.01
	> 2000 birr	309	715			
History of malaria during pregnancy	Present	287	133	4.74 [3.69–6.10]	1.81 [1.33–2.47]	<0.01
	Absent	325	714			
Use of cow milk before 6 months	Used	434	508	1.63 [1.30–2.04]	1.82 [1.35–2.45]	<0.01
	Not used	178	339			
Residence	Urban	118	519	0.13 [0.10–0.17]	0.09 [0.06–0.13]	<0.01
	Rural	494	288			
Cough or fever 7 days preceding the survey	Present	395	282	3.65 [2.91–4.57]	2.71 [1.99–3.69]	<0.01
	Absent	217	565			

AOR = adjusted odds ratio, CI = confidence interval, COR = crude odds ratio, HIV = human immunodeficiency virus.

access to different varieties of foods rich in iron and other nutrients necessary for red blood cell production.

Infants born from malaria-infected mother during pregnancy had 1.81 higher risk of anemia than those born from malaria-free mother during pregnancy (AOR 1.81 [95% CI: 1.33–2.47]).

This finding agrees with those from other parts of the world.^[21] This is because malaria parasite decreases the hemoglobin level of the mother, thereby decreasing the amount of iron transferred from mothers to the infants.

Infants who used cow milk before 6 months had 1.82 times higher risk of anemia than those who didn't used cow milk before 6 months (AOR 1.82 [95% CI: 1.35–2.45]). This is because the bioavailability of cow milk is less than human milk.^[3,38]

Infants from urban residence were 91% protected from anemia than those from rural residence (AOR 0.09 [95% CI: 0.06–0.13]). This finding agrees with those from Mexico.^[20] This is because the rural area anemia control and prevention activities are limited as compared with urban area.

Infants who had a history of cough or fever 7 days preceding the survey had 2.71 higher risk of malaria than infants who were free from cough or fever 7 days preceding the survey (AOR 2.71 [95% CI: 1.99–3.69]). This finding agrees with those from Zimbabwe.^[36] This is because of the effects of acute childhood illness on the blood cell production.

The hemoglobin of infant is directly related to the hemoglobin of mother. The hemoglobin of infant increases as the hemoglobin of her/his mother increases. This signals that intervention against maternal anemia also benefits in fighting infantile anemia. This result agrees with those from other parts of the world.^[39,40] This is because mothers are the principal source of iron for infants.

The hemoglobin of infant increases as the educational status of his/her mother increases. This finding agrees with those from Indonesia, Mexico, and Ethiopia.^[20,25,32] This implies that women's education can act as one of anemia prevention strategies for the next generation.

The hemoglobin level of infant was negatively associated with maternal age; infants born from old-aged mothers are most likely to have low hemoglobin level. This finding agrees with those from Indonesia and Kenya.^[25,28] This is because old-aged mothers are most likely to have high parity and gravidity making them a risky group for hemorrhage.

The hemoglobin counts of infants were negatively associated with family size. Infants from large family sizes are most likely to have low hemoglobin level. This finding agrees with finding from Indonesia.^[25] This is because infants from large family sizes are not able to get enough quantity of nutrients including iron.

This research was implemented on a representative sample of infants born from HIV-positive and HIV-negative mothers so can be generalized safely to the population of infants born from HIV-positive and HIV-negative mothers to determine the burden and determinants of anemia.

The main limitation of this study is that the HIV status of mothers was assessed using antibody tests. This test will not detect HIV in its window period because in this period antibody against HIV is not prepared by the body defense mechanism so mothers declared HIV-negative might be HIV positive. However, the number of mothers with a window period in the community is so small that this limitation will not create much problem.

5. Conclusion

The burden of iron-deficiency anemia was highest in infants. Infantile anemia was associated with maternal HIV status,

stunting, residence, history of maternal malaria during pregnancy, history of cough or fever 7 days preceding the survey, income, use of cow milk before 6 months, family size, age of the mother, educational status of the mother, and maternal hemoglobin level.

5.1. Recommendation

Decision makers should give special emphasis on intervention against infantile anemia. Both maternal and infant factors should be considered in targeting anemia control and prevention in infants. Multisectoral intervention should be considered in infantile anemia prevention and control programs.

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