Coverage and factors associated with vitamin A supplementation among children aged 6–59 months in twenty-three sub-Saharan African countries

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Abstract

Objective: The present study aimed to give an overall view of the pattern of high-dose vitamin A supplementation (VAS) coverage in twenty-three sub-Saharan African countries and factors associated with receipt of VAS among children aged 6–59 months.
Design: Cross-sectional data from the twenty-three Demographic and Health Surveys conducted from 2011 to 2015 in twenty-three sub-Saharan African countries were pooled. A multilevel logistic regression model was used to explore factors associated with VAS.
Setting: Twenty-three sub-Saharan African countries.
Participants: Children (*n* 215 511) aged 6–59 months.
Results: The overall coverage of VAS among children aged 6–59 months for the surveys included was 59·4 %. In the multivariable analysis, children whose mothers had primary (adjusted OR (aOR) = 1·43; 95 % CI 1·39, 1·47) or secondary or above (aOR = 1·72; 95 % CI 1·67, 1·77) educational status were more likely to receive VAS than children whose mothers had no formal education. Other factors associated with significantly increased likelihood of VAS were: living in urban areas; children of working mothers; children whose mothers had higher media exposure; children of older mothers *v.* children of mothers aged 15–19 years; and older children *v.* children aged 6–11 months. At the country level, lower media exposure was significant and negatively associated with VAS.
Conclusions: Broader VAS coverage is needed according to our data. More efforts are needed to scale up coverage, focusing mostly on groups at risk of non-receipt of vitamin A.

Vitamin A is an essential nutrient needed for the normal functioning of the visual system, maintenance of cell function for growth, red blood cell production, immunity and reproduction[1,2]. Globally, in 2013 one-third of children aged 6–59 months had vitamin A deficiency with one of the highest rates (48 %) observed in sub-Saharan Africa (SSA)[3]. Furthermore, in the regions of South Asia and SSA, vitamin A deficiency accounted for about 2 % of child deaths[4].

The WHO recommends semi-annual high-dose vitamin A supplementation (VAS) for children aged 6–59 months in countries where vitamin A deficiency is recognised as a public health problem and in countries with under-5 mortality rate above 70 per 1000 live births[5]. According to a previous study, vitamin A supplements can improve a child's chance of survival by 12 to 24 %[6]. Recent food-based approaches, such as food fortification and

consumption of foods rich in vitamin A, are ongoing and are essential to ending vitamin A deficiency in the long term. However, until such programmes are sustained at a large scale, delivery of high-dose supplements remains the principal strategy in use for controlling vitamin A deficiency for children aged 6–59 months, despite its inability to maintain normal serum retinol levels[7,8]. In addition, VAS has been proven to be safe, with a cost:benefit ratio of 17:1 for South Asia, East Asia and SSA, and an equitable way of reaching the most vulnerable children[7,9]. Ensuring universal VAS coverage (100 %) in SSA or at least effective coverage (≥80 %) needed to improve child survival is important[10] and is also a central component of the child survival agenda in the region. In the literature, some studies have been done with the aim of identifying differentials for uptake of VAS among children aged

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6–59 months[11–24]. Identifying these differentials for vitamin A uptake among children aged 6–59 months in SSA will aid international efforts aimed at increasing VAS coverage in SSA. Thus, the present study's objective was to give an overall view of the pattern of high-dose VAS coverage for the surveys we included as well as examine factors associated with receipt of VAS among children aged 6–59 months.

Methods

Study sample

Out of fifty-four countries in Africa, forty-six are listed as sub-Saharan Africa[25]. We used pooled cross-sectional data from the Demographic and Health Surveys (DHS) conducted in twenty-three SSA countries from 2011 to 2015, with the countries selected based on availability of comparative data[26]. The pooled DHS data have a hierarchical structure with individuals nested within countries. Our study sample was restricted to children aged 6–59 months and the sample size ranged from 4279 in Namibia to 25 607 in Nigeria (Table 1).

Vitamin A supplementation

Our outcome variable VAS was defined as receipt of VAS in the last 6 months prior to the survey and was expressed as a dichotomous variable, with category 1 for receipt of VAS and category 0 for non-receipt of VAS. Explanatory variables were chosen based on previous studies and grouped into individual-level and contextual country-level variables. Individual-level variables included the following: mother's age; mother's educational status; mother's occupational status; marital status; place of residence; sex of household head; sex of child; age of child; and media exposure score, which was created from the variables (i) frequency of reading newspapers or magazines, (ii) frequency of listening to the radio and (iii) frequency of watching television. To each of these variables, a score of 0 was given if the response was 'not at all', 1 if the response was 'less than once a week' and 2 if the response was 'at least once a week or almost every day' (five countries additionally measured response for 'almost every day'). The three variables were later summed up to create the variable 'media exposure score'. Contextual country-level factors included gross domestic product per capita based on purchasing power parity[27] and proportion of respondents with media exposure score of 0 in the country.

Statistical analysis

The demographic and socio-economic characteristics of respondents are given as unweighted case numbers and percentages, whereas the overall prevalence of VAS among children aged 6–59 months in SSA and receipt of

Table 1 The Demographic and Health Surveys conducted from 2011 to 2015 in the sub-Saharan African countries included in the present study

Country	Survey year	Children aged 6–59 months (n)*	Received vitamin A supplementation in the last 6 months†	
			n	%
Benin	2011–12	11 422	5485	48·6
Congo DR	2013–14	15 255	10 587	70·4
Congo	2011–12	7883	4479	64·9
Côte d'Ivoire	2011–12	6299	3714	60·8
Cameroon	2011	9582	5284	55·3
Gabon	2012	5101	2317	53·8
Ghana	2014	4982	3171	65·2
Gambia	2013	6818	4572	68·7
Guinea	2012	5692	2329	40·8
Kenya	2014	18 256	12 202	71·7
Liberia	2013	6329	3278	60·2
Mali	2012–13	8566	5273	60·8
Mozambique	2011	9221	7199	74·6
Nigeria	2013	25 607	10 723	41·3
Niger	2012	10 281	6422	59·6
Namibia	2013	4279	3417	83·6
Rwanda	2014–15	6845	6022	86·4
Sierra Leone	2013	9464	7959	83·2
Senegal	2015	5964	4826	88·4
Chad	2014–15	15 058	6607	44·1
Togo	2013–14	5918	4664	81·7
Zambia	2013–14	11 506	8745	76·5
Zimbabwe	2015	5183	3633	67·0
All	2011–2015	215 511	–	59·4‡

*Unweighted case numbers.
†Individual countries' sample weight numbers and percentages.
‡Based on pooled sample weights, derived from women's individual weights and population size of women aged 15–49 years for respective countries.

VAS according to demographic and socio-economic characteristics of respondents are reported as weighted percentages based on women's individual weights and population size of women aged 15–49 years in the respective countries[28]. Due to the hierarchical structure of the data, for the multivariable analysis we applied a multilevel logistic regression to explore factors associated with VAS among children aged 6–59 months using MLwiN multilevel software[29]; mother–children pairs made up the first level, while countries made up the second level. Parameter estimates using MLwiN were based on the second-order predictive (or penalized) quasi-likelihood procedure. The proportion of the variance in VAS among children aged 6–59 months due to differences between countries, the intra-country correlation coefficient, was calculated as $\rho = \sigma_u^2 / (\sigma_u^2 + \sigma_e^2)$, where σ_u^2 is the total variance at the country level and σ_e^2 is the total variance at the individual level. In multilevel logistic regression model, the level 1 residuals, e_{ij}, are assumed to follow a standard logistic distribution with a mean of 0 and variance $\sigma_e^2 = \pi^2/3$[30]. Country-level residuals were used to explore country-level variations in VAS among children aged 6–59 months by constructing simultaneous 95 % CI using caterpillar plots. The width of the interval to achieve a 5 % significance was set at $1\cdot39\sigma$[31]. Countries whose 95 % CI did not overlap were considered significant at the 5 % level. The simultaneous CI were constructed before (Model 0) and after controlling for individual and contextual factors (Model 1).

Ethics

The surveys were reviewed and approved by the Ethics Committee of ICF International at Calverton, MD, USA and by the National Ethics Committee of the various countries involved in the study. Permission to use and analyse the data set was obtained by registering the study on the DHS website.

Results

VAS coverage among children aged 6–59 months for the surveys we included was 59·4 % (Table 1). Of mothers, 27·9 % were in the age bracket 25–29 years old and 43·8 % had no formal education. A higher proportion of mothers were working mothers, 65·5 %, and 67·9 % resided in rural areas. Most (45·2 %) mothers had a media exposure score of 1–3 and males headed the majority of households (80·2 %). The majority of mothers were currently in a union/living with a man (88·1 %); male (50·2 %) and female children (49·8 %) were more or less equal; and the majority of children were in the age group 36–47 months (Table 2).

Descriptive, unadjusted associations with vitamin A supplementation in twenty-three sub-Saharan African countries

VAS coverage was higher among children whose mothers were in the age group 30–34 years (Table 2). However, this varied considerably by country (see online supplementary material, Supplemental Table 1). At 69·3 %, VAS coverage was highest among children whose mothers had secondary or above educational status (Table 2). Coverage increased significantly with higher maternal education in sixteen countries (Supplemental Table 1). Coverage was also significantly higher in fourteen countries among children who had working mothers (Supplemental Table 1). Compared with male-headed households, in seven countries, female-headed households had significantly higher VAS coverage among children aged 6–59 months; on the other hand, in five countries, coverage among children aged 6–59 months was observed to be significantly higher in male-headed households (online supplementary material, Supplemental Table 2). Coverage was significantly higher among children aged 12–23 months in eighteen countries (online supplementary material, Supplemental Table 3). Overall, coverage was observed to be higher among children living in urban areas, children whose mothers had a media exposure score of 4 or above, children whose mothers were never in a union/formerly in a union and among male children (Table 2).

Country variations

In Model 0 (null model), the intra-country correlation was 12·9 %; however, after taking account of background sociodemographic characteristics (Model 1), approximately 9·9 % of the total unexplained variation in VAS could be attributed to unobserved country-level factors. Figure 1 shows the simultaneous CI of country-level residuals in the null model (Model 0). Senegal had significantly higher likelihood of having received VAS than the remaining countries except Rwanda, Togo, Namibia and Sierra Leone, with which the simultaneous CI overlapped. Figure 2 shows the simultaneous CI of country-level residuals after controlling for contextual country-level factors (Model 1). Sierra Leone had significantly higher likelihood of coverage among children aged 6–59 months than the remaining countries with the exception of Senegal, Togo and Namibia, with which the simultaneous CI overlapped.

Explanatory factors associated with vitamin A supplementation among children aged 6–59 months

Table 3 shows the adjusted associations between VAS and explanatory variables. Children with older mothers were significantly more likely to receive VAS than children with mothers aged 15–19 years. Children whose mothers

Table 2 Characteristics of children aged 6–59 months who received vitamin A supplementation (VAS), by demographic and socio-economic characteristics, in twenty-three sub-Saharan African countries, 2011–2015, using pooled cross-sectional data from Demographic and Health Surveys

Characteristic	Total*		
	n	%	VAS coverage (%)†
Mother's age (years)			
15–19	11 901	5·5	53·6
20–24	46 091	21·4	57·4
25–29	60 193	27·9	59·9
30–34	45 867	21·3	61·4
≥ 35	51 459	23·9	60·0
Mother's educational status			
No education	94 316	43·8	46·9
Primary	66 778	31·0	65·6
Secondary or above	54 392	25·2	69·3
Mother's occupational status			
Not working	70 261	34·5	54·5
Working	133 447	65·5	60·7
Type of place of residence			
Urban	69 230	32·1	65·7
Rural	146 281	67·9	56·2
Mass media exposure score			
0	74 590	34·8	49·2
1–3	96 788	45·2	62·2
4 or above	42 928	20·0	68·9
Sex of household head			
Male	172 816	80·2	57·8
Female	42 695	19·8	67·0
Marital status			
Never in a union/formerly in a union	25 722	11·9	67·1
Currently in union/living with a man	189 789	88·1	58·6
Sex of child			
Male	108 288	50·2	59·5
Female	107 223	49·8	59·4
Age of child (months)			
6–11	26 268	12·2	54·1
12–23	48 305	22·4	63·9
24–35	46 935	21·8	60·9
36–47	48 436	22·5	58·6
48–59	45 567	21·1	57·1

*Unweighted case numbers and percentages.
†Based on pooled sample weights, derived from women's individual weights and population size of women aged 15–49 years for respective countries.

had primary education and children whose mothers had secondary or above educational status had higher likelihood of receiving VAS than children whose mothers had no formal education. Children who resided in urban areas were significantly more likely to receive VAS compared with children living in rural areas. Children with working mothers were more likely to receive VAS compared with children who had non-working mothers. Children whose mothers had a media exposure score of 1–3 and of 4 or above had higher likelihood of receiving VAS compared with children whose mothers had a media exposure score of 0. Finally, older children were significantly more likely to receive VAS than those aged 6–11 months. At the country level, lower media exposure score was significantly associated with lower coverage.

Discussion

Achieving substantial reductions in child mortality means that all children aged 6–59 months living in affected areas need to receive high-dose vitamin A supplements every 4–6 months. UNICEF strives for at least 80 % coverage as a measure of strong and effective VAS programming[10]. The overall VAS coverage based on our data was 59·4 %, which is below this recommended minimal coverage level and indicates a need for policy makers and public health practioners in the region to scale up VAS among children aged 6–59 months.

The factors significantly associated with receipt of VAS among children aged 6–59 months were maternal age, maternal education, place of residence, maternal occupational status, media exposure index and age of child. Furthermore, at the country level, media exposure also affected VAS.

We observed that children with older mothers were more likely to receive VAS than children with teenage mothers. This finding is similar to that in a study by Aremu et al., which revealed that children with younger mothers were less likely to receive VAS[15]. These results may be explained by the fact that on the mother's part, nutritional knowledge may increase with age[32].

From our study, it is also envident that the mother's educational status had a role in the reciept of VAS among children aged 6–59 months. Previous studies have also linked higher maternal educational status with receipt of VAS[17,19,22]. A plausible explanation for this finding is that formal education increases health and nutritional awareness vis-à-vis increasing awareness on the benefits of VAS.

Another study also found that rural children were approximately 10 % more likely never to have received a vitamin A supplement compared with their counterparts in urban locales[7]. The reasons for the disparity in VAS coverage between the two settings might be attributed to differences in accessabilty to health information and heath services, infrastructures and technological advancements.

In agreement with previously published studies[13,15], children with working mothers where more likely to receive VAS compared with children with non-working mothers. This might be explained by the fact that working mothers have more access to information about the advantages of VAS and its use from sources such as peers in their workplace, or increased access to community mobilization efforts[13].

In line with our study, previous studies have also shown an association between access to media and VAS coverage[11,20,21]. Gebremedhin[23], in twenty-eight SSA countries, also reported that children in the age group 6–11 months had a lower likelihood of VAS. These results warrant further investigation in order to understand the factors leading to the age differential observed in the receipt of VAS.
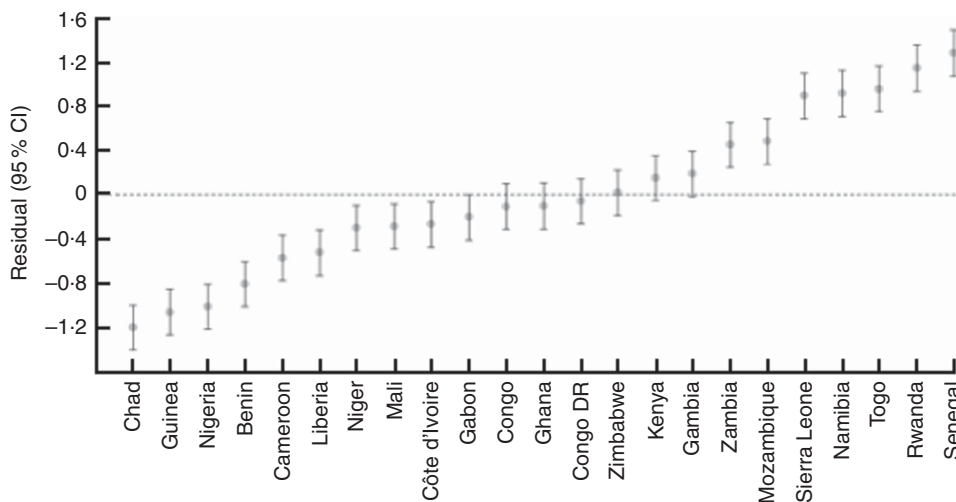
Fig. 1 Simultaneous 95 % CI (vertical bars) for country-level residuals (●) of vitamin A supplementation among children aged 6–59 months (*n* 215 511) in twenty-three sub-Saharan African countries, 2011–2015, using pooled cross-sectional data from Demographic and Health Surveys: Model 0 (null model)
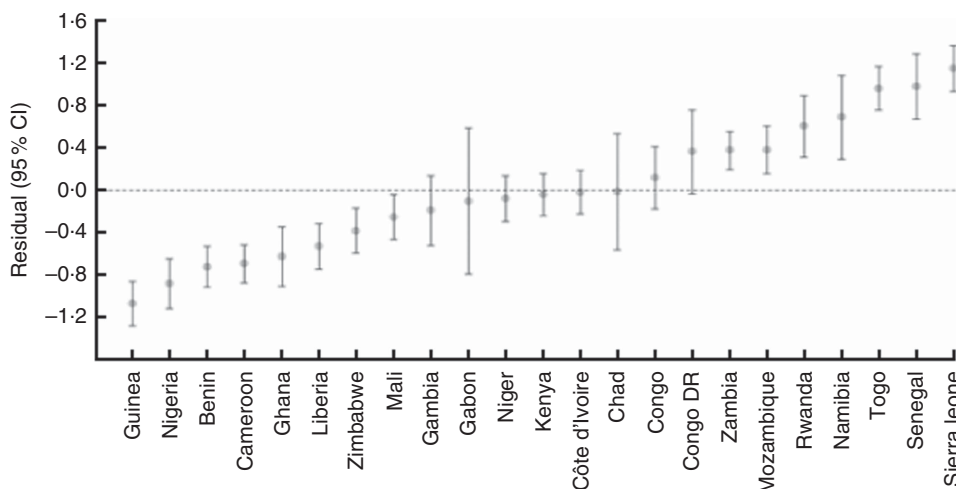

Fig. 2 Simultaneous 95 % CI (vertical bars) for country-level residuals (●) of vitamin A supplementation among children aged 6–59 months (*n* 215 511) in twenty-three sub-Saharan African countries, 2011–2015, using pooled cross-sectional data from Demographic and Health Surveys: Model 1 (controlling for individual-level and contextual country-level factors)

The intra-country correlation coefficients suggest that 9·9 % of the total unexplained variation in VAS is attributable to unobserved country-level factors. Some other variables unaccounted for in the present study might have had an additional effect. Furthermore, after controlling for all study explanatory variables, Sierra Leone had a significantly higher likelihood of VAS than all but three of the other countries. This finding may be attributed to Sierra Leone having a higher proportion of women in the higher risk subgroup of VAS coverage with respect to background characteristics.

Study limitations and strengths
Coverage estimates from the DHS may be affected by the time interval between survey and mass supplementation and in addition, also subject to recall bias; however, estimates from the DHS can help inform improvements in routine coverage monitoring. It is also worth noting that difference in VAS delivery mechanisms between countries not accounted for in the present study might impact coverage. Future studies looking at VAS delivery mechanisms and coverage in SSA will help in enriching the knowledge on VAS in SSA. Futhermore, the cross-sectional nature of the data makes it possible to establish an association between VAS and explanatory variables but cannot establish causality. Although we controlled for potential confounding variables, there may have been confounding by other factors not included in the study. The main study's strength lies in the fact that it is based on data that are nationally representative. In addition, information obtained

Table 3 Multilevel logistic regression analysis for the receipt of vitamin A supplementation among children aged 6–59 months in twenty-three sub-Saharan African countries, 2011–2015, using pooled cross-sectional data from Demographic and Health Surveys

Variable	Model 0			Model 1		
	OR	95 % CI	P value	OR	95 % CI	P value
Fixed effects, constant	2·07	1·56, 2·75	<0·001	1·44	0·70, 2·98	0·327
Maternal age (years)						
20–24 v. 15–19				1·10	1·06, 1·15	<0·001
25–29 v. 15–19				1·20	1·15, 1·26	<0·001
30–34 v. 15–19				1·27	1·21, 1·33	<0·001
≥35 v. 15–19				1·31	1·25, 1·37	<0·001
Maternal educational status						
Primary v. no education				1·43	1·39, 1·47	<0·001
Secondary or above v. no education				1·72	1·67, 1·77	<0·001
Type of place of residence						
Urban v. rural				1·13	1·11, 1·16	<0·001
Maternal occupational status						
Working v. not working				1·29	1·26, 1·32	<0·001
Mass media exposure score						
1–3 v. 0				1·33	1·30, 1·36	<0·001
4–6 v. 0				1·52	1·47, 1·57	<0·001
Sex of household head						
Female v. male				1·03	1·00, 1·05	0·068
Marital status						
Currently in union/living with a man v. never in a union/formerly in a union				1·03	1·00, 1·07	0·076
Sex of child						
Male v. female				1·00	0·98, 1·02	0·930
Age of child (months)						
12–23 v. 6–11				1·63	1·58, 1·69	<0·001
24–35 v. 6–11				1·38	1·34, 1·43	<0·001
36–47 v. 6–11				1·24	1·20, 1·28	<0·001
48–59 v. 6–11				1·15	1·11, 1·19	<0·001
Contextual country factors						
GDP per capita PPP (thousands)				0·95	0·88, 1·03	0·240
Proportion with media exposure score of 0				0·14	0·02, 0·82	0·029
Random effects						
Country-constant, variance		0·486			0·363	
SE		0·143			0·107	

GDP, gross domestic product, PPP, purchasing power parity.

from the study could be used in informing international efforts aimed at increasing VAS in SSA.

Conclusion

The coverage of VAS among children aged 6–59 months based on our data is not optimal and below the recommended minimal coverage level. The study highlighted groups at risk of non-receipt of VAS. Efforts are needed to scale up coverage in this region, mostly focusing on young, low-literate, rural and non-working mothers. It is also important to maximize the utilization of media channels during VAS campaigns.

Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1368980018004056

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