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Determinants of successful vitamin A supplementation coverage among children aged 6–59 months in thirteen sub-Saharan African countries

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Abstract

Objective: Vitamin A supplementation (VAS) for children aged 6–59 months occurs regularly in most sub-Saharan African countries. The present study aimed to explore child, household and delivery platform factors associated with VAS coverage and identify barriers to compliance in thirteen African countries.

Design: We pooled data (n ~60 000) from forty-four household coverage surveys and used bivariate and multivariable regression analyses to assess the effects of supplementation strategy, rural *v.* urban residence, child sex, child age, caregiver education and campaign awareness on child VAS status.

Setting/Subjects: Primary caregivers of children aged 6–59 months in thirteen countries.

Results: Door-to-door distribution resulted in higher VAS coverage than fixed-site plus outreach approaches (91 *v.* 63 %) and was a significant predictor of supplementation in the adjusted model (OR = 19·0; 95 % CI 17·2, 21·1; $P < 0·001$). Having been informed about the campaign was the main predictor of VAS in the door-to-door (OR = 6·8; 95 % CI 5·8, 7·9; $P < 0·001$) and fixed-site plus outreach (OR = 72·5; 95 % CI 66·6, 78·8; $P < 0·001$) groups.

Conclusions: Door-to-door provision of VAS may achieve higher coverage than fixed-site models in the African context. However, the phase-out of door-to-door polio immunization campaigns in most sub-Saharan African countries threatens the main distribution vehicle for VAS. Our findings suggest well-informed communities are key to attaining higher coverage using fixed-site delivery alternatives.

Keywords
Vitamin A
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Vitamin A is important for child health and survival. About one-third of young children globally are affected by vitamin A deficiency[(1)]. The burden of deficiency is highest in low-resource settings where poor-quality diets provide inadequate intakes of vitamin A and high rates of infection and illness perpetuate chronic undernutrition. In 2013, the prevalence of vitamin A deficiency was highest in sub-Saharan Africa (48 %) and has remained stagnant for more than 20 years[(2)]. Further, in 2013, vitamin A deficiency accounted for 2 % of all deaths in children under 5 years of age in the region[(2)].

Semi-annual high-dose vitamin A supplementation (VAS) is recommended by the WHO for children aged 6–59 months in countries where vitamin A deficiency and child mortality are public health problems[(3)]. This guideline is based on evidence showing a substantial reduction in mortality (>20 %) from common childhood infections in supplemented children where coverage is at least 80 %[(4)]. However, global coverage of the recommended twice-yearly dose was ~70 % among targeted children in 2014[(5)]. Two-dose VAS coverage averaged 73 % across countries in sub-Saharan Africa in 2014, ranging from 62 % in the eastern and southern zones to 83 % in the western and central regions[(5)]. National Immunization Days and twice-yearly Child Health Days have been important platforms for reaching children with vitamin A supplements in the African context[(6)]. Both of these strategies are designed to bring health services closer to communities and are especially important for repeatedly missed harder-to-reach groups. National Immunization Days utilize a door-to-door delivery approach for immunizations, VAS and deworming treatment. In contrast, Child Health Days primarily employ a fixed-site model and provide a package of essential child survival services (e.g. VAS, deworming, immunizations,

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mosquito nets, birth registration, child growth monitoring) at health facilities and through 'mop-up' outreach sessions in remote communities[7].

Coverage estimates for child health interventions (e.g. immunizations) generated from administrative tally sheets are prone to data quality concerns arising mainly from inaccurate population estimates of children in the target age group (affecting the denominator used to calculate coverage) and data computation and recording errors[8,9]. To this end, Helen Keller International, an international non-governmental organization, in collaboration with national governments, began conducting post-event coverage (PEC) surveys in 2010 following VAS campaigns in several sub-Saharan African countries. The PEC survey's main objectives are to: (i) collect information on VAS coverage from child caregivers to validate administrative (tally system) coverage data; and (ii) identify barriers to and promoters of compliance across varied geographical contexts. PEC survey results are presented to national and sub-national health authorities and programme partners, and have contributed to improving VAS coverage in the African region in recent years. We utilized data from forty-four PEC surveys conducted in thirteen sub-Saharan African countries between 2010 and 2015 to explore child, household and delivery platform factors associated with VAS coverage. The results from our analyses are intended to improve strategies to increase VAS coverage in the sub-Saharan African region.

Materials and methods

Survey design and study population

Modelled on the WHO immunization coverage survey[10], the PEC surveys utilized a cross-sectional cluster design based on probability-proportional-to-size sampling methodology. In the two-stage sampling scheme, geographic clusters were randomly selected from an available list and households were randomly chosen within each cluster. Cluster units corresponded to census enumeration areas (e.g. villages, wards) and represented the smallest unit for which population data were available. In the majority of surveys, a '30×30' sampling approach was used for a total of ~900 participating households.

Primary caregivers of children eligible for VAS (6–59 months of age) during the most recent campaign were interviewed at the household. Child age determination was based on examination of the child's health card and/or the caregiver's report. Structured survey interviews were conducted in the local language using interviewer-administered questionnaires and were carried out by trained and experienced enumerators and supervisory teams. The survey instrument used in each country included a standard module of questions in line with the objectives of the survey. Response options and other indicators examined varied according to local circumstances and information needs. VAS status was determined by the date of last supplementation recorded in the child's health card or by caregiver recall, if the health card was not available or incomplete. In all thirteen countries, PEC surveys took place within six weeks following VAS campaigns. Requisite approvals for conducting PEC surveys were obtained in each country and informed oral consent was obtained from all survey respondents.

Data collection, management and analysis

The primary outcome measured was the supplementation status of the eligible child (coded as 0 or 1; based on health card or caregiver report). Secondary outcomes examined programmatic aspects of VAS delivery and included supplementation strategy, caregiver awareness and reasons for non-supplementation. Sociodemographic and household characteristics were also collected. Survey data were recorded using two methods. Paper questionnaires were used for surveys conducted from 2010 to 2013. For surveys carried out in 2014 and 2015, data were recorded using a mobile phone platform (EpiSurveyor™). Data from paper questionnaires were double-entered into an Epi Info™ or Excel® database and electronically recorded data were directly exported into Excel for analysis.

Frequencies were calculated to describe characteristics of the survey population. Bivariate analyses and multivariable logistic regression models were used to measure associations between independent variables and VAS status. Two additional regression models were created to examine factors associated with supplementation for each delivery strategy. Model covariates were selected based on a significant ($P < 0{\cdot}05$) bivariate relationship and/or were factors known to be associated with supplementation. The covariates included supplementation strategy (door-to-door or fixed-site plus outreach), rural or urban residence, child sex, child age, caregiver education (none or any; based on self-report) and whether the caregiver had been informed about the VAS campaign. To categorize socio-economic measures (e.g. source of household drinking-water, type of household sanitation facility) as improved or non-improved, standard Demographic and Health Survey[11] definitions were used. Results are expressed as odds ratios with 95 % confidence intervals and a two-sided significance level of 0·05 was used. To account for the disproportionate representation of country survey data, a country-specific population weight adjustment was applied to each survey respondent. Analyses were conducted with the statistical software package IBM SPSS Statistics Version 20.0.

Results

Data from forty-four PEC surveys conducted during 2010–2015 were included in our analysis: six surveys in each of Burkina Faso, Cameroon and Tanzania; five in Guinea; four in Democratic Republic of the Congo (DRC) and Mozambique; three in Niger and Nigeria; two in Kenya and Sierra Leone; and one in Côte d'Ivoire, Mali and

Senegal. Twenty-eight surveys assessed coverage achieved through door-to-door distribution by health workers during national immunization campaigns and sixteen surveys measured coverage attained using fixed-site plus outreach distribution campaigns.

Participant characteristics

Survey samples ranged from ~600 (one survey in Tanzania) to ~7000 (one survey in Niger) respondents, although 60 % of surveys included 800–1000 respondents (Table 1). Samples >1000 represent surveys conducted across multiple administrative units over large areas or the entire country. The majority of survey respondents were mothers (85 %), followed by grandparents (6 %) and fathers (4 %). Approximately 50 % of respondents had some formal schooling, although considerable variation existed across countries (Kenya: 89 %; DRC: 86 %; Tanzania: 83 %; Nigeria: 74 %; Mozambique: 68 %; Senegal: 64 %; Côte d'Ivoire: 51 %; Burkina Faso: 41 %; Sierra Leone: 36 %; Guinea: 35 %; Niger: 30 %; Mali: 24 %). No data on schooling were collected in Cameroon. Income data were not collected in any of the surveys; however, ~70 % of households were located in rural areas (data from twelve countries; no data for Senegal) and the majority of respondents were considered low-income populations based on surrogate indicators of socio-economic status, including source of drinking-water (38 % improved, 62 % non-improved; no data for Cameroon, DRC, Senegal, Sierra Leone), type of toilet (15 % improved, 85 % non-improved; no data for Cameroon, DRC, Guinea, Senegal, Sierra Leone) and asset ownership (phone: 70 %; radio: 60 %; television: 37 %; no data for Côte d'Ivoire, Senegal, Sierra Leone). Less than 1 % of surveyed

Table 1 Scope, distribution strategy and coverage estimates for all post-event coverage (PEC) surveys in thirteen sub-Saharan African countries, 2010–2015

Country	Survey month/year	Scope	Distribution strategy	No. of respondents	PEC coverage (%)
Burkina Faso	November 2011	1 region	door-to-door	900	93·7
	May 2012	1 region	door-to-door	899	90·5
	November 2012	2 regions	door-to-door	1800	90·6
	May 2013	1 region	door-to-door	900	97·4
	November 2013	1 region	door-to-door	900	87·2
	May 2014	2 regions	door-to-door	1799	94·7
Cameroon	November 2011	1 region	door-to-door	899	52·9
	May 2012	1 region	door-to-door	903	71·5
	November 2012	1 region	door-to-door	900	71·1
	May 2013	1 region	door-to-door	888	71·4
	November 2013	1 region	door-to-door	900	79·8
	November 2014	2 regions	door-to-door	1796	90·5
Côte d'Ivoire	May 2012	national	door-to-door	2209	90·8
DRC	November 2010	national	door-to-door	2336	94·0
	November 2012	1 district	door-to-door	909	84·8
	November 2013	1 district	door-to-door	914	75·6
	November 2014	1 district	fixed + outreach	898	91·1
Guinea	November 2011	1 district	door-to-door	1037	85·3
	May 2012	1 district	door-to-door	885	91·3
	November 2012	1 district	door-to-door	883	94·1
	May 2013	2 districts	door-to-door	1793	91·2
	November 2013	1 district	door-to-door	989	81·1
Kenya	May 2012	1 district	fixed + outreach	886	30·9
	May 2013	1 district	fixed + outreach	889	58·3
Mali	November 2014	1 district	door-to-door	900	97·4
Mozambique	November 2010	1 district	fixed + outreach	1107	77·5
	November 2012	1 district	fixed + outreach	1145	54·7
	May 2013	1 district	fixed + outreach	985	85·3
	May 2014	1 district	fixed + outreach	900	81·7
Niger	November 2011	national	door-to-door	7038	92·5
	November 2012	3 districts	door-to-door	2620	93·5
	May 2014	1 district	door-to-door	899	81·9
Nigeria	November 2013	2 states	fixed + outreach	1775	47·8
	May 2014	1 state	fixed + outreach	896	56·6
	May 2015	2 states	fixed + outreach	1778	55·0
Senegal	November 2013	1 district	door-to-door	900	89·7
Sierra Leone	May 2012	national	door-to-door	4395	96·7
	November 2012	national	door-to-door	5910	91·6
Tanzania	May 2010	2 districts	fixed + outreach	2239	70·6
	May 2012	2 districts	fixed + outreach	1776	85·4
	November 2012	1 district	fixed + outreach	892	65·7
	November 2013	1 district	fixed + outreach	879	36·1
	May 2014	1 district	fixed + outreach	623	34·3
	May 2015	1 district	fixed + outreach	898	53·5

DRC, Democratic Republic of the Congo.

households had electricity (no data for Cameroon, DRC, Guinea, Senegal, Sierra Leone).

Vitamin A supplementation coverage

PEC survey coverage estimates ranged from 31 % in Kenya to 97 % in Mali and exceeded 80 % in 27/44 (60 %) surveys (Table 1). In the bivariate analysis, supplementation strategy, area type (rural or urban residence), child age group, caregiver education and caregiver awareness of the campaign were independently associated with VAS. Large differences in coverage were observed between delivery strategies (91 % door-to-door *v.* 63 % fixed-site plus outreach) and between caregivers who were informed and not informed prior to the campaign (94 *v.* 22 %; Table 2). In the adjusted model, VAS was more likely among children supplemented through the door-to-door distribution strategy (OR = 19·0; 95 % CI 17·2, 21·1; $P < 0·001$) and among children of caregivers who had previously been informed about the campaign (OR = 47·2; 95 % CI 43·9, 50·7; $P < 0·001$; Table 3). As child gender did not add significantly to the prediction of VAS, it was not included in the final model.

In the analysis by delivery model, caregiver education and campaign awareness were predictive of VAS in children targeted through a door-to-door strategy (Table 4). In the fixed-site plus outreach group, caregiver education, campaign awareness and area type were significantly associated with VAS (Table 4). Prior caregiver awareness of the campaign was the strongest predictor of VAS in both delivery models. Caregivers with some formal schooling were more likely to have their children supplemented in the fixed-site plus outreach group, whereas VAS was less likely among children of caregivers with some formal schooling in areas targeted through door-to-door distribution.

Various modes of communication were used to raise community awareness about VAS campaigns, depending on the country context. Among caregivers who had heard about the recent campaign, the main communication channels were community health workers (24 %), community broadcasts using vehicle loudspeakers (21 %), health facility personnel (19 %) and radio messages (16 %).

Table 2 Bivariate associations* between predictor variables and vitamin A supplementation (VAS) among children aged 6–59 months in thirteen sub-Saharan African countries, 2010–2015

	Received VAS		
	n	%	*P* value
Strategy			
Door-to-door	18 988	91·4	<0·001
Fixed-site + outreach	34 320	62·8	
Area type			
Rural	29 366	72·5	<0·001
Urban	11 275	70·3	
Child sex			
Female	26 224	71·0	0·075
Male	27 065	70·4	
Child age group			
6–11 months	8099	71·4	0·005
12–60 months	44 013	70·1	
Caregiver education			
None	12 224	73·3	<0·001
Any	25 241	67·6	
Campaign awareness			
Yes	45 770	94·1	<0·001
No	3579	21·6	

*Chi-square analysis.

Table 3 Predictors in regression model* of vitamin A supplementation (VAS) among children aged 6–59 months in thirteen sub-Saharan African countries, 2010–2015

	Unadjusted OR	95 % CI	Adjusted OR	95 % CI
Door-to-door strategy	6·32	6·00, 6·65	19·01	17·17, 21·05
Rural residence	1·12	1·07, 1·16	0·94	0·88, 1·01
Child age	1·00	0·99, 1·00	1·00	0·99, 1·00
Caregiver education	0·76	0·73, 0·79	0·98	0·91, 1·06
Aware of VAS campaign	57·74	54·77, 60·86	47·20	43·92, 50·73

*Reference groups for categorical variables: fixed-site plus outreach, urban residence, no education, not aware of campaign. Age included as a continuous variable in the model.

Table 4 Predictors in regression model* for door-to-door and fixed-site plus outreach strategy of vitamin A supplementation (VAS) among children aged 6–59 months in thirteen sub-Saharan African countries, 2010–2015

	Door-to-door				Fixed-site plus outreach			
	Unadjusted OR	95 % CI	Adjusted OR	95 % CI	Unadjusted OR	95 % CI	Adjusted OR	95 % CI
Rural residence	1·06	0·95, 1·17	0·97	0·82, 1·15	1·22	1·16, 1·27	0·91	0·83, 0·99
Child age	1·01	1·00, 1·01	1·01	1·00, 1·01	0·99	0·99, 0·99	0·99	0·99, 1·00
Caregiver education	1·15	1·01, 1·31	0·73	0·62, 0·86	1·05	1·00, 1·10	1·20	1·09, 1·31
Aware of VAS campaign	5·85	5·22, 6·56	6·78	5·80, 7·94	193·92	179·11, 209·97	72·46	66·60, 78·83

*Reference groups for categorical variables: urban residence, no education, not aware of campaign.

A large percentage of respondents reported receiving information about VAS campaigns from community health workers in Burkina Faso (55 %) and Sierra Leone (45 %) and from health facility workers in Guinea (44 %) and Kenya (34 %). Community leaders were important communication agents in Tanzania (46 %) and Mozambique (38 %) and community broadcasts were key information sources in Nigeria (43 %) and Sierra Leone (34 %).

Reasons for non-supplementation

The main reasons for non-supplementation of eligible children reported by caregivers across the countries were a lack of awareness about the campaign (40 %), target children or caregivers being away from their residence at the time of VAS distribution (20 %) and health workers not coming to the community to provide supplements or not distributing them to eligible children (14 %). Demand-related factors affecting caregiver willingness and/or ability to have the child supplemented (e.g. lack of time, long distance to supplementation site, long waiting time, family refusal) were reported by <5 % of total respondents.

Discussion

In the present multi-country study, we estimated VAS coverage of children aged 6–59 months and identified factors that promoted or limited supplement uptake in various geographic contexts. Although VAS coverage varied widely across the forty-four surveys, coverage exceeded 80 % in >60 % of the surveys. Door-to-door distribution resulted in 30 % higher coverage than the fixed-site plus outreach delivery model, for which 75 % of surveys estimated coverage below 80 %. This can be explained by the fact that in the fixed-site plus outreach model caregivers first need to be aware of the campaign and then make the appropriate arrangements to attend the closest health facility or outreach site with their eligible children, whereas the door-to-door delivery model places the effort on health personnel and requires only that caregivers and children are present at the time of distribution.

Interestingly, supplementation was more likely among children of caregivers with some formal schooling in the fixed-site strategy and among those with no formal schooling in the door-to-door model. This suggests caregiver education may not be a major contributor to coverage in areas where health workers provide supplements directly at the household, but may be more important for programmes that require active participation in a community health event. Although few data exist for VAS[12], maternal education has been shown to be an important determinant of childhood immunization coverage[13,14]. In a meta-analysis involving data from ninety-six low- and middle-income countries, Bosch-Capblanch *et al.*[15] showed low caregiver educational status was a major barrier to childhood vaccination. This is thought to be due to little or no education being an obstacle to accessing and understanding information about the importance of health services and because low health service utilization tends to be rooted in the poorer living conditions of uneducated populations[15]. No gender bias in supplementation was observed in our analysis. This finding is encouraging and consistent with results of recent Demographic and Health Surveys conducted in Burkina Faso[16], Côte d'Ivoire[17], DRC[18], Guinea[19], Kenya[20], Mali[21], Mozambique[22], Niger[23], Nigeria[24], Sierra Leone[25] and Tanzania[26] that indicate no significant gender differences in VAS status in these countries.

Although a significant contributor to coverage in both delivery strategies, caregivers being informed prior to campaigns was a much stronger predictor of VAS in the fixed-site plus outreach group. This suggests prior awareness about VAS campaigns may be less essential in a household distribution context. The high level of respondent awareness (99 %) about VAS campaigns and the >90 % coverage achieved in the two surveys conducted in Sierra Leone support the importance of effective awareness-raising in target communities. Further, the very low coverage achieved in Kenya, based on two surveys conducted in 2012 and 2013, highlights the negative consequences of programming in under-informed communities. In a 2012 study, Kamau *et al.*[27] attributed low (~50 %) VAS coverage in Kenya to a lack of knowledge among health workers and mothers of eligible children. Interestingly, >90 % of informed respondents in the study expressed positive attitudes towards VAS and reported no challenges or obstacles in obtaining supplements for their children.

Reasons for non-supplementation did not vary much across countries or by overall VAS coverage. The fact that supply-driven barriers to compliance (lack of awareness, no distribution) outweighed constraints on women's ability to bring their children to a fixed site (family refusal, too busy, long distance, long waiting time) was unexpected. This indicates a rather high level of community acceptance for VAS and suggests higher coverage can be achieved with effective distribution in well-informed communities. The fact that community health workers were key sources of information about VAS campaigns in several countries was not surprising as this cadre of health personnel has been shown to be effective in improving maternal and child health in many countries through their role in informing and mobilizing communities for health promotion[28–30]. Health facility staff and radio messages were also important communication channels for VAS campaigns and, therefore, should be utilized more effectively to sensitize populations about the importance of vitamin A supplements for young children and for broader nutrition messaging. Posters often constitute large proportions of programme budgets for VAS and other services. As so few respondents reported posters as key sources of information in our study, we recommend this not be considered a priority strategy in efforts to sensitize local communities.

The present study provides a regional analysis of the proportion of children who received VAS in recent years. Consistent sampling methodology was used to select enumeration areas and households in each country and standardized survey instruments were used for data collection. A limitation of our study was the unequal representation of country survey data. However, as the study was not designed to detect differences in primary or secondary outcomes between countries, we do not believe this negatively affected the validity of our findings. Further, a weighting scheme accounted for the proportional differences. As data were collected using both a paper questionnaire and a mobile phone platform, the frequency of recording errors may have differed between the two-step manual and one-step electronic method that combined the data recording and data entry processes. In addition, surveys did not decipher whether the child's VAS status was determined based on the child's health card or caregiver's report. Although both methods are prone to inaccuracy due to errors in completeness and recall, respectively, conducting the surveys soon after supplementation campaigns reduced the potential for recall bias. Finally, we did not examine wealth indices and birth order which are known to be associated with utilization of child health services in low-resource settings(31,32). Although vitamin A supplements are offered at no cost in national government programmes, household wealth may influence access in terms of indirect opportunity costs related to time and transport to the distribution site, albeit not reported as major barriers to VAS in our study. Lastly, while we identified predictors of VAS in this regional context, the cross-sectional nature of descriptive surveys precludes causal inferences between examined variables.

Conclusion

PEC surveys are important considering the challenges in estimating VAS coverage using routine health facility monitoring systems. The present study contributes to the understanding of factors associated with VAS receipt in the sub-Saharan African region. The fact that coverage exceeded 80 % in most surveys included in our analysis is a favourable result. However, as these estimates do not account for local disparities that may exist due to geographic, ecological, social, ethnic and other divisions, such intra-country variation should be investigated with concerted efforts made to improve coverage in underperforming areas. Best practices and key success factors from high-performing areas should be leveraged for programme improvements.

VAS is integral to the prevention of child mortality associated with a high prevalence of vitamin A deficiency. Achieving and maintaining high twice-yearly coverage for all children under 5 years of age is a challenging task in resource-poor settings. The fact that large numbers of children are still being missed, despite longstanding VAS programmes in most countries, is a call to action. For two decades, provision of vitamin A supplements to young children has piggybacked on national immunization campaigns. However, with the fast-approaching expected eradication of polio(33), the backbone of these campaigns, this is becoming a less viable option for vitamin A delivery in sub-Saharan Africa. In parallel, semi-annual Child Health Days have scaled up in recent years and have consistently exhibited high coverage using a door-to-door approach. However, when conducted as fixed-site plus outreach campaigns, coverage has been far below 80 %. The transition from door-to-door to sustainable and cost-effective fixed-site delivery alternatives is, therefore, paramount. In sub-Saharan Africa, improving coverage of Child Health Days using fixed sites will enable delivery of a package of child survival interventions, while strengthening local health systems and promoting population demand for essential services. Building evidence on effective facility-based delivery modes is urgently needed to ensure vitamin A supplements continue to be provided to children in the African context.

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References

1. UNICEF (2016) *Vitamin A Supplementation: A Statistical Snapshot*. New York: UNICEF.
2. Stevens GA, Bennett JE, Hennocq Q *et al.* (2015) Trends and mortality effects of vitamin A deficiency in children in 138 low-income and middle-income countries between 1991 and 2013: a pooled analysis of population-based surveys. *Lancet Glob Health* **3**, e528–e536.

3. World Health Organization (2011) *Guideline: Vitamin A Supplementation in Infants and Children 6–59 Months of Age*. Geneva: WHO.
4. Imdad A, Herzer K, Mayo-Wilson E *et al*. (2010) Vitamin A supplementation for preventing morbidity and mortality in children from 6 months to 5 years of age. *Cochrane Database Syst Rev* issue 12, CD008524.
5. UNICEF (2016) Vitamin A deficiency: current status and progress. http://data.unicef.org/nutrition/vitamin-a.html (accessed June 2016).
6. UNICEF (2007) *Vitamin A Supplementation: A Decade of Progress*. New York: UNICEF.
7. Oliphant NP, Mason JB, Doherty T *et al*. (2010) The contribution of child health days to improving coverage of periodic interventions in six African countries. *Food Nutr Bull* **31**, 3 Suppl., S248–S263.
8. Murray CJ, Shengelia B, Gupta N *et al*. (2003) Validity of reported vaccination coverage in 45 countries. *Lancet* **362**, 1022–1027.
9. Dhillon CN, Subramaniam H, Mulokozi G *et al*. (2013) Overestimation of vitamin A supplementation coverage from district tally sheets demonstrates importance of population-based surveys for program improvement: lessons from Tanzania. *PLoS One* **8**, e58629.
10. World Health Organization (2005) *Immunization Coverage Cluster Survey – Reference Manual*. Geneva: WHO.
11. The DHS Program (2015) Demographic Health Survey (DHS) model household questionnaire. http://dhsprogram.com/publications/publication-dhsq7-dhs-questionnaires-and-manuals.cfm (accessed June 2016).
12. Ayoya MA, Bendech MA, Baker SK *et al*. (2007) Determinants of high vitamin A supplementation coverage among pre-school children in Mali: the National Nutrition Weeks experience. *Public Health Nutr* **10**, 1241–1246.
13. Etana B & Deressa W (2012) Factors associated with complete immunization coverage in children aged 12–23 months in Ambo Woreda, Central Ethiopia. *BMC Public Health* **12**, 566.
14. Maina LC, Karanja S & Kombich J (2013) Immunization coverage and its determinants among children aged 12–23 months in a peri-urban area of Kenya. *Pan Afr Med J* **14**, 3.
15. Bosch-Capblanch X, Banerjee K & Burton A (2012) Unvaccinated children in years of increasing coverage: how many and who are they? Evidence from 96 low- and middle-income countries. *Trop Med Int Health* **17**, 697–710.
16. Institut National de la Statistique et de la Démographie, Ministère de l'Économie et des Finances & ICF International (2012) *Burkina Faso Demographic and Health Survey*. Ouagadougou and Calverton, MD: INSD, Ministère de l'Économie et des Finances and ICF International.
17. Ministère de la Santé et de la Lutte contre le Sida, Institut National de la Statistique, Ministère d'État et Ministère du Plan et du Développement *et al*. (2013) *Côte d'Ivoire Demographic and Health Survey*. Abidjan and Calverton, MD: MSLS, INS, MEMPD and ICF International.
18. Centre National de la Statistique et des Études Économiques & ICF International (2012) *Congo Demographic and Health Survey*. Brazzaville and Calverton, MD: CNSEE and ICF International.
19. Institut National de la Statistique, Ministère du Plan & ICF International (2013) *Guinea Demographic and Health Survey*. Conakry and Calverton, MD: INS, Ministère du Plan and ICF International.
20. National Bureau of Statistics, Ministry of Health, National AIDS Control Council *et al*. (2015) *Kenya Demographic and Health Survey*. Nairobi and Rockville, MD: NBS, Ministry of Health, National AIDS Control Council, Kenya Medical Research Institute, National Council for Population and Development and ICF International.
21. Cellule de Planification et de Statistiques, Institut National de la Statistique, Centre d'Études et d'Information Statistiques *et al*. (2014) *Mali Demographic and Health Survey*. Bamako and Rockville, MD: CPS/SSDSPF, INSTAT, INFO-STAT and ICF International.
22. Instituto Nacional de Estatística, Ministério da Saúde & ICF International (2013) *Mozambique Demographic and Health Survey*. Maputo and Calverton, MD: INE, Ministério da Saúde and ICF International.
23. Institut National de la Statistique, Ministère de l'Économie et des Finances & ICF International (2013) *Niger Demographic and Health Survey*. Niamey and Rockville, MD: Institut National de la Statistique, Ministère de l'Économie et des Finances and ICF International.
24. National Population Commission, Federal Republic of Nigeria & ICF International (2014) *Nigeria Demographic and Health Survey*. Abuja and Rockville, MD: NPC and ICF International.
25. Statistics Sierra Leone, Ministry of Health and Sanitation & ICF International (2014) *Sierra Leone Demographic and Health Survey*. Freetown and Rockville, MD: SSL, Ministry of Health and Sanitation and ICF International.
26. National Bureau of Statistics & ICF Macro (2011) *Tanzania Demographic and Health Survey*. Dar es Salaam and Calverton, MD: NBS and ICF Macro.
27. Kamau MW, Makokha AO, Mutai JK *et al*. (2012) Factors influencing vitamin A supplementation among mothers of children under five years old at Mbagathi District Hospital, Kenya. *East Afr Med J* **89**, 134–141.
28. Perez F, Ba H, Dastagire SG *et al*. (2009) The role of community health workers in improving child health programmes in Mali. *BMC Int Health Hum Rights* **9**, 28.
29. Gilmore B & McAuliffe E (2013) Effectiveness of community health workers delivering preventive interventions for maternal and child health in low- and middle-income countries: a systematic review. *BMC Public Health* **13**, 847.
30. Lewin S, Munabi-Babigumira S, Glenton C *et al*. (2010) Lay health workers in primary and community health care for maternal and child health and the management of infectious diseases. *Cochrane Database Syst Rev* issue 3, CD004015.
31. Agrawal S & Agrawal P (2013) Vitamin A supplementation among children in India: does their socioeconomic status and the economic and social development status of their state of residence make a difference? *Int J Med Public Health* **3**, 48–54.
32. Mukungwa T (2015) Factors associated with full immunization coverage amongst children aged 12–23 months in Zimbabwe. *Afr Popul Stud* **29**, 2.
33. Global Polio Eradication Initiative (2017) Polio eradication and endgame timeline. http://www.polioeradication.org/ (accessed May 2017).