2011 UGANDA DHS - ADDENDUM TO CHAPTER 11

11.9 VITAMIN A

11.9.1 Background and Methodology

Vitamin A is an essential micronutrient for vision, for the maintenance of epithelial cells, and for regulation of systemic functions such as cellular differentiation, growth, reproduction, bone development, and modulation of the immune system. Vitamin A deficiency (VAD) is well documented as a leading cause of all-cause morbidity and mortality among children (Sommer et al., 1984; Fawzi et al., 1993; Sommer and West, 1996). VAD increases the severity of infections, such as measles and diarrhoeal diseases in children, and slows recovery from illness. Severe VAD can cause keratinisation (loss of epithelial cells) of mucous membranes and eye damage that can result in irreversible blindness.

The 2011 Uganda DHS (UDHS) measured the prevalence of vitamin A deficiency (VAD) in children age 6-59 months and women age 15-49 in one-third of the households selected for the survey. Vitamin A status was also measured in the 2000-2001 and 2006 UDHS surveys. In the 2000-01 UDHS, vitamin A status was determined by measuring serum retinol concentrations in dried blood spot samples (DBS) that were prepared by allowing blood drops from a finger prick to fall into pre-printed circles on a filter paper card. These filter paper cards were shipped to Craft Technologies in the United States, where the blood samples were analysed using high-performance liquid chromatography (HPLC). For many years, measuring serum retinol using HPLC has been the gold standard in measuring vitamin A status. However, this technique has some disadvantages, including its cost, the complexity of the procedure, and the fact that retinol is not very stable and may degrade under the field conditions observed in household surveys, which leads to an overestimate of VAD.

Therefore, in the 2006 and 2011 UDHS surveys, VAD was assessed using the retinol binding protein enzyme immunoassay (RPB-EIA) method. Rather than measuring retinol, this test measures retinol-binding protein (RPB), a surrogate marker for retinol that is more stable than retinol. The RBP-EIA has been rigorously evaluated on both venous blood and capillary blood in the form of DBS (Hix et al., 2006; Hix et al., 2004). It is generally considered to be an acceptable alternative to HPLC with serum retinol for measuring vitamin A deficiency in population-based surveys in resource-limited settings.

The field procedures for collecting samples to test for VAD remained unchanged between the 2000-01, 2006, and 2011 UDHS surveys. Blood spots were collected on a filter paper card from a finger prick, or occasionally a heel prick for very young and malnourished children. The filter paper sample for each individual was immediately placed in a specially designed box where it was protected from sunlight, dirt, and moisture while drying overnight. On the following day, each sample was packed in a low-gas permeable ziploc bag with a desiccant and humidity-indicating card and placed into another re-sealable plastic bag in a portable, battery-operated refrigerator for storage until the samples could be delivered to the Biochemistry Laboratory at Makerere University, where testing of the samples was conducted. The 2011 UDHS field procedures for blood specimen collection are explained in detail in Chapter 1, Section 1.8.

To run the RPB-EIA on the dried blood spot (DBS) samples from the 2011 UDHS, two 6 mm (¼ inch) discs punched out of the centres of two DBS were first eluted by soaking overnight in a pre-prepared buffer. The following day, the concentration of RBP in the eluted DBS samples was determined using a commercial enzyme immunoassay kit manufactured by Scimedx Corporation, Denville, New Jersey, USA. Because the elution does not remove 100 percent of the RPB that is in the dried blood spot on the filter paper card, it was necessary to use a correction factor that makes the concentration of RBP measured in the DBS sample equal to the concentration of RBP measured in a serum sample from the same

individual. The Biochemistry Laboratory performed a validation comparing RPB from DBS and serum samples for 50 individuals and found that on average the concentration of RPB in the serum sample was 1.4 times higher than the concentration of RBP measured in the eluted DBS sample. Therefore, a correction factor of 1.4 was applied to the RBP measurements of DBS samples of all individuals tested in the 2011 UDHS.

Because RBP levels decrease during infection/inflammation and, if not corrected for, may lead to the overestimation of the prevalence of VAD, C-reactive protein (CRP) was used to correct RBP values for the influence of infection or inflammation. To obtain a correction factor to adjust the RBP levels for the effects of infection and inflammation, about 25 percent of the DBS samples were tested for CRP. To measure CRP in the DBS, one 3.2 mm (1/8 inch) disc was punched from the centre of the DBS. The punched disc was placed into a micro-centrifuge tube, and 500 µL of CRP assay buffer was added. The tubes were vortexed for 15 seconds and centrifuged at 5,000 rpm for 2 minutes. Samples were incubated overnight at 4°C. The following day, samples were removed from the refrigerator and rotated at 350 rpm at room temperature for 1 hour. The eluted samples were then tested in duplicate using a commercial test kit (Bender MedSystems GmbH, Vienna, Austria). The cut-off used to define infection or inflammation was set at 3 mg/L of CRP: CRP of >3 mg/L means that the person has infection/inflammation, and CRP of ≤3 mg/L means that the person does not have infection/inflammation.

The method suggested by Thurnham, et al. (2003) was used to adjust the RBP values for infection/inflammation. Based on the CRP level, women and children were classified into two groups, the healthy group (A, CRP ≤3 mg/L) and the group with infection or inflammation (B; CRP >3 mg/L). Adjustment factors were then calculated separately for women and children as the ratio of the geometric mean of the RBP concentrations for the healthy group versus the group with raised CRP (the difference between mean log RBP value for Group A and mean log RBP for Group B is back-transformed to give the adjustment factor). RBP values for the group with raised CRP were then multiplied by the adjustment factor to give the adjusted RBP values.

To adjust the prevalence of VAD for all women and children—including those who were not tested for CRP— the VAD prevalence was determined after increasing their RBP values by the difference between the means of the RBP values of the CRP subsamples. First, the mean RBP values of the CRP subsample for women and children were calculated. Next, the RBP values of 'Group B' were multiplied by 1.255 and added to the 'Group A' RBP values, and a new mean RBP value for the subsample was calculated.[1] Then, all RBP values of the women and children who were not tested for CRP were adjusted by the difference between the new mean and the original mean as a percentage of the original mean. The prevalence of VAD among all women and children was calculated using the newly adjusted RBP values.

When vitamin A status is assessed using serum retinol, the concentration of retinol used to indicate VAD in children is 0.7 µmol/L. Current research suggests that a concentration of 0.7 µmol/L of retinol is equivalent to a concentration of 0.825 µmol/L of RBP (Gorstein et al., 2008). Thus, the cut-off to define VAD in children in the 2011 UDHS is 0.825 µmol/L or 17.325 µg/mL of RBP. For women, the cut-off is 1.24 µmol/L of RBP. The cut-offs for the different levels of VAD were calculated on the same basis; marginal VAD is 0.82-1.24 µmol/L of RBP, moderate VAD is 0.41-0.81 µmol/L of RBP, and severe VAD is <0.41 µmol/L of RBP.

11.9.2 Vitamin A Deficiency among Children

Response rates are important because a high rate of nonresponse may affect the results. A total of 2,319 children age 6-59 months were eligible for vitamin A testing in the 2011 UDHS. Blood samples were collected for 90 percent of these children (data not shown).

[1] The multiplication factor (1.255) is an estimate of the percent reduction of RBP (and vitamin A) in the presence of infection, based on CRP results from previous studies (Thurnham, et al., 2003).

Table 11.13 shows the prevalence of vitamin A deficiency (VAD) among children 6-59 months old using RBP as a surrogate marker for retinol to assess vitamin A status. On the basis of the whole sample and without adjustment for infection/inflammation, 38 percent of children have VAD (RBP <0.825 µmol/L).

Table 11.13 Unadjusted prevalence of vitamin A deficiency in children

Percentage of children age 6-59 months tested for retinol binding protein (RBP) who have any vitamin A deficiency (VAD), by background characteristics, Uganda 2011

Background characteristic	Any VAD (RBP <0.825 µmol/L)	Number of children with a valid RBP test
Age in months		
6-8	32.0	117
9-11	44.7	117
12-17	34.4	244
18-23	34.2	259
24-35	37.6	434
36-47	43.9	469
48-59	36.0	449
Sex		
Male	40.0	1,040
Female	35.9	1,050
Mother's interview status		
Interviewed	38.1	1,758
Not interviewed but in household	40.1	102
Not interviewed and not in the household	35.6	231
Residence		
Urban	32.1	269
Rural	39.2	1,760
Region		
Kampala	32.6	131
Central 1	32.7	191
Central 2	24.8	162
East Central	46.4	243
Eastern	49.2	404
Karamoja	27.9	81
North	36.2	178
West Nile	34.8	134
Western	35.5	266
Southwest	38.7	239
Mother's education[1]		
No education	40.2	247
Primary	39.6	1,201
Secondary+	33.3	396
Wealth quintile		
Lowest	35.8	455
Second	42.7	432
Middle	40.8	426
Fourth	41.6	360
Highest	29.9	355
Total	38.0	2,091

Note: In these analyses, 0.7 µmol/L of retinol is assumed to be equivalent to 0.825 µmol/L or 17.325 µg/ml of RBP.
VAD = Vitamin A deficiency
RBP = Retinol binding protein
[1] Children whose mothers were interviewed

As mentioned before, approximately one-quarter of children were tested for CRP. Table 11.14 shows the percentage of children 6-59 months with VAD after correction for infection/inflammation, according to background characteristics. After correcting for infection/inflammation, the overall prevalence of VAD among all children 6-59 months is reduced from 38 percent to 33 percent.

Table 11.14 Adjusted prevalence of vitamin A deficiency in children

Percentage of children age 6-59 months tested for retinol binding protein (RBP) who have any vitamin A deficiency (VAD), by background characteristics, Uganda 2011

Background characteristic	Any VAD (RBP <0.825 µmol/L)	Number of children with a valid RBP test
Age in months		
6-8	26.4	117
9-11	37.0	117
12-17	29.4	244
18-23	29.6	259
24-35	31.7	434
36-47	37.2	469
48-59	32.9	449
Sex		
Male	34.4	1,040
Female	30.9	1,050
Mother's interview status		
Interviewed	32.6	1,758
Not interviewed but in household	36.5	102
Not interviewed and not in the household	31.5	231
Residence		
Urban	26.4	269
Rural	34.0	1,760
Region		
Kampala	27.9	131
Central 1	29.1	191
Central 2	21.7	162
East Central	39.7	243
Eastern	42.4	404
Karamoja	22.1	81
North	29.3	178
West Nile	28.8	134
Western	30.4	266
Southwest	35.4	239
Mother's education[1]		
No education	33.6	247
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Wealth quintile		
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Highest	25.7	355
Total	32.6	2,091

Note: In these analyses, 0.7 µmol/L of retinol is assumed to be equivalent to 0.825 µmol/L or 17.325 µg/ml of RBP.
VAD = Vitamin A deficiency
RBP = Retinol binding protein
[1] Children whose mothers were interviewed

The adjusted VAD prevalence fluctuates and does not follow a clear pattern by the child's age. It ranges from 26 percent among children age 6-8 months to 37 percent among children age 9-11 and 36-47 months old. Boys have a slightly higher adjusted prevalence of VAD than girls (34 percent versus 31 percent), and children in rural areas have a higher adjusted VAD prevalence than those in urban areas (34 percent versus 26 percent). At 42 percent, the Eastern region has the highest rate of VAD, followed by the East Central region (40 percent). On the other hand, Central 2 region has the lowest VAD prevalence among children 6-59 months old (22 percent). Children whose mothers have at least some secondary education have the lowest VAD prevalence (28 percent) compared with 34 percent of children whose mothers are uneducated or have only primary education. Variation in the rate of VAD by wealth quintile does not show a uniform pattern. However, it is lowest among children in the highest wealth quintile (26 percent) compared with children in the lowest wealth quintiles (31 to 38 percent).

11.9.3 Vitamin A Deficiency among Women

In the 2011 UDHS, a total of 2,717 women age 15-49 months were eligible for vitamin A testing. Blood samples were collected for 95 percent of these women (data not shown).

Table 11.15 shows the unadjusted prevalence of VAD in the whole sample of women age 15-49. Without correcting for infection/inflammation, 36 percent of women have VAD—27 percent have marginal VAD, 8 percent have moderate VAD, and 1 percent has severe VAD.

Table 11.15 Unadjusted prevalence of vitamin A deficiency in women

Percentage of women age 15-49 with any, marginal, moderate, and severe vitamin A deficiency (VAD), according to background characteristics, Uganda 2011

Background characteristic	Any VAD (<1,24 µmol/L)	Level of VAD			Number of women with a valid RBP test
		Marginal deficiency (0.82-1.24 µmol/L)	Moderate deficiency (0.41-0.81 µmol/L)	Severe deficiency (<0.41 µmol/L)	
Age					
15-19	40.3	29.6	9.9	0.8	627
20-29	35.4	25.5	9.2	0.7	938
30-39	33.0	26.2	5.9	0.9	648
40-49	35.3	26.6	7.8	1.0	370
Number of children ever born					
0	38.9	28.9	9.2	0.7	684
1	36.7	24.5	12.0	0.1	240
2-3	35.1	25.1	9.0	0.9	526
4-5	32.1	25.3	5.7	1.1	465
6+	36.2	27.8	7.5	0.9	667
Pregnancy status					
Pregnant	37.7	28.9	8.4	0.4	283
Breastfeeding	34.0	24.9	8.3	0.8	752
Neither	36.6	27.4	8.3	0.9	1,547
Residence					
Urban	35.4	27.0	7.7	0.7	516
Rural	36.1	26.8	8.5	0.9	2,066
Region					
Kampala	31.4	23.9	7.2	0.4	244
Central 1	33.4	27.8	5.6	0.0	254
Central 2	31.0	28.7	1.8	0.4	242
East Central	42.4	29.4	13.0	0.0	272
Eastern	52.8	34.4	17.4	1.0	393
Karamoja	20.0	16.8	3.1	0.0	81
North	27.4	21.6	5.4	0.3	219
West Nile	36.8	25.9	9.6	1.3	162
Western	28.1	24.3	3.1	0.6	381
Southwest	38.0	24.9	10.0	3.1	334
Education					
No education	29.7	21.7	6.6	1.3	313
Primary	37.7	27.4	9.6	0.7	1,554
Secondary+	35.0	27.8	6.4	0.8	715
Wealth quintile					
Lowest	33.6	25.3	7.8	0.5	453
Second	40.1	27.8	11.5	0.8	463
Middle	33.9	24.2	8.1	1.5	478
Fourth	39.4	28.2	9.9	1.2	545
Highest	33.4	27.9	5.3	0.3	644
Total	36.0	26.8	8.3	0.8	2,582

Note: In these analyses, 0.7 µmol/L of retinol is assumed to be equivalent to 0.825 µmol/L or 17.325 µg/ml of RBP.
VAD = Vitamin A deficiency
RBP = Retinol binding protein

As with children, the data on vitamin A deficiency were adjusted to correct for those who had high levels of C-reactive protein (CRP) caused by current infections or inflammation. Table 11.16 shows that the VAD prevalence is reduced only slightly from 36 percent to 35 percent. The adjusted prevalence of VAD for all women varies by their background characteristics. The level of VAD declines with age from 40 percent among women age 15-19 to 32 percent among women aged 30-39; it then increases to 34 percent among women age 40-49. Women with no children (38 percent) and pregnant women (36 percent) have a higher VAD prevalence than other women. VAD prevalence is slightly higher in rural than in urban areas (35 versus 33 percent). Eastern region has the highest proportion of women with any VAD (51 percent), while Karamoja region has the lowest (16 percent). Women with no education have the lowest prevalence of VAD (29 percent) compared with women with any education (34 to 37 percent). As with children, the variation of VAD prevalence by wealth does not follow a clear pattern. It is lowest among women in the lowest and highest wealth quintiles (32 percent, each).

Table 11.16 Adjusted prevalence of vitamin A deficiency in women

Percentage of women age 15-49 with any, marginal, moderate, and severe vitamin A deficiency (VAD), according to background characteristics, Uganda 2011

Background characteristic	Any VAD (<1,24 µmol/L)	Level of VAD			Number of women with a valid RBP test
		Marginal deficiency (0.82-1.24 µmol/L)	Moderate deficiency (0.41-0.81 µmol/L)	Severe deficiency (<0.41 µmol/L)	
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Number of children ever born					
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Pregnancy status					
Pregnant	35.8	28.0	7.4	0.4	283
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Total	35.0	26.3	7.9	0.8	2,582

Note: In these analyses, 0.7 µmol/L of retinol is assumed to be equivalent to 0.825 µmol/L or 17.325 µg/ml of RBP.
VAD = Vitamin A deficiency
RBP = Retinol binding protein

11.9.4 Trends in Vitamin A Deficiency

When compared with the results from the 2006 UDHS, the unadjusted VAD prevalence had increased substantially. For children 6-59 months it increased from 20 percent to 38 percent, and for women 15-49, it had increased from 19 percent to 36 percent over the last five years. This increase is difficult to explain given that vitamin A supplementation in children and postpartum women and consumption of vitamin A-rich foods in children have increased slightly since the 2006 UDHS. The increase in VAD among both children and women could be partially due to potential problems in the field with blood sample collection and storage and during transportation to Kampala. There was a long, heavy rainy season in the second half of 2011 that coincided with fieldwork ,which resulted in roads being washed away, delaying the transfer of samples from the field to Kampala for proper storage. These delays in storing the samples under the appropriate conditions, together with the heavy rains that might have slowed the drying of the samples, could have adversely affected the qua1ity of the samples.

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