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Vitamin A Deficiency among Rural Primary School Children, A still Neglected Group for Vitamin A Supplementation Strategies

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ABSTRACT

Background: Vitamin A deficiency (VAD) is still a public health problem across the globe and also in Burkina Faso, especially for under-five-years-old children. Since less information is available about the prevalence of VAD among the primary school children, this study aimed to study this area. **Methods**: A randomised double-blind placebo-controlled trial was conducted to assess the effect of high dose of vitamin A (VA) and daily zinc versus high dose of VA and daily zinc placebo (6 days per week) during four months among the primary school children. Of the total number of 200 school children, 100 were allocated to two random groups. Participants' gender, age, weight, and height were measured, a blood smear was performed for malaria diagnosis, stool samples were collected for intestine parasites' assessment, and blood samples were collected for haemoglobin and serum retinol measurement. **Results:** Baseline data of 183 school children were analysed and the findings showed that 20.6% of the school children were underweight (23.2% in girls vs. 16.5% in boys; *P* = 0.043). Anemia affected 36.2%, 39% had *Plasmodium Falciparum*, and 37.6% had intestine parasites. Furthermore, VAD prevalence was 46.1% (51.0% in boys vs. 41.2% in girls; *P* = 0,072). **Conclusion**: Among primary school children in the Western part of Burkina Faso, VAD is not only higher than other regions of the country, but also twice the critical level and defined as a severe public health problem by WHO. This result calls for action among the primary school children and recalls the importance of taking strategies against VAD among under-five-year-old children.

Key Word: *Vitamin A deficiency; Primary school children; Burkina Faso*

Introduction

Vitamin A deficiency (VAD) is a public health concern worldwide and especially in the developing countries. According to the World Health Organisation (WHO), around 190 million preschool children are affected by VAD with or without clinical manifestation. It is also known to contribute to childhood mortality and morbidity (Stevens *et al.*, 2015, World health organization,

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2009). In sub-Saharan African, almost all the data available on VAD, whether in term of VAD prevalence or its adverse effects, are referring to the under-five-year-old children or pregnant or lactating women (Bishai *et al.*, 2005, Imdad *et al.*, 2017, Sahile *et al.*, 2020, Schmitz *et al.*, 2012). In the developing countries, the common strategy against VAD has been vitamin A supplementation among under-five-years-old children and indeed many studies have proven its efficacy previously (Fawzi *et al.*, 1993, Glasziou and Mackerras, 1993).

In Burkina Faso, for instance, it is accepted that VAD is a public health concern for under-five-years-old children even though data at the national level are not available yet. Report from a study in some part of the country suggested that more than 60% of this group of children are affected by VAD (Zagré *et al.*, 2003). One of the national strategies against this deficiency, presented since 2005 is a biannual supplementation of under-five-years-old children with vitamin A capsules.

Apparently under-five-years-old children are not the only individuals at concern with regards to VAD in Burkina Faso. In fact, data showed that more than 40% of the school children in the Eastern and Norden rural settings of Burkina Faso (Zeba *et al.*, 2006) and even in the capital city (Daboné *et al.*, 2011) are affected by VAD.

The current study aimed to assess the impact of double supplementation of vitamin A and zinc versus vitamin A and zinc placebo. Moreover, we targeted at assessing the baseline vitamin A status among school children living in a Western rural setting of Burkina Faso. The findings can be used to provide more insight on this matter in the rural Western part of the country.

Materials and Methods

Study design and participants: The study was carried out between March and July 2014 in the "Vallée du Kou" primary school in Bama village. It is a rural area located in the "Dandé" health district, at around 30 km away in the Western part of the city of Bobo Dioulasso. Bama is a village where fishing activity is dominant and many households are in good food security status, whether in term of food availability or food accessibility. In this regard, this village is in a better condition than other areas in the Eastern or Northern parts of the country (MAAHA, 2020).

A randomized double-blind placebo-controlled trial was conducted, assessing the effect of a combined supplementation of a high dose (200 000 UI) of vitamin A in addition to a daily zinc supplementation (six days per week). The results were compared with the effect of a high dose (200 000 UI) of vitamin A plus daily zinc placebo (six days per week) in the primary school children of 7 to 12 years old. The baseline data were collected form the selected children at the inclusion and a daily follow-up were conducted with the same children for zinc vs. zinc placebo intake during a four-month period. At the end of the fourth months, the study ended with an end line data collection.

The primary outcomes of the study included decrease of intestine parasites prevalence among the primary school children by 50% and the decrease of anemia by 25% as an effect of the combined supplementation of vitamin A and zinc compared to the supplementation of vitamin A and zinc placebo. Initially, the sample size of 180 school children was considered using the 80% power and $\alpha = 0.05$). In order to take into account the drop-out during the follow-up, 10% was added to this initial sample size. A total number of 200 school children were selected and 100 were allocated to each of the two random groups for the study. The first random group (AG) received a high dose of vitamin A in addition to the daily zinc supplementation and the second group received a high dose of vitamin A in addition to daily zinc placebo (PG).

The supplements and placebos were provided by U-Pharma unit of the National Health Science Research Institute of Burkina Faso (IRSS). Zinc powder was included in capsules containing 10 mg Zn in the form of zinc gluconate and placebo was a zinc-free capsule with maize powder, having colour, taste, and appearance similar to those of zinc gluconate. All capsules were coded based on the two groups and investigators, clinical staff, field workers, and parents were blind to the codes. The children in the AG received one high dosage of vitamin A and a daily dosage (except Sunday) of zinc gluconate, while the children in the PG received one high dose of vitamin A and a daily dose of zinc gluconate placebo.

Study participants and follow up process: The study inclusion criteria were: studying at "Vallée du Kou" school, being within the age range of 7 to 12 years, having no clinical sign of VAD, planning to remain at the selected school till the end of the school year, submitting a signed informed consent form by the legal representative of the selected child. Before the enrolment day, village meetings were held in the local language to explain the purpose, methods, and risks of the study.

At the enrolment, children were individually allocated into the AG or PG in two blocks using computer-generated randomly permutated codes. Children were then visited at home every day, six days per week during four months of follow-up from March to July 2014 by the trained village-based field workers to distribute zinc or zinc placebo supplements.

The above-mentioned flowchart describes the study profile and the data collection process from the selection to the end line of the data collection. After the selection, only children for whom a blood sample was collected at the baseline were enrolled and followed-up.

Study variables laboratory procedures: Part of the study variables and laboratory processing are described in an already published paper (Bationo *et al.*, 2018). Variables such as gender, age, weight, and height were measured, blood smear was performed for malaria diagnosis, stool samples were collected for intestine parasites assessment, and blood samples were collected at the baseline and at the end line.

Age, gender, weight, and height were computed into body mass index for age used for children from 5 to 19 years old. A z-score was derived from it with a z-scores < -2 SD indicating underweight children and z-scores > 1 SD, indicating overweight children.

At the end of each data collection session, the blood samples were brought to the IRSS Laboratory and centrifuged the same day. The serum samples were then collected, frozen, and kept at -20°C until analysed. The serum samples were shipped to the University of Wisconsin-Madison, USA, in dry ice and subsequently stored at -80°C before being analysed by Gas Chromatography-combustion-isotope ratio mass spectrometry (GC-C-IRMS) technics as published for vitamin A body store determination and HPLC for serum retinol (Gannon *et al.*, 2014). With serum retinol, case of VAD and a severe case of vitamin A deficiency was defined with serum retinol <0.7 µmol/l and < 0.35 µmol/l, respectively as recommended by WHO.

Haemoglobin (Hb) was directly measured in the field with a drop of whole blood using a HemoCue_R (Hemocue HB 2011, Angelholm, Sweden), so that anemia was defined as Hb <11,5 g/dl for children < 12 years and Hb < 12 g/dl for children ≥ 12 years (World health organization, 2004) .

The same blood drop was used to perform a blood smear for malaria diagnosis. Thick and thin giemsa-stained blood films were collected and analysed for the plasmodium species-specific density per 200 white blood cells. Each film was examined by a technician in the field, re-examined by an experienced laboratory technician, and checked by a third investigator in cases of discrepancy. The total parasite count per µL was quantified and a thick was declared negative if no parasites were seen on the film.

Data processing and analysis: Data were analysed with "IBM-SPSS" version 26.0 (IBM Corp, Armonk, NY, USA). Quantitative variables were expressed as mean ± standard deviation (SD) and categorical variables as percentages with 95% confidence intervals (CI). Differences between quantitative variables were assessed using the independent *t-test* and the Analysis of variance (ANOVA) test for comparison of more than two groups followed by the Bonferroni post hoc test.

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Differences between categorical variables were assessed by *χ2 test*.

Ethical aspects: An ethical approval of the study protocol was received from the ethical committee of Centre Muraz (011-2014/CE-CM). The trial was registered at Pan African Clinical Trials Registry (PACTR201702001947398). The study was also explained to the "Dandé" health district authorities, the villagers, and the head of each participating compound individuals. Written informed consent was obtained from parents or guardians of all included children before enrolment. Children who got sick during the surveys or visits by the supervisors were treated in the village or referred to Bobo Dioulasso hospital free of charge.

Results

From the original 200 school children included in the study, we were able to have enough blood samples from 183 in order to carry out the vitamin A assessment. A total number of 17 children were excluded from the study because it was impossible after two to three attempts to draw a blood sample from them. The baseline characteristics in **Table 1** shows that 20.6% of the school children were underweight and girls were more affected than boys even though the difference was not significant (23.2% in girls vs. 16.5% in boys; *P* = 0.185).

Mean haemoglobin was 12.24 g/dl, which was significantly higher in girls than in boys marginally (12.38 g/dl vs. 12.09 g/dl; *P* = 0.057). Anemia affected 36.2% of the school children with no difference between boys and girls. *Plasmodium falciparum* was found in the blood of 39% of the children, which was in a similar proportion between boys and girls, with a geometric mean parasite density of 542.43 *Plasmodium falciparum* positive /µl. Alongside with plasmodium falciparum, intestine parasites were found among the school children, so that 37.6% of them were affected in a similar proportion for boys and girls. The mean serum retinol level was 0.8 µmol/l (0,75 in boys vs. 0.85 in girls; *P* = 0.059) and 46.1% of the school children had VAD, which was higher in boys than in girls, although it was not statistically significant (51.0% vs. 41.2%; *P* = 0,072).

In considering **Table 2**, we can see that the mean serum retinol remained almost similar between girls and in boys despite the nutritional variety of the infectious status. Despite these conditions, the mean serum retinol levels were above the threshold of 0.70 µmol/l determining the deficiency status.

The odds of VAD, as shown in **Table 3** were not significant for school children with underweight, anemia, intestine parasite, plasmodium falciparum, or both parasites. Even children with these conditions exhibited more deficiencies.

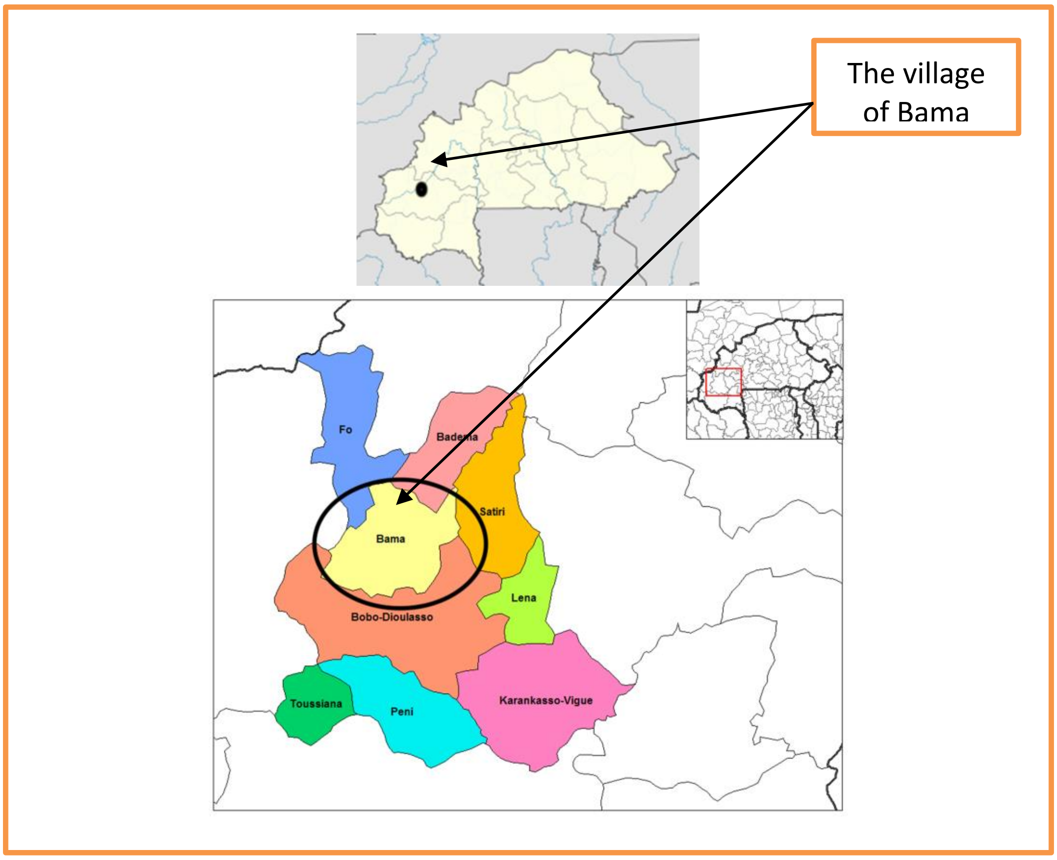

Figure 1. Burkina Faso maps, representing the study area (the village of Bama), in the Western part of the country (from Wikipedia.org)

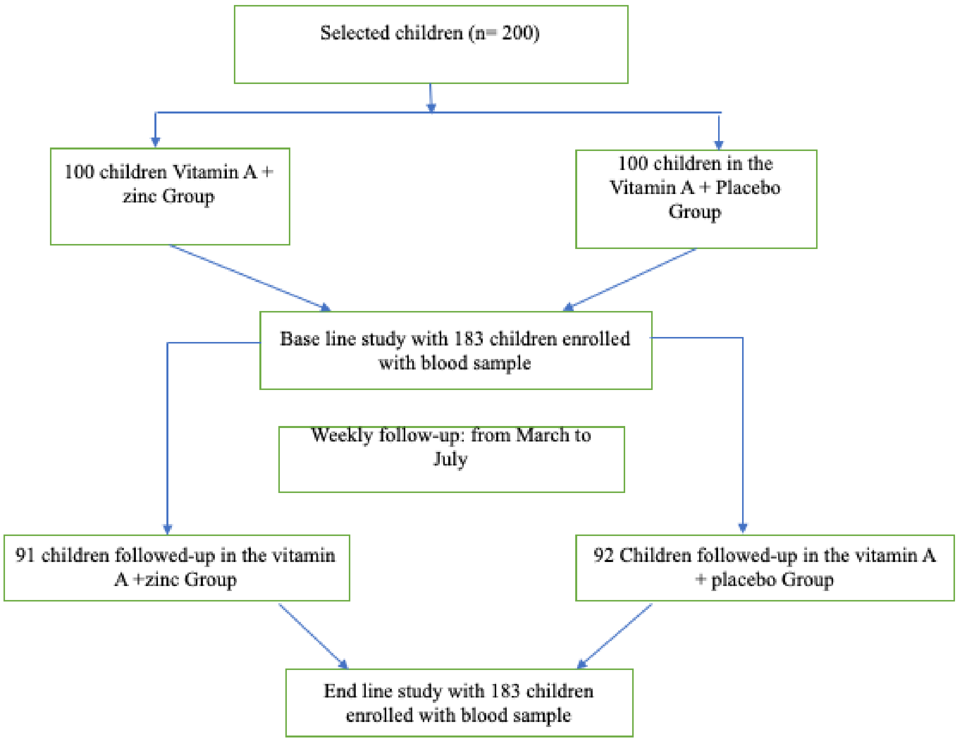

Figure 2. Flowchart of the study profile and data collection

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Table 1. Baseline nutritional, clinical, and parasitological characteristics

Variables	All (n = 183)		Boys (n = 89)		Girls (n = 94)		P-value[a]
Age (y)	9.32 ± 1.56[b]		9.31 ± 1.53		9.33 ± 1.59		0.933
Weight (kg)	24.75 ± 5.37		24.94 ± 4.95		24.57 ± 5.76		0.626
Height (cm)	129.08 ± 12.42		128.08 ± 14.39		130.03 ± 10.19		0.274
Haemoglobin (g/dl)	12.24 ± 1.09		12.09 ± 1.12		12.38 ± 1.04		0.057
Body mass index (kg/m²)	14.91 ± 1.70		14.96 ± 1.46		14.86 ± 1.88		0,060
Serum retinol µmol/l	0.80 ± 0.35		0.75 ± 0.34		0.85 ± 0.35		0.059
Weight status according to body mass index z-score							
Normal ((≥-2 and ≤ +1)	151(78.40)[c]		(74) 83.5		(70) 74.7		0.185
Underweight (< -2 Z)	40 (20.60)		(15) 16.5		(22) 23.2		
Overweight (> +1 to ≤ +2)	2(1.0)		0		(2) 2.0		
Anemia	36.2		39.8		32.7		0.185
Positive *Plasmodium falciparum*	39.0		35.7		42.2		0.215
Geometric mean density *Plasmodium falciparum* positive /µl ± SE[d]	542.43	596.67	516.01	193.25	565.58	1081.19	0.284
Positive intestine parasite	37.6		38.5		36.7		0.462
Serum retinol < 0.70 µmol/l (%)	46.1		51.0		41.2-		0.072

[a]: *Qualitative variable Student t-test and quantitates X^2 test;* [b]: *Mean ± SD;* [c]:N (%); [d]: Geometric mean± *SE (Standar Error)*

Table 2. Retinol concentration (µmol/l) according to nutritional and infection status

	All (n = 183)	P-value	Boys (n = 89)	P-value	Girls (n = 94)		P-value
Weight status according to body mass index z-score							
Normal (-2 - 1)	0.82 ± 0.34[b]	0.479[c]	0.79 ± 0.34[c]	0.341[c]	0.84 ±	0.34[c]	0.618
Underweight (< -2)	0.79 ± 0.33		0.70 ± 0.29		0.85 ±	0.35	
Overweight (1 - 2)	1.09 ± 0.46		-		1.09 ±	0.46	
Anemia							
Yes	0.76 ± 0.35	0.225[a]	0.72 ± 0.35	0.483[a]	0.81 ±	0.34	0.415[a]
No	0.82 ± 0.34		0.77 ± 0.33		0.87 ±	0.35	
Intestine parasite							
Yes	0.85 ± 0.37	0.315[a]	0.71 ± 0.35	0.704[a]	0.96 ±	0.36	0.080[a]
No	0.78 ± 0.35		0.75 ± 0.37		0.80 ±	0.34	
Presence of *Plasmodium falciparum*							
Yes	0.79 ± 0.35	0.902[a]	0.73 ± 0.34	0.827[a]	0.87 ±	0.37	0.784[a]
No	0.80 ± 0.36		0.74 ± 0.35		0.84 ±	0.36	

[a]: *Student t-test;* [b]*:Mean ± SD;* [c]: ANOVA with Bonferroni post hoc test.

Table 3. Odds of low retinol level related to nutritional and infection status

Variables	n	% Serum retinol < 0.70 µmol/l	Odds	CI 95%	P-value[a]
Weight status according to body mass index z-score					
Normal (-2-1)	145	43.4	1		
Underweight (< -2)	36	52.8	1.24	0.0-10.24	0.182
Overweight (1 -2)	2	0	1.80	0.0-10.80	
Anemia					
No	123	44.7	1		
Yes	69	47.8	1.03	0.56-1.91	0.903
Intestine parasite					
No	114	43.0	1		
Yes	69	52.2	0.70	0.38-1.29	0.261
Plasmodium falciparum					
No	118	46.6	1		
Yes	75	45.3%	1.09	0.59-1.99	0.771

[a]: *Binary logistic regression*

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Discussion

The present study investigated the opportunity of assessing vitamin A status of 7-12 year-old school children in a rural setting of the western Burkina Faso. The western part of the country is richer in terms of food availability and household food security (MAAHA, 2020). Most families of the children were involved in fishing occupation. The prevalence of VAD is expected to be lower in such settings, that was found in the Central Norden part (47.2% in Kaya and 37.1% in Bogandé) (Zeba *et al.*, 2006) and in the Capital city (40% in Ouagadougou) (Daboné *et al.*, 2011) of the country. Unfortunately, we found that the prevalence of VAD was higher up to 46.1% in the western settings. Obviously, school children are not in a better condition than those of under five years with regards to VAD in Burkina Faso. According to WHO, VAD is a severe public health problem when its prevalence, measured as serum retinol <0.70 µmol/l reaches more than 20% (World health organization, 2011). In this study we found twice this threshold and yet little is done to mitigate the impact of this deficiency among this group of people. School children are at a particular stage of their development, through which they are in need of their optimum nutritional status to ensure the best conditions for learning abilities.

Vitamin A is known to contribute not only to immune system (Cantorna *et al.*, 2019, Erkelens and Mebius, 2017, Mora *et al.*, 2008) or to vision (Chiu *et al.*, 2016, Saari, 2016, Wiseman *et al.*, 2017) or else to the reduced morbidity or mortality (Darlow *et al.*, 2016, Haider and Bhutta, 2011, Imdad *et al.*, 2017, Neonatal Vitamin A Supplementation Evidence Group, 2019), but also to play an important role in iron metabolism (da Cunha *et al.*, 2019). Iron deficiency is also known to be detrimental to children mental development, which can lead to impairment in school performance (Taras, 2005, Zimmermann and Hurrell, 2007). Indeed, a recent randomized double blinded trial over vitamin A supplementation suggested that children who received VA supplement had better performance in reading, spelling, and math computation than those who did not (Ali *et al.*, 2017). Vitamin A strategies are commonly applied for under-five-year-old children and even for child bearing potential, pregnant, and breastfeeding women, but rare interventions focused on the primary school children. According to the present data, which corroborate those found in Central Northern and the capital city of Burkina Faso (Daboné *et al.*, 2011, Zeba *et al.*, 2006), more attention should be paid to this specific group, in which VAD is at the stage of severe public health problem in Burkina Faso (World health organization, 2011).

The study bears some limitations mainly due to its experimental design and limited sample size. Furthermore, the findings are neither generalizable to other regions nor to other parts of the country. However, the findings can provide a good insight into what might be the situation of the primary school children. To eliminate hidden hunger, providing enriched school meals to children is highly recommended.

Conclusion

The current study reported a high prevalence of VAD (twice the level permitted by WHO) among primary school children. The prevalence remained stable and high in children with or without intestine parasite, plasmodium falciparum, and underweight condition. However, no strategy at the national or regional or local level has ever responded to this situation. Most interventions against VAD deficiency have been focused on under-five-years-old children as well as pregnant and breastfeeding women, but the primary school children should not be neglected since they are at a particular stage of their development.

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Authors' contribution

Augustin Nawidimbasba ZEBA: Developed the study, carried out data analysis and interpretation, as well as drafted the manuscript and its revision before submission. Jean Fidèle BATIONO:

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Carried out the field work, contributed to the data analysis and interpretation, and revised the manuscript before submission. Olivier Ouahamin SOMBIÉ and Jeoffray DIENDÉRÉ: Contributed to the data analysis and interpretation, and revised the final version of the manuscript before submission. All the authors read and approved the final manuscript.

Conflict of interests

The authors declare that they have no competing interests with regard to this paper.

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