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PREVALENCE AND PREDICTORS OF VITAMIN A DEFICIENCY AMONG INFANTS IN WESTERN KENYA USING A CROSS-SECTIONAL ANALYSIS

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ABSTRACT

Vitamin A (VA) deficiency (VAD) is a major nutritional public health problem among children under-5-years-old in the developing world including Kenya. A community-based cross-sectional survey among 1,630 children (aged 6-23 mos) was undertaken in Western Kenya. A questionnaire was administered to collect demographic, socio-economic and dietary intake information. Prevalence of low retinol-binding protein (RBP) concentrations was assessed using Dried Blood Spot (DBS) methodology. Analysis of RBP was carried out using rapid enzyme immunoassay (EIA) and C-reactive protein (CRP) was carried out using enzyme linked immunosorbent assay (ELISA) to estimate VA and sub-clinical inflammation statuses, respectively. Values were adjusted for influence of inflammation using CRP (CRP >5 mg/L) and population prevalence of VAD (RBP <0.825 µmol/L, biologically equivalent to 0.70 µmol/L retinol) estimated. Anthropometric data gave three indices: stunting, wasting and underweight—all of which took age and sex into consideration. Mean (geometric± SD) concentration of RBP was adequate (1.56±0.79µmol/L) but the inflammation-adjusted mean (±SE) prevalence of VAD was high (20.1±1.1%) in this population. The level of CRP was within normal range (1.06±4.95 *mg/L)* whilst 18.4±0.9% of the children had subclinical inflammation (CRP>5 *mg/L*). Intake of VA capsule (VAC) by a child was a predictor of VAD with children who have not taken VA during the past 1 year prior to the survey having a 30% increased risk of VAD (OR (CI): 1.3 (1.1-1.7); *p*=0.025. Additionally, age of the child was a predictor with older children (18-23 mos) having a 30 % increased risk of VAD (OR (CI): 1.3 (1.1-1.9); *p*=0.035); the caretaker's knowledge on VA and nutrition was also a predictor of VAD with children whose caretaker's had poor knowledge having a 40 % increased risk of VAD (OR (CI): 1.4 (1.0-1.9); *p*=0.027. A child's district of residence was also a significant predictor of VAD. Prevalence of VAD in this sample of infants was high. Predictors of VAD included child intake of VAC in the last 1 year before the survey, older children, children whose caretakers had poor VA and nutritional knowledge and a child's district of residence. There is a need to improve knowledge on nutrition and VA of caretakers; undertake a targeted VAC distribution, particularly in children older than 1 year and above and use a sustainable food-based intervention in the areas with severe VAD.

Key words: Vitamin A deficiency, prevalence, inflammation, infants, predictors, Western, Kenya

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INTRODUCTION

In Africa, 2.5 million preschool age children are estimated to suffer from night blindness and 56.4 million have subclinical vitamin A deficiency (VAD), which is indicated as serum retinol concentration less than 0.70 μmol/L, reflecting a severe public health problem [1]. Associated disorders of VAD remain common in Africa despite knowledge of its consequences and interventions undertaken [2]. Infants have increased vitamin A (VA) requirements to support rapid growth and combat infections. Severe VAD at this age can cause visual impairments, anaemia and weakened immunity, with an increased risk of morbidity and mortality from measles or diarrhoea [1]. Losses of 121,000 Disability Adjusted Life Years (DALYs) annually in Kenya is attributable to VAD, which amounts to loss of between 0.5 and 1 percent of gross national product [3]. The Western province of Kenya has the lowest national VA supplementation (VAS) coverage (19.8%), contrasting with national averages of 30.3% and 73% in sub-Saharan Africa and also ranks second in under five mortality (121/1,000 live births) [3,4].

Occurrence of VAD tends to cluster rather than be evenly distributed. Epidemiologic traits or risks that characterize situations where it occurs include economic, social, ecological, and host-related factors [5]. A good understanding of these situations is important for appropriate and effective interventions. Western Kenya lacks data on VAD prevalence among children 6-23 months but it is likely important because the neighbouring province, Nyanza, has VAD of about 23% among children aged 6-59 months [6]. In the measurement of VA status, subjects with infections need to be identified because Retinol Binding Protein (RBP) levels are lowered by infection [7]. Participants in the study with raised Creatine-reactive protein (CRP) should be excluded from evaluation or values adjusted, otherwise the results for VA markers could give a false-high rate of VAD [8].

Onset of growth faltering such as stunting in infants is commensurate with inappropriate complementary feeding, that may be compounded by maternal undernutrition and intrauterine growth retardation, where the first 24 months represent a window of opportunity for intervention [9]. In some African countries such as Mauritania, Ghana and Ethiopia there is some reduction in stunting, although further reduction is unlikely to occur in the future if recent trends continue [10]. Important to this study is the target population of children aged 6-23 months, who are within the critical window where linear growth responds most to environmentally modifiable factors related to feeding, infections and psychosocial care [9, 11]. In western Kenya, 34.2% of children under five are stunted compared to the national figure of 35.3% meaning an alarming situation as per the WHO classification [3, 12]. Addressing stunting through integrated packages of nutrition-specific and nutrition-sensitive actions that focus on the first 1,000 days is one of WHO's global targets, endorsed by the 65th World Health Assembly, as part of the post-2015 sustainable development agenda [12]. Vitamin A deficiency begins by the body depleting its stores of VA as a result of various causes, which progresses to sub-clinical and then clinical signs which in some cases lead to death. It is, therefore, important to identify the correct VAD status and identify potentially important predictors/risk factors so that the progression of VAD is controlled or halted. The objective of this study was, therefore, to determine the prevalence of vitamin A deficiency, malnutrition (wasting, stunting, and underweight) sub-clinical infection

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and identify risk/predictor factors associated with VAD among children 6-23 months in selected study sites of Western Kenya.

METHODOLOGY

Study design and sampling

This was a community-based, cross-sectional survey within catchment areas served by health facilities offering ante-natal care services in Busia and Bungoma Counties. The sampling frame constituted all villages of the catchment area of the health facilities with the number of households/village, as per the Census of *2009* (average of 113 households/village). Cluster sampling design was used where clusters were selected using "probability proportionate-to-size" based on the list of villages covered by the health facilities [13]. A total of 104 sample points were identified. A household was defined as a person or a group of persons, related or unrelated, who live together and who share a common source of food [3].

Research setting

This study was done in Busia and Bungoma counties, specifically in the sub-counties of Bunyala, Kimilili, Bungoma North and Bungoma East. Economic activity in Busia is mainly trade with neighbouring Uganda, particularly in Busia town. Away from town, the county's economy is reliant on fishing and agriculture, with cassava, millet, sweet potatoes, beans, and maize being the principal food crops [14]. Sugarcane-growing is important in Bungoma, with one of the country's largest sugar factories and numerous smallholder sugar mills. Subsistence crops include maize, pearl millet and sorghum. Dairy and poultry farming is widely practiced. Due to high rainfall experienced in the area throughout the year, Bungoma has several large rivers, which are used for small-scale irrigation [15].

Study Population

All sampled children aged 6-23 months and their caretakers.

Data collected

Demographic and socio-economic information

Demographic and socio-economic information about caretakers, household and index child was collected using a questionnaire.

Consumption of VA-rich foods during past 7 days

The Helen Keller International (HKI) food frequency method was used to assess the community risk of VAD [16]. The HKI food table was adjusted to fit the local requirement/conditions and total number of foods included was recorded. A community is considered to have a VAD problem if: the mean frequency of consumption of animal sources of VA is 4 days/week or less; or the mean frequency of total consumption of animal and plant sources of VA (weighted by the food sources) is 6 days/week or less.

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Child nutritional status

Anthropometric measurements for the children were performed to determine weight-for-length, length-for-age and weight-for-age z-scores. Weights were obtained using a SECA® electronic UNISCALE. Length measurements were carried out using a Schorr® measuring board. All children were measured recumbent on the board. Definitions of nutritional status were: *stunted:* height for age z-score <–2 SD, *wasted:* weight for height z-score <–2 SD of the WHO Child Growth Standards median and *underweight* a composite indicator for both stunting and wasting.

Blood sample collection using dried blood spots

Capillary blood for dried blood spot (DBS) collection was obtained from randomly selected target children by trained laboratory technicians using single-use sterile micro-lancets. The child's hand was first warmed followed by finger cleaning using 70% alcohol and piercing with the lancet. The first drop of blood was wiped with sterile gauze and subsequent drops were spotted five times on a filter paper labeled with the participant's identification number. The filter papers were dried two to three hours in closed airtight plastic boxes and covered with black paper to prevent any potential photo-oxidation of the sample. Dried filter papers were placed in zipper-locked polythene bags along with silica gel and sent to the laboratory to be stored in deep freezers at KEMRI (< –20°C) until analysis.

Selection of samples

Dried blood spots were obtained from 1,482 respondents. The samples were analyzed in singletons, with approximately 10% analyzed in duplicates. All analyses were carried out at KEMRI/CDC Malaria Laboratory in Kisian, Kenya. The DBS samples were selected using systematic sampling and analyzed for RBP as indicator of VA status, and CRP as indicator of sub-clinical inflammation. Validation of DBS as a matrix using 60 matching serum-DBS samples was carried out and the relationship between serum and DBS, RBP and CRP was used to obtain factors to correct DBS, RBP and CRP values to serum RBP and CRP values, respectively.

Analysis of samples for retinol binding protein

Analysis of RBP, an indicator of VA status, was carried out using rapid enzyme immunoassay technique [17]. This was quantified with the use of the SCANLISA RBP Assay (Scimedx Corporation). The inter-assay and intra-assay CV of the assay were <10%. Definition of VA status was serum RBP concentration <0.825 µmol/L (biologically equivalent to <0.70 µmol/L retinol) [18].

Analysis of samples for Creatine reactive protein

Creatine reactive protein is the most commonly used sensitive acute phase protein for monitoring infection and inflammation, particularly in assessing bacterial and connective tissue diseases [19-20]. Enzyme-linked immune-sorbent assay (ELISA) kit (Immuno-Biological Laboratories, Inc., Cat. No.: IB59126) with a high sensitivity CRP was used to quantify CRP. The intra- and inter-assay CV were <10%. The threshold for defining inflammation was CRP>5mg/L.

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Ethical Considerations

Authority to conduct this study was obtained from Maseno University and permission from local administrative officers in the four sub-counties was granted. Blood data were analyzed for groups and no individual response was identifiable. Verbal consent and assent for children was obtained from respondents prior to participation. The study was granted approval for implementation by both national as well as Program for Appropriate Technology in Health (PATH)'s Ethical Review Board (ERB).

Statistical analysis

Data were analyzed using the Statistical Package for Social Sciences statistical software package version 19.0 for Windows (SPSS Inc., Chicago IL, USA). Normal distribution of quantitative data was tested using normal distribution curve. Two-sample proportion z-test was used for child characteristics (age & gender), point prevalence of VAD between sub-counties, and nutritional status of children (stunted & wasted). Pearson's χ^2 test was used to compare knowledge scores of caretakers by individual and household characteristic and determine predictors for VAD in the multivariate analysis. First, a bivariate analysis was carried out to identify potential predictors for the main study outcome. The criteria for selection of potential predictors was to eliminate variables whose risk estimate based on odds crude ratio were insignificant ($p>0.05$). A multivariate logistic regression analysis was then used to test the association between potential predictors. The level of significance was set at p-value < 0.05.

RESULTS

Demographic and socioeconomic characteristics of caretakers and children 6-23 months

Characteristics of child caretakers in the study

Mean age (years) of caretakers was 30 in Bungoma North, Bungoma East and Bunyala while in Kimilili it was 28. Average household size across the four sub-counties was 6 persons. Caretakers in formal schooling during the survey were highest in Kimilili (4%) and lowest in Bunyala (2%). Uneducated caretakers were highest in Bunyala (8%) and lowest in Kimilili (1%). More caretakers in Kimilili (27%) had education higher than primary-school level compared to those in Bunyala (15%), which had the lowest. Average years of formal education were highest for caretakers in Kimilili (8.2 years) and lowest in Bunyala (6.8 years). Majority of the caretakers were in monogamous marriages ranging from 67% in Bunyala to 81% in Bungoma North. Agriculture as a principle activity by caretakers was mainly practiced in Bungoma East (87%) while Bunyala sub-county had the least of the same (78%) (Table 1).

Characteristics of children in the study

The mean age of children across the four sub-counties was 14 months. Proportionately, age groups of children 6-11, 12-17 and 18-23 months were comparable and further analysis revealed that there were no significant differences among the age groups in the sub-counties. The proportion of males (53%) in the study sample was marginally higher than that of the females (47%), but this difference was not significant compared between sub-counties (Table 2).

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Prevalence of vitamin A deficiency and malnutrition among a sample of infants in Western Kenya

Prevalence of vitamin A deficiency and Creatine-reactive protein

Overall VAD in the study area was 20.1% while the elevated CRP was 18.1% (Fig. 1).

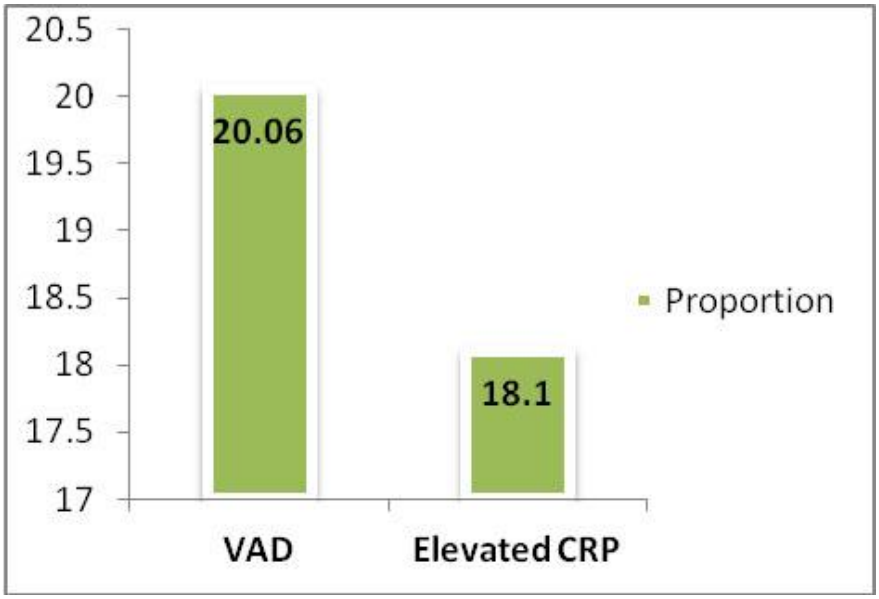

Figure 1: Distribution of children by overall VAD and CRP prevalence

Distribution of children by point prevalence of VAD and CRP across sub-counties

The prevalence of VAD was highest in Bunyala (30.3%, n=120), followed by Bungoma North (20.7%, n=924), Kimilili (17.8%, n=325), and Bungoma East (10.3%, n=113). Comparison of these prevalence, revealed that Bungoma North was significantly higher than Bungoma East (z=2.63, CI=0.03-0.18, p=0.001), while Bunyala was significantly higher than Bungoma North (z=2.40, CI=0.02-0.17, p=0.017), Bungoma East (z=3.77, CI=0.01-3.04, p=0.002) and Kimilili (z=2.86, CI=0.04-0.2, p=0.004). Bunyala had the highest (29.0%) prevalence of sub-clinical inflammation as indicated by elevated CRP (>5 *mg/L*) with Bungoma North having the least prevalence (15.3%) (Table3). Comparison of sub-clinical inflammation prevalence revealed that Bungoma East had significantly higher prevalence of sub-clinical inflammation compared to Bungoma North (z=1.96, CI=0.00-0.09, p=0.005), while Bunyala had significantly higher prevalence of sub-clinical inflammation compared to Bungoma North (z=3.77, CI=0.066-0.21, p=0.000) (Table 3). Mean (geometric± SD) level of RBP was adequate in this population (1.56±0.79µmol/L) and the level (geometric mean± SE) of CRP was within normal range (1.06±4.95 *mg/L*).

Prevalence of malnutrition across sub-counties

Overall, stunting in children was 24% while those wasted were 6%. Stunted children (both moderate and severe) was highest in Bunyala (29.0%), followed by Kimilili (26.1%), Bungoma

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North (24.8%) and least in Bungoma East (20.4%). Further analysis, showed that there were no significant differences in moderately stunted children between sub-counties, although severely stunted children were significantly higher in Bungoma North compared to Bungoma East (z=3.10, 95% CI (0.044-0.20), p=0.002), significantly higher in Bunyala compared to Bungoma East (z=3.77, 95% CI (0.091-0.29), p=0.000) and significantly higher in Bunyala compared to Kimilili (z=2.71, 95% CI (0.030-0.19), p=0.006). Bunyala had highest prevalence of severely stunted children followed by Bungoma North. In wasted children, whether moderate or severe, there were no significant differences between sub-counties (Table 4).

Caretaker's knowledge scores by individual and household characteristics

Caretakers' knowledge about health seeking behaviors and childcare was significantly associated with age (χ^2=9.5, *df=4,* p=*0.049*), that is, the older the caretaker the more knowledgeable. Highest level of formal education attained by caretaker was strongly associated with knowledge about health seeking behaviors (χ^2*=25.5, df=2 p=0.000*) and childcare and nutrition and VA (χ^2=3.3, *df=2 p=0.000*). Caretakers in monogamous marriages were more knowledgeable about health-seeking behaviors and childcare (χ^2=13.9, *df=6, p=0.030),* than about nutrition and VA. Caretakers who practiced agriculture as a principal activity were more knowledgeable about health-seeking behaviors and childcare (χ^2=6.8, *df=2, p*=0.033*),* but not about nutrition and VA. Caretakers with smaller household sizes were more knowledgeable about nutrition and VA (χ^2=9.0, *df=4, p*=0.049). Caretakers in the highest wealth quintile were highly knowledgeable in health-seeking behaviors and childcare (χ^2=26.9, *df=4, p=0.000)* and about nutrition and VA (χ^2 =3.9, *df=4, p=0.000)* (Table 5).

Child-feeding practices by sub-counties

Caretakers who initiated breastfeeding immediately or within the first hour after birth were highest in Bunyala (59%) while Kimilili had the lowest (34%). Caretakers who initiated breastfeeding after the first day were highest in Kimilili (37%) and lowest in Bunyala (11%). The average age at which complementary foods were introduced was comparable in Kimilili, Bungoma North, and Bungoma East (< 5 months) but in Bunyala it was comparatively higher (5.45 ± 1.6 months). The first complementary food introduced across the sub-counties by majority (>90%) of caretakers was porridge, which was primarily cereals, except in Bunyala where the majority of caretakers fed varied types of porridges; 18% were providing commercially fortified foods, the highest proportion compared to other sub-counties, and 17% gave porridge made from cereals only (Table 6). Generally, child-feeding practices were better in Bunyala, although this was not reflected in both VA and nutritional status of children from this sub-county.

Household vitamin A food consumption frequency in the study area

The HKI VA child food consumption frequency score was below the threshold, indicating VAD among the children aged 6-23 months. The mean number of days the children consumed VA rich foods from animal sources was 1.7 days/week while the HKI frequency score was 3.3 days. 90% of the children had a HKI food frequency score lower than the minimum threshold of more than 6 days/week. Consumption of VA did not vary with the households' wealth status and with the levels of education of the caretakers. Although there were no significant differences among sub-

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counties, consumption of VA rich animal sources continued to be lowest in Bunyala sub-county (less than 1 day in a week) (Table 7).

Potential Predictors of vitamin A deficiency in children 6-23 months in study area

Five independent potential predictors of VAD; child location (sub-counties), child's age, child's VA capsule intake 1 year before the survey, caretaker's vitamin A and nutrition knowledge, and caretaker's SES were retained in the multivariate analysis. The child's location was a predictor of VAD in all the sub-counties, where Bunyala showed the strongest predictor for a child developing VAD (Adjusted odds ratio=3.5, CI =1.7-6.9, p=0.000), this was followed by Bungoma North (Adjusted odds ratio=2.2, CI=1.2-3.9, p=0.011), then Kimilili (Adjusted odds ratio=1.9, CI=1.0-3.7, p=0.045). This shows that among the four sub-counties, a child residing in Bunyala had the highest risk of developing VAD and least risk in Bungoma East. The child's age was a significant predictor of VAD (Adjusted odds ratio=1.3, CI=1.1-1.9, p=0.035), where the odds of being VAD increases with age of child; thus children 18-23 months were 1.3 times more likely to develop VAD compared to those aged 6-11 months. Children who had not taken VA capsule within 1 year prior to the survey were 1.3 times more likely to develop VAD compared to those who had taken (Adjusted odds ratio=1.3, CI=1.1-1.7, p=0.022). The VA and nutrition knowledge was found to be a significant (Adjusted odds ratio =1.4, CI=1.0-1.9, p=0.027) predictor of VAD for those in the lowest tertile. Thus, mothers in the lowest tertile of knowledge were 1.4 times more likely to have their children develop VAD (Table 8).

DISCUSSION

This study has shown that VAD prevalence (20.1%), indicated by RBP <0.825 µmol/L is a public health concern and requires public health intervention among this age of children [1]. These findings are comparable with the neighbouring province of Nyanza where VAD prevalence is about 23% among children 6-59 months [6], but sharply contrast the national figure of 62.1% [21]. Using WHO categorization, Bunyala (30.3%) and Bungoma North (20.7%) were severely affected by VAD; Kimilili (17.8%) was moderate to severe, while Bungoma East (10.3%) was moderate to mild. In terms of location, children in Bunyala and Bungoma North were most affected, with Bunyala showing the strongest predictor of VAD. Findings that caretakers in Bunyala are better in feeding and care practices compared to the other 3 sub-counties may need further investigation because this sub-county showed the highest VAD and poor nutritional status. This could have been due to other epidemiologic traits that tend to characterize most situations where VAD occurs as a public health problem such as ecological, social factors and disease patterns. Furthermore, the differences among sub-counties confirm it as a public health problem, VAD occurs under certain underlying risk factors which tend to cluster and are not uniformly distributed [5]. This possibly reflects a convergence of several risk factors that precipitate VAD in the surrounding child population. Severely sub-clinically deficient populations of children up to 5 years of age, based on the distribution of serum retinol concentrations, are considered to be at risk of severe morbidity and mortality [5]. This is reflected in Bunyala where more than half of children (data not presented here) were reported to have been ill with fevers two weeks prior to the survey, and those who had been hospitalized for illness and suffered from measles was highest in Bunyala district, 15% and 5%, respectively.

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Results contradict the regressed-based estimates by WHO where Kenya as a whole has been categorized as severely or moderately affected by VAD [1]. Such projections may not be helpful to local situations and may hamper focused interventions for VAD, best initiated at national and local level. In fact, recent studies, have suggested that these projections need to be updated, in order to take into account more recent VAD prevalence and covariates that measure health status and development [22].

Even though retinol concentration is the recommended biomarker indicator of vitamin A status in a population, it is expensive to measure because of its high sensitivity and hence the need to use HPLC which might not be available in resource-limited and field settings. Retinol binding protein is the primary carrier of retinol in the blood and has been used in various studies as a surrogate indicator of vitamin A status in the population. The RBP has advantages of being less expensive to measure and quite robust under field conditions including exposure to heat and light. However, a primary short-coming of RBP is the lack of universally acceptable cutoff for defining VAD, hence making comparisons and interpretations of results across different populations is complicated. For our study, we applied a cut-off of <0.825 µmol RBP/L for children (corresponding to <0.70 µmol retinol/L) [18]. Secondary limitation of RBP is ability to act as a negative acute phase protein; we adjusted for this effect of infection/inflammation by applying a CRP cut-off of >5.0mg /L.

Taking a VAC in the last 1 year preceding the survey was an important predictor for VAD. This predictor is a pointer to the failure to reach the recommended VAC coverage and that VAD could be responsible for the high mortality rate that is present in Western Kenya among under five children. Despite National efforts by the Kenyan government to access VA supplements to children through its National Food and Nutrition Security Policy [23], Western Kenya has an alarmingly low VA supplementation coverage (19.8%) in the country with a persistent VAD problem. Additionally, western Kenya has the second highest under-five mortality rate of 121/1,000 live births [3]. To increase vitamin A supplementation coverage, WHO recommends integration of VA supplementation within the Expanded Programme on Immunization (EPI) [24]. UNICEF, recommends regular dosing with VAC for children 6 months to 5 years where over 70/1,000 children die before the age of 5 years [25]. A study from 28 sub-Saharan African countries found that vaccination programs could provide a platform to substantially increase coverage of non-vaccine interventions such as VAC [26].

The child's age was found to be a significant predictor of VAD. Children 6-11 months are more frequently on breast milk compared to 18-23 month old ones. Because breast milk is unadulterated and provides retinol in a readily absorbable form, this age group is less likely to experience factors that precipitate VAD. Furthermore, the mother's antibodies in breast milk provide immunity to disease. Neonates are currently not given VA supplements because studies have shown no justification in neonatal VA supplementation as a public health intervention in developing countries such as Kenya for reducing infant mortality and morbidity [27]. Even though clinical VAD rarely occurs as long as a child is receiving breast milk, depletion of an infant's body stores, leading to subclinical VAD and consequent health risk, may occur by six months of age when maternal VA status is inadequate and thus breast milk VA is low [28].

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Results show that on average, children were first given complementary food at 4.64 ± 2.05 months of age. The first complementary food given to children in the study was porridge (Cereal) with nothing else added. Results further show that approximately 90% of the children had a HKI food frequency score lower than the minimum threshold of more than 6 days per week. These results are in agreement with those of WHO which found that the diet of a newly weaned child frequently has very little VA and that until a child has begun receiving a diversified family diet, thus the post weaning period is one of great vulnerability to VAD [29].

Highest level of formal education attained was strongly associated with knowledge about 1) health-seeking behaviors and childcare, and 2) nutrition and vitamin A. Furthermore, caretaker's knowledge about vitamin A and nutrition was an important predictor for child VAD. Mothers in the lowest tertile of knowledge on VA and nutrition were 1.4 times more likely to have their children develop VAD compared to those in the highest tertile. These findings are in agreement with those from the Kenya Demographics Health Survey [3], where the education level of the mother was positively correlated with consumption of VA-rich foods. Under-educated, impoverished women tend to follow traditional ideas and practices, and are less confident in engaging in social interactions where more modern concepts and practices are promoted. Due to under-education, they are less likely to learn from educational materials typically displayed at health centers and used in health-related community educational activities, including those concerned with appropriate childcare and feeding practices [29].

CONCLUSION

Prevalence of VAD in this sample of infants was high and is of public health concern. Child location and age, taking VAC and knowledge of caretakers are important predictors of VAD in Western Kenya. Although nutritional status did not feature as a predictor for VAD, it was, nonetheless, a public health problem in the study area. Regarding child location and VAD, the distribution of VAD in western Kenya is not uniform but varies from one sub-county to another. Older children were at risk of developing VAD particularly those who had stopped breastfeeding.

RECOMMENDATIONS

These findings require varying intervention approaches according to circumstances that are influenced by child location which is in line with the current call for nutrition-specific and nutrition-sensitive interventions and programs. It is, therefore, important to further investigate the factors that are contributing to VAD particularly in parts of Bungoma North and Bunyala. There is need to educate caretakers on breastfeeding particularly just after the introduction of complementary foods. Taking VAC on a short-term basis is necessary in Western Kenya to reinforce dietary approaches in such severely deficient populations, utilizing, where possible, primary health care services, particularly in severe cases as in Bunyala sub-county. If VAC distribution is done along the EPI as a government policy, then there is a need to establish why low VAC distribution coverage exists in Western Kenya.

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Table 1: Characteristics of caretakers of children 6-23 months in western Kenya

	sub-county							
	Bungoma North (n=987)		B. East (n=136)		Kimilili (n=355)		Bunyala (n=152)	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Household size	***5.8[1]***	***2.1[2]***	***6.0[1]***	***2.1[2]***	***5.8[1]***	***2.1[2]***	***5.7[1]***	***2.3[2]***
0-5	496	50.3	60	44.1	172	55.3	84	55.3
6-10	462	46.8	72	52.9	174	40.1	61	40.1
11-16	29	2.9	4	2.9	9	4.6	7	4.6
Age (years)	***30.09[1]***	***8.9[2]***	***30.38[1]***	***9.2[2]***	***28.4[1]***	***7.9[2]***	***29.91[1]***	***6.7[2]***
Below 35	755	76.5	99	72.8	6	83.9	138	90.8
36-50	199	20.2	32	23.5	298	13.5	12	7.9
Above 50	33	3.3	5	3.7	489	2.5	2	1.3
Currently in school								
Yes	33	3.3	3	2.2	15	4.2	3	2.0
No	954	96.7	133	97.8	340	95.8	149	98.0
Formal educ. (Yrs)	***8.0[1]***	***3.0[2]***	***7.6[1]***	***3.0[2]***	***8.2[1]***	***2.9[2]***	***6.8[1]***	***3.1[2]***
Highest education								
None	24	2.4	7	5.2	3	0.9	12	7.9
Primary	678	68.7	92	67.7	250	70.4	115	75.7
Secondary	256	25.9	35	25.7	95	26.8	23	15.1
College	18	1.8	2	1.5	3	0.9	2	1.3
Graduate	11	1.1	-	-	4	1.1	-	-
Marital status								
Monogamous	796	80.7	109	80.2	273	76.9	103	67.8
Polygamous	191	19.4	27	19.9	82	23.1	49	32.2
Agric. principal activity	760	79.3	115	87.1	279	83.0	108	77.7

[1]Mean, [2](SD)

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Table 2: Characteristics of a sample of children aged 6-23 months in western Kenya sub-county

	Bungoma North (987)		Bungoma East (136)		Kimilili (355)		Bunyala (152)	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
Age (mo):	***14.0[1]***	***5.1[2]***	***13.7[1]***	***4.7[2]***	***13.7[1]***	***4.9[2]***	***13.7[1]***	***5.0[2]***
6-11	373	37.8	50	36.8	142	40.0	59	38.8
12-17	316	32.0	51	37.5	116	32.7	52	34.2
18-23	298	30.2	35	25.7	97	27.3	41	27.0
Sex:								
Female	465	47.1	67	49.3	183	51.6	81	53.3
Male	522	52.9	69	50.7	172	48.5	71	46.7

Mean[1] (SD)[2]. There is statistical difference p<0.05); 2- sample proportion z-test; 95%CI

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Table 3: Distribution of children by point prevalence of VAD and CRP across sub-counties

	sub-county							
Indicator	**Bungoma North (924)**		**Bungoma East (113)**		**Kimilili (325)**		**Bunyala (120)**	
	n	***%***	***n***	***%***	***n***	***%***	***n***	***%***
VAD	191	20.7	12	10.3	58	17.8	36	30.3
CRP > 5*mg/L*	141	15.3	24	21.3	65	20.0	35	29.0

There is statistical difference p<0.05); 2- sample proportion z-test; 95%CI. RBP <0.825µmol/L which is biologically equivalent to 0.7 µmol/L of retinol; values have been adjusted for the influence of sub-clinical inflammation (CRP ≤ 5mg/L)
Key: VAD- Vitamin A Deficiency; CRP- C-Reactive Protein; RBP- Retinol Binding Protein

Table 4: Nutritional status among a sample children aged 6-23 months in Western Kenya

	sub-county							
Nutritional status	**Bungoma North (987)**		**Bungoma East (136)**		**Kimilili (355)**		**Bunyala (152)**	
	n	***%***	***n***	***%***	***n***	***%***	***n***	***%***
Stunted								
Moderate	167	17.0	19	13.8	67	18.7	31	20.5
Severe	77	7.8	9	6.6	26	7.4	13	8.5
Wasted								
Moderate	48	4.9	6	4.6	17	4.9	9	5.7
Severe	19	1.9	3	2.0	10	2.7	1	0.6

There is statistical difference p<0.05); 2- sample proportion z-test; 95%CI

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Table 5: Women's knowledge scores by individual and household characteristics

	Women in the highest tertile of knowledge about hsb and child care n=257 (15.8%)				Women in the highest tertile of knowledge about nutrition and vitamin A n=541 (33.8%)			
	n	*%*	*χ2(df)*	*p*	*n*	*%*	*χ2(df)*	*p*
Age (years): < 35	206	80.0	*9.529(4)*	***0.049****	425	78.6	*5.462(4)*	*0.243*
36-50	43	17.0			101	18.7		
> 50	8	3.0			15	2.8		
Highest educ. completed								
Primary or lower								
Higher than primary	159	62.0	*24.49(2)*	***0.000****	243	44.9	*3.266(2)*	***0.000****
	98	38.0			298	55.1		
Marital status								
Married monogamous	193	75.0	*13.93(6)*	***0.030****	438	81.0	*6.747(6)*	*0.345*
Married polygamous	18	7.0			48	8.9		
Single	29	11.0			42	7.8		
Other	17	7.0			13	2.4		
Agric. principal activity: No								
Yes	188	73.2	*6.826(2)*	***0.033****	408	75.4	*2.992(2)*	*0.224*
	55	21.4			114	21.1		
Household size								
0-5	139	54.1	*4.675(4)*	*0.322*	260	48.1	*8.981(4)*	***0.049****
6-10	109	42.4			269	49.7		
11-16	9	3.5			12	2.2		
HHs wealth tertiles								
Poorest	84	32.7	*26.89(4)*	***0.000***	186	34.4	*3.921(4)*	***0.000****
Middle	75	29.2			153	28.3		
Least poor	98	38.1			196	36.2		

***There is statistical difference p<0.05; Pearson's χ^2 test. Health seeking behaviours (hsb)**

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Table 6: Child-feeding practices in the selected study sites in Western Kenya

	sub-county							
	Kimilili (n=355)		Bunyala (n=152)		Bungoma North (n=987)		Bungoma East (n=136)	
	n	%	n	%	n	%	n	%
Time after birth baby put to the breast?								
Immediately	53	15.0	41	27.0	171	17.3	24	17.6
Within the first hour	66	18.7	49	32.2	203	20.6	41	30.4
After first hour, within the first day	103	28.9	45	29.9	299	30.3	42	31.1
After the first day	133	37.4	17	10.9	314	31.8	28	20.9
Age at first complementary foods	4.84[1]	± 1.9[2]	5.45	± 1.6	4.45	± 2.1	4.56	± 2.0
Food first given as complementary (%)								
Porridge	324	91.3	145	95.5	913	92.5	114	84.0
Irish potato	6	1.6	3	1.7	18	1.8	3	2.0
Avocado	6	1.6	0	0	10	1.0	2	1.3
Bananas	5	1.3	2	1.1	6	0.6	3	2.0
Other	15	4.2	3	1.7	40	4.1	15	10.7
If porridge, specify type								
Cereals and nothing else	165	46.4	25	16.7	437	44.3	90	66.1
Cereals and milk	59	16.5	9	6.0	194	19.7	20	14.5
Cereals and other energy and milk	45	12.8	1	0.6	105	10.6	9	6.5
Cereals and proteins	9	2.5	12	7.7	63	6.4	4	3.2
Commercially fortifies foods only	16	4.5	27	17.9	40	4.1	0	0
Cereals and proteins and milk	14	4.0	5	3.6	27	2.9	4	3.2

[1]mean [2]SD±

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Table 7: Household vitamin A food consumption frequency among children aged 6-23 months

	Total (days/week) consumed animal VA source			HKI VA food consumption frequency score		
	mean	Std dev	median	mean	Std dev	median
Overall						
Overall (n=1630)	1.61	2.33	1.00	3.30	2.64	2.50
By sub-County						
Kimilili (n=355)	1.59	2.35	1.00	3.16	2.66	2.33
Bunyala (n=152)	2.05	2.60	1.00	3.03	2.81	2.17
Bungoma North (n=987)	1.61	2.34	1.00	3.44	2.64	2.67
Bungoma East (n=136)	1.25	1.95	0.50	2.94	2.30	2.33
By wealth status						
Lowest (n=323)	1.82	2.52	1.00	3.51	2.84	2.67
Second (n=333)	1.55	2.32	1.00	3.26	2.64	2.50
Middle (n=299)	1.43	2.19	1.00	3.09	2.45	2.33
Fourth (n=316)	1.59	2.28	1.00	3.25	2.60	2.50
Highest (n=332)	1.68	2.36	1.00	3.40	2.65	2.67
By education level of caretaker						
None (n=59)	1.76	2.14	1.00	3.36	2.31	3.00
Primary (n=1020)	1.66	2.43	1.00	3.34	2.72	2.50
Secondary (n=490)	1.46	2.13	1.00	3.18	2.49	2.50
College/graduate (n=61)	1.53	1.86	1.00	3.25	2.25	2.83
Total days/week VA from animal						
≤4days per week	1783[a]	89.5[b]				
>4 days per week	210	10.5				
HKI food frequency score						
≤ 6 days per week	1744[a]	89.8[b]				
>6 days per week	198	10.2				

[a] represents number of children [b] is the proportion of children (%) Key: HKI- Helen Keller International; VA- Vitamin A

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Table 8: Multivariate logistic regression analysis for predictors of VAD in children 6-23 months in study area

Variables retained in logistic regression analysis	No VAD- n=1303 (79.9%)	VAD n=327 (20.1%)	p-value	Adjusted odds ratio (95%CI)
sub-County				
Bungoma East	122 (89.7)	14 (10.3)	Ref	Ref
Bunyala	106 (69.7)	46 (30.3)	**0.000***	**3.5 (1.7-6.9)**
Bungoma North	783 (79.3)	204 (20.7)	**0.011***	**2.2 (1.2-3.9)**
Kimilili	292 (82.2)	63 (17.8)	**0.045***	**1.9 (1.0-3.7)**
Child Age				
6-11	509 (81.6)	115 (18.4)	Ref	Ref
12-17	433 (80.9)	102 (19.1)	0.389	1.1 (0.8-1.6)
18-23	361 (76.7)	110 (23.4)	**0.035***	**1.3 (1.1-1.9)**
Child taken VA capsule in the last 1 year				
No	803 (81.9)	177 (18.1)	**0.022***	**1.3 (1.1-1.7)**
Yes	449 (78.1)	126 (21.9)	Ref	Ref
Vitamin A and nutrition knowledge score				
Lowest tertile	446 (77.3)	131 (22.7)	**0.027***	**1.4 (1.0-1.9)**
Second tertile	411 (80.3)	101 (19.7)	0.617	1.0 (0.7-1.5)
Highest tertile	446 (82.4)	95 (17.6)	Ref	Ref
Socio Economic Status (SES)				
Poorest	559 (79.0)	149 (21.1)	0.088	1.4 (0.9-1.9)
Middle	354 (78.5)	97 (21.5)	0.074	1.3 (0.9-1.8)
Least poor	378 (83.1)	77 (16.9)	Ref	Ref

***There is statistical difference p<0.05; Pearson's χ2 test Key: VAD- Vitamin A Deficiency; CRP- C-Reactive Protein; RBP- Retinol Binding Protein**

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