Anemia among Adolescent and Young Women in Low-and-Middle-Income Countries

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Abstract: *Objective*: Anemia is a global public health problem that affects maternal and infant mortality as well as human capital development. Yet there is not much research on anemia among young women in low-and-middle-income countries with nationally representative samples. The aim of the current research is to assess the extent of anemia in a critical age group: adolescents and young adults ages 15 to 24.

Methods: The data are from 34 Demographic and Health Surveys and are used to describe the prevalence of anemia among pregnant and non-pregnant women by age, rural/urban residence, and household wealth. Anemia was assessed using the HemoCue® blood hemoglobin testing system.

Findings: The prevalence of anemia among young women ranges from 15% to over 50%. This is substantially higher than 5%, which is the cutoff to identify a population where anemia is a public health problem. African countries show the highest prevalence of anemia; Benin, Ghana and Mali have over 60% anemia prevalence. Moreover, the prevalence of moderate to severe anemia is particularly high in African countries, over 20% in Ghana and Guinea. Our results show that anemia is a public health concern for adolescents and young adult females in all 34 countries we analyzed.

Conclusion: The high prevalence of anemia among youth is alarming. Considering the importance of the adolescent and young adult years, when human capital development is consolidated and family formation begins, these findings call for interventions to redress the problem of anemia.

Keywords: Iron deficiency, anemia, DHS, Sub-Saharan countries, preconception health, public health.

INTRODUCTION

Anemia is a condition in which the number of red blood cells or their oxygen-carrying capacity is insufficient to meet physiologic needs [1]. The most common cause is iron deficiency; other causes are vitamin B12 deficiency, chronic inflammation, parasitic infections, and genetic hemoglobin disorders [1]. Asia and, particularly, Africa are regions with higher prevalence of anemia [2]. Fifty-six million pregnant women and 468 million non-pregnant women are affected globally [2]. Determinants of the prevalence and distribution of anemia in a population involve a complex interplay of political, ecological, social, and biological factors [3]. Nutritional iron deficiency is due to a low-iron diet [4]. Gastrointestinal parasites are also common in many developing countries [4]. Hookworm causes intestinal blood loss and is an important cause of iron-deficiency anemia [4]. HIV and malaria are other factors associated with anemia. One Ghana-based study found that pregnant women with malaria and HIV co-infection are at higher (twice) risk of anemia compared to pregnant women with one infection or none [5].

Anemia is a major factor in both maternal and infant mortality. Anemic mothers are more likely to experience fetal loss or stillbirth, preterm birth, and low birth weight [6, 7]. Additionally, maternal anemia is a strong predictor of anemia in children [3]. Anemia is much more than a health problem, however. Without sufficient iron, brain development is significantly impaired, adversely affecting learning and cognition [8]. Maternal anemia also deters a mother's interactions with her children; mothers are less responsive to their infants [9]. Anemia reduces workers' productivity [10, 11], particularly in developing countries where there is a predominance of physical labor [12]. Because of these negative consequences the WHO classifies populations into four groups with respect to anemia: 1) no public health concern (prevalence <=4.9%); 2) a mild public health concern (5-19.9%); 3) a moderate public health concern (20.0% to 39.9%); and 4) a severe public health concern (prevalence >=40.0 %) [13].

The adolescent period requires higher iron intake because of the body's rapid growth [14]. Although growth slows down after menarche, iron loss from menstruation must be countered by further high iron intake for young women [14]. Thus, the risk of anemia increases during adolescent years with the onset of menstruation and pregnancy [4]. The negative impacts

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of anemia on maternal and infant health and on worker productivity also brings adolescence and young adulthood to the foreground, since these are the years when young women complete schooling, begin working, and start their families. Existing research on anemia has focused on infants, children, or pregnant women, however; or, in some studies, all women of reproductive age [15-19]. Yet women's biology and life experiences differ dramatically between ages 15 and 49. This research gap is particularly troubling considering the current emphasis on the importance of preconception care for women to improve health outcomes of mother and children. For all these reasons, a study of anemia in the adolescent and young adult years is particularly important.

Despite its significance, there has yet to be specific analyses examining the prevalence and severity of anemia by age and region among adolescent and young women. In the present analyses we describe the prevalence of anemia among young women 15-24 years of age from 34 Demographic and Health Surveys (DHS) countries where the data were collected between 2003 and 2011. In addition, we explore health inequalities and anemia by age, residence, and household wealth.

METHODS

We use the Demographic and Health Surveys (DHS), which are "nationally-representative household surveys that provide data for a wide range of indicators in the areas of population, health, and nutrition," [20] usually conducted every five years, for our analysis. The DHS uses a stratified two-stage cluster sampling design. We use 34 DHS surveys conducted since 2000 with information on anemia. The countries represented include 20 from sub-Sahara African, 2 from North Africa and Middle East, 4 from West Asia and Europe, 4 from South and Southeast Asia, and 4 from Latin America. Almost all these surveys have a response rate of at least 90% [21]. We use data from women 15 to 24 who were interviewed and tested for anemia.

Our outcome is *anemia status*. DHS staff tested women for anemia with the HemoCue® blood hemoglobin testing system [22]. Testing is voluntary. DHS defines mild anemia among women as between 10.0 and 11.0 grams of hemoglobin per deciliter (g/dl). Women with 7.0 to 9.9 g/dl have moderate anemia; and those with less than 7.0 g/dl of hemoglobin have severe anemia. For pregnant women, a hemoglobin level below 12 g/dl is considered anemic. We created two dichotomous variables where "0" denotes no anemia and "1" any anemia and, secondly, where "0" denotes no anemia and mild anemia and "1" denotes moderate or severe anemia based on the DHS definition.

Age is a categorical variable distinguishing between young women who are 15-19 and 20-24 years of age.

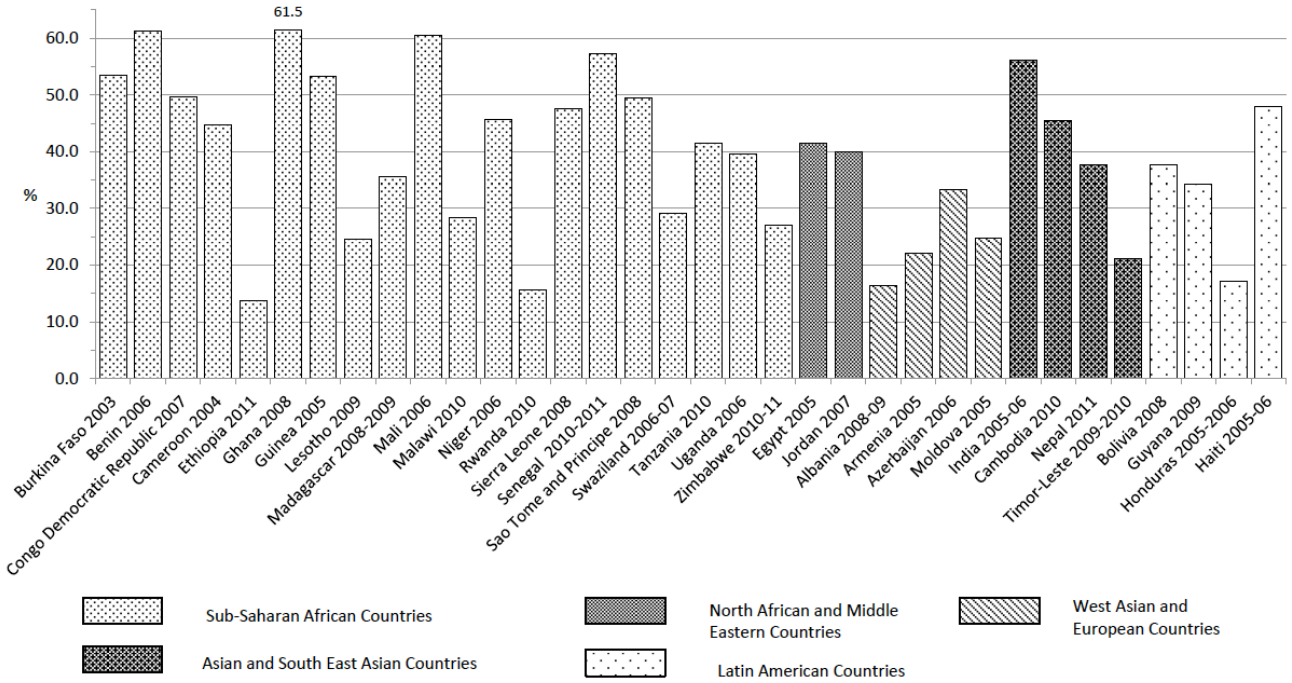

Figure 1: Prevalence of Anemia among Young Women 15-24 in 34 DHS Countries.

Table 1: Prevalence of Anemia among Youth by Age, Residence and Household Wealth (%)

Country and Year	Total	Age		Residence		Wealth Quintiles (I=Low)				
		15-19	20-24	Rural	Urban	I	II	III	IV	V
a. Sub-Saharan African Countries										
Burkina Faso 2003	53.5	51.9	55.7	54.6	50.4	57.6	52.0	53.4	58.6	49.7
Benin 2006	61.2	59.2	63.1	61.2	61.1	64.1	61.0	61.1	61.1	59.9
Congo Democratic Republic 2007	49.7	48.7	50.6	51.2	48.0	47.3	57.8	48.8	42.8	52.2
Cameroon 2004	44.7	45.6	43.7	41.3	47.3	42.6	42.0	44.0	45.6	47.4
Ethiopia 2011	13.7	13.4	14.1	15.4	9.1	17.1	15.8	15.4	13.0	9.9
Ghana 2008	61.5	62.9	59.9	63.8	59.3	62.3	63.7	61.9	63.3	56.9
Guinea 2005	53.2	51.0	56.5	56.2	48.6	61.7	56.3	53.9	46.6	51.3
Lesotho 2009	24.5	21.3	28.1	23.7	26.8	18.9	20.2	23.9	26.5	30.1
Madagascar 2008-2009	35.6	35.1	36.3	36.9	29.9	45.9	40.8	35.2	28.4	30.5
Mali 2006	60.5	59.9	61.3	64.1	55.3	63.6	63.6	64.8	61.1	54.3
Malawi 2010	28.4	28.8	28.0	30.0	21.9	34.1	27.4	30.7	29.2	23.0
Niger 2006	45.7	46.7	44.7	47.8	38.5	46.7	48.5	52.8	43.3	39.0
Rwanda 2010	15.6	15.0	16.2	15.5	15.9	16.3	16.5	15.2	15.1	15.0
Sierra Leone 2008	47.6	50.6	44.8	45.6	50.4	47.0	42.7	45.9	49.4	50.7
Senegal 2010-2011	57.3	55.5	59.3	54.8	59.8	57.4	56.5	57.0	57.1	58.3
Sao Tome and Principe 2008	49.5	51.4	47.2	48.0	50.7	54.8	54.2	49.4	48.4	43.0
Swaziland 2006-07	29.2	28.3	30.4	28.1	33.0	24.3	25.2	31.9	33.0	29.7
Tanzania 2010	41.4	42.2	40.5	40.0	44.7	42.8	40.4	38.6	40.6	44.1
Uganda 2006	39.6	36.9	42.6	41.2	32.4	48.7	42.2	41.8	40.4	30.9
Zimbabwe 2010-11	27.1	25.7	28.5	24.7	30.9	24.1	26.3	24.3	32.5	26.9
b. Aggregate Statistics of Sub-Saharan African Countries										
Minimum	13.7	13.4	14.1	15.4	9.1	16.3	15.8	15.2	13.0	9.9
First Quartile	29.0	28.7	29.9	29.5	30.7	31.7	27.1	31.6	31.7	30.0
Median	45.2	46.2	44.2	43.5	46.0	46.9	42.5	45.0	43.1	43.6
Third Quartile	53.3	51.5	55.9	54.7	50.5	57.5	56.4	53.5	51.3	51.5
Maximum	61.5	62.9	63.1	64.1	61.1	64.1	63.7	64.8	63.3	59.9

(Table 1). Continued.

Country and Year	Total	Age		Residence		Wealth Quintiles (I=Low)				
		15-19	20-24	Rural	Urban	I	II	III	IV	V
c. North African and Middle Eastern Countries										
Egypt 2005	41.5	44.9	40.5	42.4	39.7	43.2	40.2	43.2	41.5	38.5
Jordan 2007	39.9	38.3	40.2	35.4	40.7	38.9	42.4	42.8	32.6	36.6
d. West Asian and European Countries										
Albania 2008-09	16.3	17.9	13.9	18.7	13.0	18.1	19.5	18.5	14.1	10.9
Armenia 2005	22.1	21.4	22.9	21.2	22.7	23.4	22.2	17.1	25.2	22.9
Azerbaijan 2006	33.4	30.5	36.6	35.2	31.9	36.6	40.9	31.1	28.5	30.2
Moldova 2005	24.8	23.9	26.0	25.5	23.8	27.7	25.4	24.0	25.7	22.1
e. Asian and South East Asian Countries										
India 2005-06	56.1	55.7	56.6	58.1	51.9	65.2	60.4	56.4	53.6	46.9
Cambodia 2010	45.5	47.8	42.8	48.2	36.6	57.8	47.2	51.7	42.8	34.7
Nepal 2011	37.7	38.6	36.8	39.3	27.7	35.5	36.4	41.2	38.5	36.3
Timor-Leste 2009-2010	21.1	21.5	20.7	21.4	20.4	20.0	21.7	20.8	19.3	23.8
f. Latin American Countries										
Bolivia 2008	37.7	37.7	37.7	41.8	35.8	42.9	42.9	39.3	36.9	30.2
Guyana 2009	34.2	34.1	34.4	34.1	34.6	40.9	36.0	32.5	35.1	27.7
Honduras 2005-2006	17.1	16.8	17.5	18.0	16.4	18.8	17.1	16.9	16.9	16.5
Haiti 2005-06	47.9	48.7	46.9	41.9	53.8	36.0	38.8	50.1	51.9	53.7

Residence is a dichotomous variable distinguishing between urban and rural. DHS provides household wealth quintiles of the household based on the wealth index. The wealth index is calculated using principal components analysis "on a household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities" [23].

We report the prevalence of anemia in each of the countries and then the prevalence of moderate to severe anemia. In addition we present the prevalence by world region, age, urban residence, and household wealth. Our estimates are weighted and adjusted for the complex survey design using Stata11.

RESULTS

In Figure **1** and Tables **1a** through **1f** we present estimates of anemia prevalence for all the countries in our analysis by region. Figure **1** shows the prevalence of anemia among young women from 34 DHS countries. No country has prevalence lower than 5%, so anemia is a public health concern for all 34 countries.

For Sub-Saharan African countries (Table **1a**), we have a sufficient number of countries to also present aggregate statistics (Table **1b**). In Table **1c** to Table **1f** we present data on North African and Middle East, West Asian and European, South and Southeast Asian, and Latin American countries.

In Sub-Saharan Africa (Table **1a**), the lowest prevalence of anemia observed was in Ethiopia, with a prevalence of lower than 15%. In sub-Saharan Africa, 12 countries in the present analyses had prevalence of anemia at or above 40%. It is striking that in Table **1a** the inequalities by age, residence, and wealth are small and not consistent. In North Africa and Middle East and

in West Asia and European countries (Tables **1c** and **d**) the levels of anemia are lower but still rise to the level of public health problem. Just as in Sub-Saharan Africa, wealth inequalities for anemia are not particularly notable.

Table **1e** contains the results for four countries in South and Southeast Asia. The table shows that the prevalence of anemia in India and Cambodia is considerably higher than in Nepal and Timor-Leste. While the inequalities by age and residence are not notable, the inequalities by wealth are more substantial than in countries in Sub-Saharan Africa and in West Asia and European countries. For example, the prevalence of anemia among the highest wealth quintile in India is over 46 percent, which while very high is twenty points lower than that in the lowest quintile, where two-thirds of the population is anemic.

In Table **1f** we present data for the four Latin American countries. For Bolivia and Guyana the patterns are similar to those in the other regions: very high prevalence with few age and residence inequalities, some inequalities by household wealth, but unacceptably high levels even among young people in the wealthiest households. Honduras is similar to these other two Latin American countries with little variance by wealth.

Haiti is unique among the countries we examined because the inequalities by wealth are not as seen in other countries. Specifically, rather than the poorest quintile with the highest prevalence of anemia, in Haiti it is the wealthiest quintile. And rather than the rural population, in Haiti the urban population of young women has the highest prevalence of anemia.

When we turn to more severe anemia, we see results that parallel those for anemia in general. Tables **2a** through **2f** are analogous to the tables we just discussed, but they contain information on moderate to severe anemia. Overall, the patterns are similar to those described. The inequalities by wealth, however, in Sub-Saharan Africa are more notable, where the median prevalence is 19.3% for the lowest wealth quintile and 13.05% for the highest wealth quintile.

DISCUSSION

Our study has limitations. The DHS does not include an anemia assessment in all countries, thus leaving large gaps in our understanding of prevalence worldwide. Use of population-based data is not especially revealing about the mechanisms through which anemia is produced, which undoubtedly vary in different settings. For example, the relatively low prevalence of anemia in Ethiopia might be due to the widespread consumption of “teff”, an iron-rich food [24]. In addition, the countries in our analysis differ in within-household patterns of food allocation; in some countries women may eat last [25, 26]. Such customs could lead to anemia among young women even if the conventional diet is adequate. Nevertheless, the external generalizability of the data we use and its geographic scope are the compelling strengths of our analysis, as is our focus on a population that is most of interest for preconception care and which has been neglected in past research.

The prevalence of anemia among young women between ages 15 and 24 is a public health concern in all 34 countries we examined. Moreover, anemia is a *severe* public health concern in sixteen countries: the highest prevalence rate is 61.52% of young women in Ghana. While there are age and residence inequalities in many countries, the differences are not large. Household wealth inequalities are somewhat larger but still indicate high levels of anemia among the most advantaged households. Interventions, therefore, should be at the population level and not targeted at any specific group.

Iron supplementation is the most common mechanism for preventing and treating iron-deficiency anemia [22]. It is a cost-effective intervention, which makes it attractive [14], although a barrier to this intervention is compliance problems [4] due to side effects such as nausea [14]. Pregnant women and infants and children are often the target of iron supplementation [22], but supplementation to female adolescents generally has been shown to be effective in reducing anemia [27].

Iron supplementation might not be the most effective intervention everywhere, however. In areas with high HIV and malaria prevalence, controlling malaria and HIV is also important to reduce anemia [5]. Similarly, in countries where intestinal worms are common, it may be necessary to reduce infection since it exacerbates malnutrition and worsens anemia [28]. For these countries, deworming is “an often overlooked intervention for improving nutritional status” [30].

Iron fortification is another intervention. One research found that iron fortification is more cost effective than iron supplementation [29]. The

Table 2: Prevalence of Moderate to Severe Anemia among Youth by Age, Residence and Household Wealth (%)

Country and Year	Total	Age		Residence		Wealth Quintiles (I=Low)				
		15-19	20-24	Rural	Urban	I	II	III	IV	V
a. Sub-Saharan African Countries										
Burkina Faso 2003	15.7	14.3	17.6	16.1	14.6	18.3	17.1	13.3	20.5	12.9
Benin 2006	18.6	16.7	20.4	20.1	16.6	19.9	20.8	19.8	18.6	15.6
Congo Democratic Republic 2007	18.0	16.8	19.0	21.2	14.4	20.6	22.9	21.8	10.0	16.0
Cameroon 2004	12.1	10.9	13.4	12.3	11.9	12.5	12.7	12.1	12.0	11.5
Ethiopia 2011	2.7	2.6	3.0	3.1	1.6	4.5	2.9	3.2	2.3	1.7
Ghana 2008	20.1	19.3	20.9	21.4	18.7	24.0	18.9	18.8	22.8	16.8
Guinea 2005	20.8	21.5	19.7	24.1	15.6	27.3	24.3	23.9	15.0	17.3
Lesotho 2009	6.1	4.2	8.2	6.1	6.1	4.6	4.4	4.6	7.0	8.6
Madagascar 2008-2009	5.6	5.0	6.3	5.5	5.7	6.2	7.4	4.8	4.9	4.9
Mali 2006	19.1	16.7	21.8	24.6	10.8	26.1	23.3	21.6	22.4	8.9
Malawi 2010	7.0	6.0	8.1	7.2	6.1	8.1	7.2	8.4	6.8	5.2
Niger 2006	14.9	16.7	13.1	15.6	12.2	14.5	16.7	17.5	14.6	11.7
Rwanda 2010	2.5	2.2	2.7	2.3	3.3	3.6	1.9	2.9	1.6	2.6
Sierra Leone 2008	13.2	14.2	12.2	13.1	13.3	15.1	9.5	11.9	17.1	11.8
Senegal 2010-2011	16.0	15.6	16.4	17.5	14.5	19.1	21.4	14.3	15.2	12.5
Sao Tome and Principe 2008	10.8	9.3	12.6	8.1	13.0	15.7	12.8	15.2	7.5	5.6
Swaziland 2006-07	6.4	6.3	6.4	5.8	8.5	4.8	6.1	7.9	7.5	5.2
Tanzania 2010	11.5	10.1	13.2	10.4	14.2	10.6	11.3	10.4	11.2	13.3
Uganda 2006	9.9	8.6	11.3	10.5	7.4	10.9	11.6	10.2	12.7	6.3
Zimbabwe 2010-11	7.1	7.1	7.2	5.9	9.2	6.1	5.6	5.9	9.5	7.7
b. Aggregate Statistics of Sub-Saharan African Countries										
Minimum	2.50	2.20	2.70	2.30	1.60	3.60	1.90	2.90	1.60	1.70
First Quartile	6.85	6.23	7.88	6.05	7.08	6.18	6.93	7.40	7.38	5.50
Median	16.50	16.70	17.95	18.15	14.43	19.30	19.38	17.83	15.68	13.00
Third Quartile	16.50	16.70	17.95	18.15	14.43	19.30	19.38	17.83	15.68	13.00
Maximum	20.80	21.50	21.80	24.60	18.70	27.30	24.30	23.90	22.80	17.30

(Table 2). Continued.

Country and Year	Total	Age		Residence		Wealth Quintiles (I=Low)				
		15-19	20-24	Rural	Urban	I	II	III	IV	V
c. North African and Middle Eastern Countries										
Egypt 2005	7.2	8.6	6.8	8.2	5.1	8.6	7.1	8.7	5.5	5.3
Jordan 2007	7.7	6.7	7.9	5.8	8.0	8.9	8.7	7.9	6.2	0.5
d. West Asian and European Countries										
Albania 2008-09	1.2	1.0	1.5	1.5	0.7	1.4	1.9	0.9	1.2	0.4
Armenia 2005	3.2	4.0	2.4	3.5	3.1	5.8	2.8	1.5	2.1	4.1
Azerbaijan 2006	6.3	5.8	7.0	6.4	6.3	7.6	7.4	6.0	6.5	4.5
Moldova 2005	2.8	2.2	3.5	3.4	1.9	2.7	3.3	3.4	2.2	2.3
e. Asian and South East Asian Countries										
India 2005-06	17.5	16.6	18.4	18.1	16.2	21.5	19.4	18.4	16.0	12.8
Cambodia 2010	6.9	7.3	6.4	7.6	4.5	9.9	7.0	8.5	6.5	4.1
Nepal 2011	6.1	6.1	6.2	6.4	4.4	5.5	7.3	7.3	5.3	5.2
Timor-Leste 2009-2010	3.6	2.5	5.0	3.1	4.8	2.1	3.7	2.7	3.2	5.8
f. Latin American Countries										
Bolivia 2008	8.7	7.8	9.8	9.9	8.1	10.8	9.3	9.5	10.1	5.0
Guyana 2009	7.1	7.9	6.0	7.0	7.4	10.7	5.2	8.8	6.8	4.4
Honduras 2005-2006	2.1	2.0	2.3	2.3	1.9	2.6	2.6	2.2	1.7	1.8
Haiti 2005-06	14.7	14.8	14.5	11.4	17.9	12.0	9.0	14.1	18.7	16.0

infrastructure such as large rural population and the technology for food fortification could be an issue. Moreover, fortified food might not be affordable for all.

Our findings that anemia is not particularly concentrated among the most disadvantaged young women makes a population-level intervention especially attractive. Our findings show that the prevalence of anemia is high enough to be an alarming public health concern for young women among all 34 countries, and this has serious negative repercussions for human capital development and population health. They indicate that the focus of past research—on women of the full range of reproductive age and on children—is insufficient, and the unique circumstances of women at different stages of reproductive age ought not to be ignored. As Stoltzfus and colleagues said: "The control of iron deficiency in women and children requires a comprehensive strategy that is based on a lifecycle approach to the problem" [30].

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REFERENCE

[1] World Health Organization. Anaemia [Internet]. 2013; [cited 2013 Feb 24]: Available from: http: //www.who.int/topics/anaemia/en/

[2] McLean E, Cogswell M, Egli I, Wojdyla D, de Benoist B. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. Public Health Nutr 2009; 12(04): 444. http://dx.doi.org/10.1017/S1368980008002401

[3] Balarajan Y, Ramakrishnan U, Özaltin E, Shankar AH, Subramanian S. Anaemia in low-income and middle-income countries. Lancet 2012; 378(9809): 2123-35. http://dx.doi.org/10.1016/S0140-6736(10)62304-5

[4] Zimmermann MB, Hurrell RF. Nutritional iron deficiency. Lancet 2007 8/11–17; 370(9586): 511-20.

[5] Orish VN, Onyeabor OS, Boampong JN, Acquah S, Sanyaolu AO, Iriemenam NC. The effects of malaria and HIV co-infection on hemoglobin levels among pregnant women in Sekondi-Takoradi, Ghana. Int J Gynaecol Obstet Available online 4 December 2012.

[6] Mehta S, Manji KP, Young AM, Brown ER, Chasela C, Taha TE, *et al*. Nutritional indicators of adverse pregnancy outcomes and mother-to-child transmission of HIV among HIV-infected women. Am J Clin Nutr 2008; 87(6): 1639-49.

[7] Naniche D, Lahuerta M, Bardaji A, Sigauque B, Romagosa C, Berenguera A, *et al*. Mother-to-child transmission of HIV-1: association with malaria prevention, anaemia and placental malaria. HIV Med 2008; 9(9): 757-64.

[8] Madan N, Rusia U, Sikka M, Sharma S. Developmental and neurophysiologic deficits in iron deficiency in children. Indian J Pediatr 2011; 78(1): 58-64. http://dx.doi.org/10.1007/s12098-010-0192-0

[9] Perez EM, Hendricks MK, Beard JL, Murray-Kolb LE, Berg A, Tomlinson M, *et al*. Mother-infant interactions and infant development are altered by maternal iron deficiency anemia. J Nutr 2005; 135(4): 850-55.

[10] Haas JD, Brownlie T. Iron deficiency and reduced work capacity: a critical review of the research to determine a causal relationship. J Nutr 2001; 131(2): 676S-690S.

[11] Gardner GW, Edgerton VR, Senewiratne B, Barnard RJ, Ohira Y. Physical work capacity and metabolic stress in subjects with iron deficiency anemia. Am J Clin Nut 1977; 30(6): 910-17.

[12] Horton S, Ross J. The economics of iron deficiency. Food Policy 2003; 28(1): 51-75. http://dx.doi.org/10.1016/S0306-9192(02)00070-2

[13] World Health Organization. Iron deficiency anemia: assessment, prevention, and control. A guide for program managers. Geneva, Switzerland: World Health Organization; 2001.

[14] Schulze KJ, Dreyfuss ML. Anemia / Iron-deficiency anemia. In: Caballero B, Allen L, Prentice A, Eds. Encyclopedia of human nutrition. 2nd ed. Oxford: Elsevier Ltd. 2005; pp. 101-109. http://dx.doi.org/10.1016/B0-12-226694-3/00015-6

[15] Crawley J. Reducing the burden of anemia in infants and young children in malaria-endemic countries of Africa: from evidence to action. Am J Trop Med Hyg 2004; 71(2 suppl): 25-34.

[16] Stoltzfus RJ, Chwaya HM, Tielsch JM, Schulze KJ, Albonico M, Savioli L. Epidemiology of iron deficiency anemia in Zanzibari schoolchildren: the importance of hookworms. Am J Clin Nut 1997; 65(1): 153-59.

[17] Mukuri A, Aboulafia C, Themme A. The context of women's health: results from the demographic and health surveys, 1994-2001. Comparative Reports No. 11. Calverton, Maryland: ORC Macro 2005.

[18] Lutter CK. Iron deficiency in young children in low-income countries and new approaches for its prevention. J Nutr 2008; 138(12): 2523-28. http://dx.doi.org/10.3945/jn.108.095406

[19] Lutter CK. Iron deficiency in young children in low-income countries and new approaches for its prevention. J Nutr 2008; 138(12): 2523-28. http://dx.doi.org/10.3945/jn.108.095406

[20] ICF International. DHS Overview. [cited 2012 Sept 21]: Available from: http: //www.measuredhs.com/What-We-Do/Survey-Types/DHS.cfm

[21] ICF International. Demographic and Health Surveys (various) [Datasets]. Calverton, Maryland: ICF International [Distributor], 2012. 2012.

[22] ICF International. DHS Overview. [cited 2012 Sept 21]: Available from: http: //www.measuredhs.com/topics/Anemia.cfm

[23] ICF International. Wealth Index [Internet]. [cited 2012 Sept 21]: Available fom: http: //www.measuredhs.com/topics/Wealth-Index.cfm

[24] Wolde-Gebriel Z, West CE, Gebru H, *et al.* Interrelationship between vitamin A, iodine and iron status in schoolchildren in Shoa Region, Central Ethiopia. Br J Nutr 1993. http://dx.doi.org/10.1079/BJN19930151

[25] Sudo N, Sekiyama M, Maharjan M, Ohtsuka R. Gender differences in dietary intake among adults of Hindu communities in lowland Nepal: assessment of portion sizes and food consumption frequencies. Eur J Clin Nutr 2006; 60: 469-77. http://dx.doi.org/10.1038/sj.ejcn.1602339

[26] Shannon K, Mahmud Z, Asfia A, Ali M. The social and environmental factors underlying maternal malnutrition in rural Bangladesh: implications for reproductive health and nutrition programs. 2008: 29(8): 826-40.

[27] Tee E, Kandiah M, Awin N, Chong S, Satgunasingam N, Kamarudin L, *et al*. School-administered weekly iron-folate supplements improve hemoglobin and ferritin concentrations in Malaysian adolescent girls. Am J Clin Nut 1999; 69(6): 1249-56.

[28] Kothari M, Abderrahim N. Nutrition Update 2010. Calverton, Maryland, USA: ICF Macro 2010.

[29] Baltussen R, Knai C, Sharan M. Iron fortification and iron supplementation are cost-effective interventions to reduce iron deficiency in four subregions of the world. J Nutr 2004; 134(10): 2678-84.

[30] Stoltzfus RJ. Iron interventions for women and children in low-income countries. J Nutr 2011; 141(4): 756S-762S. http://dx.doi.org/10.3945/jn.110.128793

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