



# Spatial Distribution and Determinants of Inadequate Vitamin A–Rich Food Consumption Among Children Aged 6–23 Months in Somalia: Evidence from the 2020 Somalia Demographic and Health Survey

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**Purpose:** Vitamin A deficiency (VAD) is a critical public health issue in Somalia, yet evidence regarding dietary practices remains limited. This study assessed the prevalence, geographical distribution, and determinants of Vitamin A-rich food consumption among children aged 6–23 months.

**Methods:** Using 2020 Somali Demographic and Health Survey (SDHS) data (n=2,806), we employed two-level multilevel mixed-effects logistic regression to identify individual and community-level determinants. Spatial analysis, including Global Moran's I and Getis-Ord Gi\* statistics, was performed to assess geographical clustering and identify consumption hotspots.

**Results:** Only 33.75% of children consumed adequate Vitamin A-rich foods. Multilevel analysis revealed that children aged 18–23 months (AOR=2.78), those with formally educated mothers (AOR=1.42), and urban residents were more likely to consume these foods. Conversely, children with a birth order of two or more (AOR=0.44), and those from rural (AOR=0.72) or nomadic (AOR=0.22) households, had significantly lower odds of consumption. Spatial analysis confirmed significant geographical clustering (Moran's I = 0.24, p=0.048), identifying high-consumption hotspots in Awdal and Shabeellaha Dhexe, and low-consumption coldspots in Bari, Gedo, and Woqooyi Galbeed.

**Conclusion:** Somali children face a substantial deficiency in Vitamin A-rich food intake, driven by pronounced sociodemographic and geographical disparities. These findings underscore the urgent need for multisectoral interventions. Strategies should prioritize enhancing maternal education and implementing context-specific programs for rural and nomadic communities to mitigate the burden of VAD in Somalia.

**Keywords:** vitamin A-rich foods, children, multilevel analysis, spatial distribution, Somalia

## Introduction

Vitamin A, a nutrient that dissolves in fat, is available in two main forms: retinol, which is preformed vitamin A found in animal-based foods, and pro-vitamin carotenoids, which are present in fruits and vegetables.<sup>1</sup> Vitamin D plays a crucial role in several bodily functions, such as maintaining vision, bolstering the immune system, producing red blood cells, and encouraging growth.<sup>2,3</sup> Worldwide, approximately 190 million preschool-aged children (33.3%) are at risk of vitamin A deficiency (VAD), with 124 million requiring vitamin A-rich food or supplements. This deficiency is especially common in low-income areas, such as sub-Saharan Africa (48%) and South Asia (44%).<sup>4–6</sup> According to a 2015

UNICEF report, VAD is the third most prevalent and severe nutritional problem among young children, following protein-energy malnutrition and iron-deficiency anaemia.<sup>7</sup>

Vitamin A deficiency (VAD) is a significant public health challenge in low-income countries.<sup>8</sup> This issue remains a public health concern in sub-Saharan Africa (SSA).<sup>9</sup> VAD is associated with elevated rates of morbidity and mortality from measles, diarrhoea, malaria, and other infectious diseases among children in low- and middle-income countries (LMICs). Research indicates that the prevalence of VAD in Africa ranges from 8.5% to 79%.<sup>10</sup> Previous studies conducted in various regions of Africa have revealed that the consumption of vitamin A and vitamin A-rich foods in Ghana was insufficient at 52%. The Demographic and Health Surveys (DHS) reports from Malawi in 2015 and Uganda in 2016 indicated that 79.1% and 66.5% of children, respectively, consumed foods high in vitamin.<sup>9,11</sup> The World Health Organization (WHO) recommends the inclusion of appropriate plant-based complementary foods and animal products, such as meat, poultry, fish, and eggs, to fulfil the nutritional requirements of children. Vitamin A deficiency (VAD) in children significantly contributes to mortality from measles, diarrhoea, malaria, and other infectious diseases.<sup>12,13</sup> Key global strategies to combat VAD include exclusive breastfeeding, vitamin A supplementation, dietary diversification, and food fortification.<sup>14</sup>

In Somalia, a demographic and health survey indicated that 27% of children under the age of five exhibit stunted growth, signifying a height deficit relative to their ages. Additionally, 12% of these children were classified as wasted, denoting a lower than normal weight for their height, and 21% were underweight, reflecting a weight below the expected norm for their age. Furthermore, 41% of breastfed children under two years of age received solid or semi-solid complementary foods in conjunction with breast milk. Among children aged 0–23 months, 23% consumed grain-based foods, while 18% ingested fruits and vegetables rich in vitamin A. Moreover, 13% and 12% of children in this age group were provided with dairy products such as cheese and yoghurt and animal-based foods including meat, fish, and poultry, respectively.<sup>15</sup>

Only 33% of children aged 6–23 months consumed vitamin A-rich foods during the day or night before the survey. Nationally, more than one-third of children exhibit vitamin A deficiency when assessed using RBP, with those under 2 years of age being less susceptible to this deficiency than older children.<sup>15,16</sup> Several significant factors influence the consumption of foods high in vitamin A and iron among children, including the mother's age, occupation, and education level; the child's age and gender; birth order; media exposure; wealth index; prenatal and postnatal care; and the location of birth and residence.<sup>17–20</sup>

Although recent studies like Ali et al (2025) have employed the 2020 Somalia Demographic and Health Survey (SDHS) to explore the sociodemographic factors influencing Vitamin A intake using multilevel modeling, there remains a notable gap in research concerning the geographic variability of these risks. Current research successfully identifies individuals at risk, such as children with mothers who are uneducated or living in poverty, but lacks the spatial analysis needed to determine where these risks are most prevalent. By combining multilevel mixed-effects modeling with sophisticated spatial analysis techniques (Moran's I and Getis-Ord  $G_i^*$ ), this study addresses the "spatial blindness" of earlier models and pinpoints specific areas of nutritional deprivation. This integrated approach offers a precision public health framework that goes beyond administrative borders, providing a more focused strategy for interventions in Somalia's complex and geographically varied environment.<sup>21</sup>

The findings of this study will contribute to the advancement of the United Nations' Sustainable Development Goals (SDGs), specifically SDG 2 (Zero Hunger) and SDG 3 (Good Health and Well-being).<sup>22–24</sup> These insights will be valuable for policymakers, program managers, and researchers focusing on child nutrition.

## Material and Methods

### Data Source and Study Design

A cross-sectional study examined data from the 2020 Somali Demographic and Health Survey (SDHS), a nationally representative survey that collects comprehensive health and demographic information from Somali women aged 15–49. The analysis employed the Kids Recode (KR) dataset, which provides a detailed array of child health indicators, particularly those related to immunisation rates, childhood diseases, and vitamin A supplementation.<sup>15</sup> The study was

deemed exempt from full review by the Hargeisa Group Hospital Research IRB the primary ethical review body for health-related research associated with the University of Hargeisa College of Medicine and Health Science because it involved the secondary analysis of de-identified, publicly available data from the Somalia Demographic and Health Survey (SDHS), posing no risk to participants.

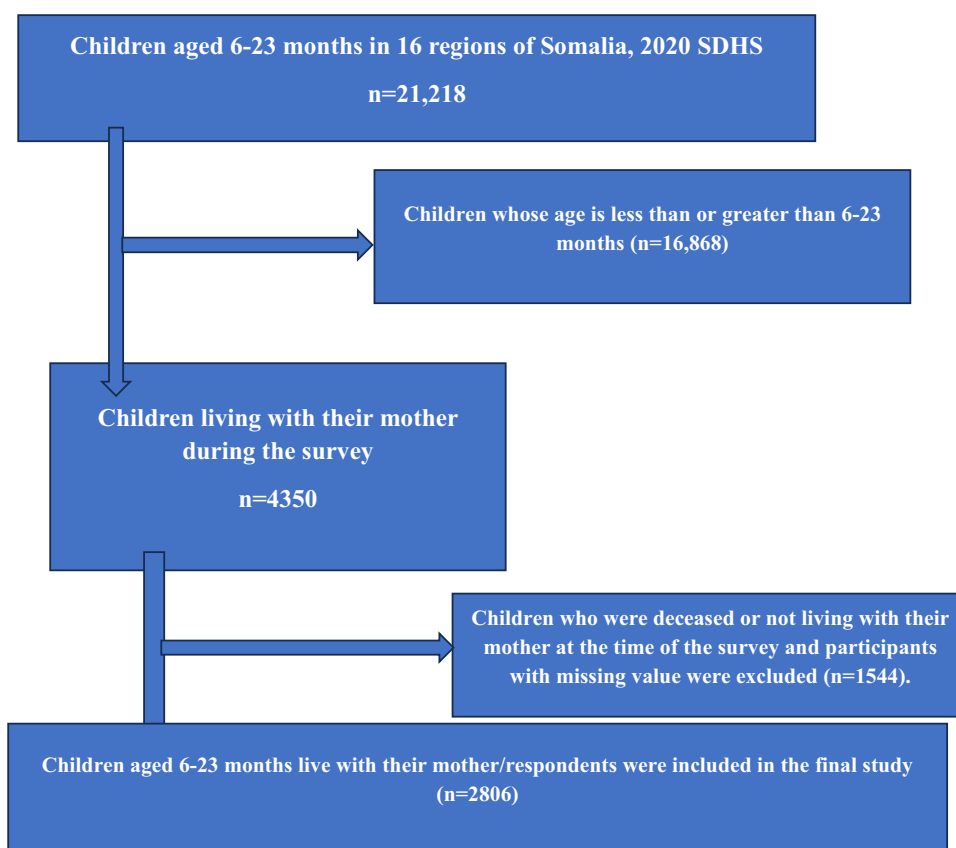
## Study Population and Sampling Technique

This study focused on infants and young children (IYC) aged 6–23 months in Somalia during the survey period. The sample comprised a subset of this demographic, specifically IYC residing in the selected enumeration areas (EAs), who were included in the analysis. A two-stage sampling approach was employed to ensure balanced representation of urban and rural areas. Initially, 500 EAs were selected, with 112 and 388 allocated to the urban and rural regions, respectively. In the second stage, 26 households were systematically chosen from each EA, resulting in 13,000 total households. [Figure 1](#) shows that 2,806 infants and young children (IYC) were included, and sampling weights were applied to ensure that the results were representative at the national level.<sup>15</sup>

## Measurement of Variables

### Outcome Variable

In this study, the dependent variable was the consumption of foods rich in vitamin A. Children’s responses were classified as “Met=0” if they had eaten at least one of the seven vitamin A-rich foods (egg, meat, vegetables, green leafy vegetables, fruits, organ meat, and fish) within the 24 hours preceding the interview. On the other hand, they were categorised as “Not-Met=1” if they had not consumed any of these seven food items during the same period.<sup>25,26</sup>



**Figure 1** Sample study selection of children aged 6–23 months in emerging regions, SDHS 2020.

## Independent Variables

Maternal-related factors included maternal age, education, place of delivery, and media exposure.

Child related factors: child age, child sex, birth order, number of children under five years.

Household related factors: wealth index, family size, and source of water.

Community-related factors: Region and place of residence.

## Data Management and Statistical Analysis

Data processing activities, including cleaning, recording, and analysis, were performed using STATA version 16, with variables derived from KR files. Participants without outcome variables were excluded from the analysis. Additionally, to adjust for potential biases due to sampling and non-responses, sample weights were incorporated into the analysis. Descriptive statistics were used to summarise the characteristics at both the individual and community levels using frequency distribution, tables, and charts. Given the hierarchical structure of the DHS data, in which children are nested within households and households within geographic clusters, standard logistic regression is unsuitable because of the potential correlation of outcomes within clusters. To address this, a two-level multilevel mixed-effects logistic regression model was employed that accounts for community-level clustering through random effects while estimating the effects of the predictor variables. The degree of clustering was assessed using the intraclass correlation coefficient (ICC), and the proportional change in deviance (PCV) was used to evaluate the impact of community-level factors on variance. Model selection was based on deviance, and the model exhibiting the lowest deviance was considered best fit. Variables with a  $p$ -value  $< 0.05$  in the bivariable analyses were included in the multivariable model. This multivariable analysis comprised four models: (1) a null model (Model 0) without explanatory variables to assess the variation between clusters and calculate the ICC; (2) Model I with only individual-level variables to examine their effects; (3) Model II with only community-level factors to evaluate their effects; and (4) Model III with both individual- and community-level variables to assess their combined fixed and random effects. Variables with  $p < 0.05$  in the multivariate analysis were identified as significant predictors of complementary feeding among infants and young children, with adjusted odds ratios (AORs) and 95% confidence intervals (CIs). In the spatial analysis, the spatial autocorrelation statistic (Global Moran's I) was used to explore the spatial distribution of complementary feeding practices among infants and young children in the study area, specifically to determine whether these practices were dispersed, clustered, or randomly distributed in the study area. Moran's I, a spatial statistic, measures spatial autocorrelation by producing a single value between  $-1$  and  $+1$  that indicates the level of clustering or dispersion. It is more sensitive to standardised spatial covariance than Geary's C, which depends on the sum of squared distances. The spatial distribution of vitamin A-rich foods was examined using the Getis-Ord Local Spatial Statistics Tool, which identified statistically significant hotspots, indicating areas with high rates of Vitamin A-rich food consumption, and cold spots, indicating areas with low rates of Vitamin A-rich food consumption.

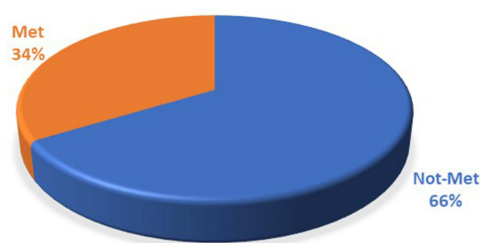
## Results

### Prevalence of Vitamin A Rich Food Consumption

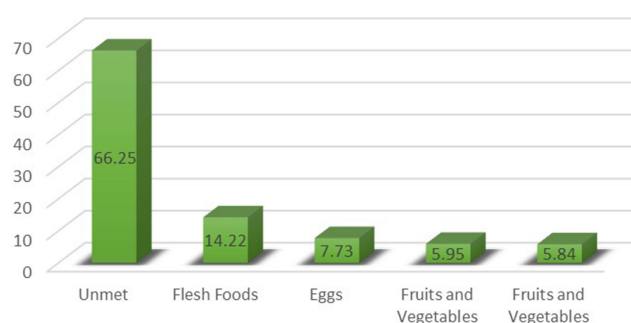
In the age group of 6–23 months, just 33.75% of children consumed foods high in Vitamin A whereas 66.25% did not reach the recommended Vitamin A intake (Figure 2). The findings also revealed that a significant majority (66.2509%) were classified as “Unmet”, indicating insufficient consumption of Vitamin A-rich foods. Regarding specific food categories, “Flesh Foods” were consumed by 14.2195% of the children, “Eggs” by 7.73343%, “Vitamin A Fruits and Vegetables” by 5.95153%, and “Other Fruits and Vegetables” by 5.84462%. These statistics underscore that, although some Vitamin A-rich foods were part of the diet, the overall intake was inadequate for a significant number of children in this age group, as shown in (Figure 3).

### Sociodemographic Characteristics of the Study Participants

(Table 1) This research examined 2,806 children, with the majority being 12–17 months old (46.9%), male (52.2%), and firstborn (87.9%). Most families had fewer than five children under five years old (58.5%) and consisted of 4–6 members



**Figure 2** Prevalence of Vitamin A rich food consumption among children aged 6–23 months (SDHS, 2020).



**Figure 3** Proportion of Vitamin A rich Foods consumed by children aged 6–23 months (SDHS, 2020).

(46.0%). Maternal characteristics showed a significant lack of formal education (82.6%) and a high rate of home births (80.6%), with 61.7% of mothers citing distance as a significant obstacle to accessing healthcare. Media exposure was extremely limited, with 96.3% not exposed. Participants were located in urban (38.4%), nomadic (33.5%), and rural (28.1%) areas, with the largest regional representation from the Sanaag (10.1%) and Sool (9.9%) regions. Economically, nearly half (47.2%) were classified as poor, and the majority (69.5%) used non-improved water sources for drinking.

## Factors Associated with Vitamin A Rich Foods Consumption Among Children Aged 6–23 Months in Somalia Using Chi-Square Test: Further Analysis of Somalia Demographic and Health Survey 2020

(Table 2) Chi-square tests in bivariate analysis indicated a significant correlation between all examined factors and the consumption of Vitamin A-rich foods ( $p < 0.05$ ). Infants aged 6–11 months had the lowest consumption rate at 24.3%, compared to older age groups ( $\chi^2 = 51.11$ ,  $p < 0.001$ ), and males consumed slightly more than females (35.6% vs. 31.8%,  $p = 0.034$ ). Maternal influences were notable, with children of mothers who had formal education showing higher consumption rates (48.9% vs. 30.6%,  $p < 0.001$ ), as well as those born in health facilities (52.7% vs. 29.2%,  $p < 0.001$ ). Factors such as proximity to health centers, media exposure (65.4% vs. 32.5%), and access to improved water sources ( $P = 0.004$ ) were also positive indicators. There were significant spatial and socioeconomic disparities ( $\chi^2$  values  $> 219$ ,  $p < 0.001$ ); urban dwellers (50.5%) and the wealthiest households (49.0%) had higher consumption compared to nomadic (13.2%) and impoverished (20.1%) groups. Regionally, the highest consumption was in Banadir (75.0%), while the lowest was in Lower Juba (15.5%).

## Multilevel Analysis of Factors Associated with Vitamin A Rich Foods Among Children Aged 6–23 Months in Somalia: Further Analysis of Somalia Demographic and Health Survey 2020

(Table 3) Through multilevel analysis, several key factors influencing the consumption of Vitamin A-rich foods were identified. Among child-related factors, age was significant, with children aged 12–17 months (AOR=2.37, 95% CI:

**Table 1** Socio-Demographic Characteristics of Mothers and Children of Study Participants: Further Analysis of Somalia Demographic and Health Survey, 2020

Variable	Category	Frequency (n=2806)	Percentage (%)
<b>Child Age</b>	6–11 months	873	31.11
	12–17 months	1216	46.9
	18–23 months	617	21.99
<b>Child Sex</b>	Male	1465	52.21
	Female	1341	47.79
<b>Birth Order</b>	1	2466	87.88
	2 or More	340	12.12
<b>Children_U5</b>	Less than 5 years	1641	58.48
	More than 5 years	1165	41.52
<b>Maternal Age</b>	15–24 Years	957	34.11
	25–34 Years	1381	49.22
	≥35 Years	468	16.68
<b>Educational Status</b>	No Formal Education	2317	82.57
	Formal Education	489	17.43
<b>Place Of Delivery</b>	Home	2261	80.58
	Health Institution	545	19.42
<b>Distance Of HC</b>	Problem	1730	61.65
	Not Problem	1076	38.35
<b>Media Exposure</b>	Yes	104	3.71
	No	2702	96.29
<b>Region</b>	Awdal	93	3.31
	Woqooyi Galbeed	159	5.67
	Togdheer	195	6.95
	Sool	277	9.87
	Sanaag	283	10.09
	Bari	146	5.2
	Nugaal	161	5.74
	Mudug	148	5.27
	Galgaduud	173	6.17
	Hiraan	166	5.92
	Middle Shabelle	146	5.2
	Banadir	256	9.12
	Bay	67	2.39
	Bakool	166	5.92
	Gedo	170	6.06
	<b>Residence Place</b>	Lower Juba	200
Urban		1077	38.38
Rural		788	28.08
Nomadic		941	33.54
<b>Wealth Index</b>	Poor	1323	47.15
	Middle	521	18.57
	Rich	962	34.28
<b>Family Size</b>	1–3	637	22.7
	4–6	1291	46.01
	7–9	878	31.29
<b>Water Source</b>	Improved	856	30.51
	Non-Improved	1950	69.49

**Table 2** Factors Associated with Vitamin Rich Foods Consumption Among Children Aged 6–23 Months: Further Analysis of Somalia Demographic and Health Survey, 2020

Variable	Category	Not-Met	Met	X2 (P-Value)
<b>Child Age</b>	6–11 months	661(75.72%)	212(24.28%)	51.1109(0.00)
	12–17 months	810(61.55%)	506(38.45%)	
	18–23 months	388(62.88%)	229(37.12%)	
<b>Child Sex</b>	Male	944(64.44%)	521(35.56%)	4.5116 (0.034)
	Female	915(68.23%)	426(31.77%)	
<b>Birth Order</b>	1	1620(65.69%)	846(34.31%)	2.8286(0.093)
	2 or More	239(70.29%)	101(29.71%)	
<b>Children_U5</b>	=<5	1071(65.27%)	570(34.73%)	1.7179(0.190)
	≤5	788(67.64%)	377(32.36%)	
<b>Maternal Age</b>	15–24 Years	651(68.03%)	306(31.97%)	2.7159(0.257)
	25–34 Years	895(64.81%)	486(35.19%)	
	≥35 Years	313(66.88%)	155(33.12%)	
<b>Educational Status</b>	No Formal Education	1609(69.44%)	708(30.56%)	60.6001(0.000)
	Formal Education	250(51.12%)	239 (48.88%)	
<b>Place Of Delivery</b>	Home	1601(70.81%)	660(29.19%)	108.1879(0.000)
	Health Institution	258(47.34%)	287(52.66%)	
<b>Distance Of HC</b>	Problem	1191(68.84%)	539(31.16%)	13.5671(0.000)
	Not Problem	668(62.08%)	408(37.92%)	
<b>Media Exposure</b>	Yes	36(34.62%)	68(65.38%)	46.0617(0.000)
	No	1823(67.47%)	879(32.53%)	
<b>Region</b>	Awdal	52(55.91%)	41(44.09%)	333.8677(0.000)
	Woqooyi Galbeed	78(49.06%)	81(50.94%)	
	Togdheer	137(70.26%)	58(29.74%)	
	Sool	233(84.12%)	44(15.88%)	
	Sanaag	221(78.09%)	62(21.91%)	
	Bari	105(71.92%)	41(28.08%)	
	Nugaal	109(67.70%)	52(32.30%)	
	Mudug	87(58.78%)	61(41.22%)	
	Galgaduud	128(73.99%)	45(26.01%)	
	Hiraan	113(68.07%)	53(31.93%)	
	Middle Shabelle	80(54.79%)	66(45.21%)	
	Banadir	64(25.00%)	192(75.00%)	
	Bay	42(62.69%)	25(37.31%)	
	Bakool	123(74.10%)	43(25.90%)	
	Gedo	118(69.41%)	52(30.59%)	
	Lower Juba	169(84.50%)	31(15.50%)	
<b>Residence Place</b>	Urban	533(49.49%)	544(50.51%)	314.4005(0.000)
	Rural	509(64.59%)	279(35.41%)	
	Nomadic	817(86.82%)	124(13.18%)	
<b>Wealth Index</b>	Poor	1057(79.89%)	266(20.11%)	219.7151 (0.000)
	Middle	311(59.69%)	210(40.31%)	
	Rich	491(51.04%)	471(48.96%)	
<b>Family-size</b>	1–3	405(63.58%)	232(36.42%)	3.3914(0.183)
	4–6	856(66.31%)	435(33.69%)	
	7–9	598(68.11%)	280(31.89%)	
<b>Water Source</b>	Improved	534(62.38%)	322(37.62%)	8.2410(0.004)
	Non-Improved	1325(67.95%)	625(32.05%)	

**Note:** Statistical significance is defined as  $p < 0.05$ .

**Abbreviations:** X2, Chi-square; HC, Health Center.

**Table 3** Multilevel Analysis of Vitamin Rich Foods Consumption Among Children Aged 6–23 Months: Further Analysis of Somalia Demographic and Health Survey, 2020

AOR (95% CI)					
Variable	Category	Null Model (Empty)	Model I	Model II	Model III
Child Age	6–11 months		REF		REF
	12–17 months		2.15(1.72–2.67)***		2.37(1.89–2.96)***
	18–23 months		2.63(2.02–3.43)***		2.78(2.11–3.67)***
Child Sex	Male		REF		REF
	Female		0.88(0.742–1.05)		0.83(0.699–1.00)
Birth Order	1		REF		REF
	2 or More		0.54(0.406–726)***		0.44(0.328–0.605)***
Children_U5	=<5		REF		
	≤5		0.83(0.694–1.01)		0.84(0.693–1.02)
	15–24 Years		REF		REF
Maternal Age	25–34 Years		1.21(0.993–1.48)		1.28(1.04–1.58)**
	≤35 Years		1.30(0.982–1.73)		1.38(1.03–1.86)**
	No Formal Education		REF		REF
Educational Status	Formal Education		1.30(1.02–1.65)**		1.42(1.11–1.82)***
	Home		REF		REF
Place Of Delivery	Health Institution		2.75(1.39–2.20)***		1.21(0.952–1.54)
	Problem		REF		REF
Distance Health Center	Not Problem		1.0(0.830–1.20)		1.08(0.893–1.32)
	Yes		REF		REF
Media Exposure	No		0.44(0.274–0.715)***		0.53(0.326–0.862)***
	Poor		REF		REF
Wealth Index	Middle		2.38(1.83–3.11)***		1.17(0.861–1.59)
	Rich		3.04(2.36–3.92)***		1.14(0.841–1.56)
	1–3		REF		REF
Family Size	4–6		0.85(0.682–1.07)		0.86(0.682–1.08)
	7–9		0.79(0.624–1.02)		0.85(0.666–1.10)
	Improved		REF		REF
Water Source	Non-Improved		0.76(0.623–0.928)***		0.83(0.666–1.04)
	Awdal			REF	REF
Region	Woqooyi Galbeed			1.22(0.691–2.18)	1.21(0.669–2.21)
	Togdheer			0.55(0.314–0.994)**	0.62(0.341–1.13)
	Sool			0.22(0.125–0.402)***	0.22(0.123–0.424)***
	Sanaag			0.29(0.167–0.525)***	0.31(0.172–0.573)***
	Bari			0.41(0.223–0.782)***	0.42(0.220–0.823)***
	Nugaal			0.51(0.281–0.937)**	0.55(0.295–1.03)
	Mudug			0.78(0.438–1.39)	0.82(0.448–1.51)
	Galgaduud			0.36(0.200–0.675)***	0.38(0.201–0.723)***
	Hiraan			0.45(0.250–0.816)***	0.44(0.238–0.829)***
	Middle Shabelle			0.78(0.439–1.40)	0.80(0.428–1.49)
	Banadir			1.64(0.929–2.90)	1.99(1.08–3.64)***
	Bay			0.30(0.142–0.645)***	0.35(0.160–0.777)***
	Bakool			0.27(0.147–0.514)***	0.29(0.150–0.585)***
	Gedo			0.42(0.234–0.758)***	0.43(0.233–0.822)***
	Lower Juba			0.14(0.076–0.281)***	0.13(0.067–0.270)***

(Continued)

**Table 3** (Continued).

Variable	Category	AOR (95% CI)			
		Null Model (Empty)	Model I	Model II	Model III
Residence Place	Urban			REF	REF
	Rural			0.64(0.475–0.864)***	0.72(0.535–0.991)**
	Nomadic			0.17(0.130–0.228)***	0.22(0.157–0.35)***

**Notes:** \*\*\* p<0.001, \*\* p<0.01.

**Abbreviations:** AOR, Adjusted Odds Ratio; CI, Confidence Interval; REF, Reference category.

1.89–2.96) and 18–23 months (AOR=2.78, 95% CI: 2.11–3.67) having higher odds compared to those aged 6–11 months. Conversely, children with a birth order of two or more had reduced odds (AOR=0.44, 95% CI: 0.33–0.61). Maternal influences were also notable; increased consumption was associated with mothers aged 25 years or older, those with formal education (AOR=1.42, 95% CI: 1.11–1.82), and those exposed to media (AOR=0.53 for no exposure; 95% CI: 0.33–0.86). Regional differences were pronounced: children in Banadir had nearly twice the odds of consuming these foods compared to those in Awdal (AOR=1.99), while children in nine other regions, such as Sool, Sanaag, and Lower Juba, had significantly lower odds (AOR range 0.13–0.44). Additionally, children from rural (AOR=0.72) and nomadic (AOR=0.22) households were much less likely to consume these foods than those from urban areas.

(Table 4) Hierarchical modeling was utilized to evaluate the influences at various levels on the consumption of foods rich in Vitamin A. The initial model showed a significant intra-class correlation coefficient (ICC) of 0.34 (pandlt;0.001), suggesting that 34.0% of the variance in consumption was due to differences at the cluster level. This ICC progressively decreased to 13.0% in Model I, which considered individual and household factors, and further to 3.7% in Model II, which accounted for community factors. The comprehensive final model (Model III) accounted for most of the cluster-level variation, leaving a residual ICC of 2.65% (pandlt;0.001). Model III was the best fitting model, as indicated by the lowest AIC (2972.16) and BIC (3180.04) values, and a significant improvement in the Likelihood Ratio test compared to Model II (p=0.03). These findings confirm that the consumption of Vitamin A is significantly affected by factors spanning multiple levels, from individual traits to broader contextual settings.

## Spatial Distribution of Vitamin A-Rich Food Consumption Among Children

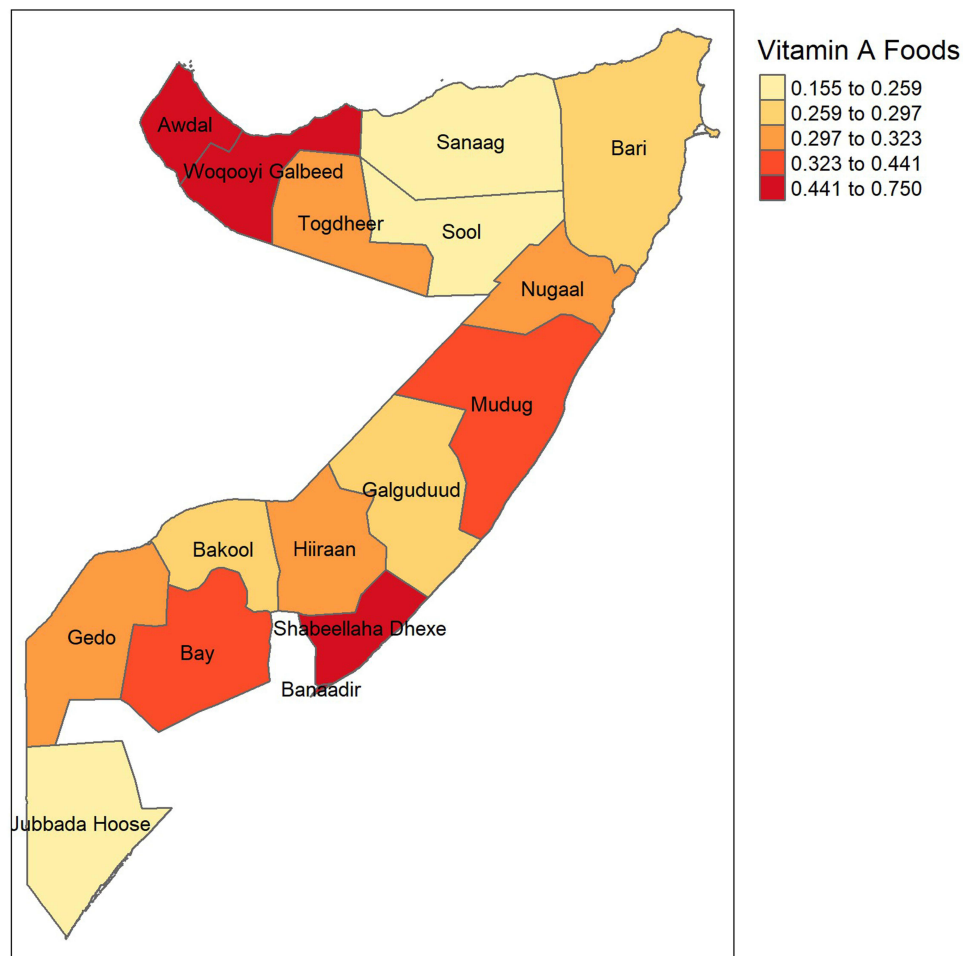
Figure 4 THE spatial distribution of Vitamin A-rich food intake among children in Somalia, as depicted on the map, reveals significant geographical patterns and regional disparities crucial for pinpointing high-risk zones and guiding targeted nutritional interventions. The map illustrates a clear division, with the highest consumption rates (0.441 to 0.750)

**Table 4** Random Effect Analysis and Model Comparison

Random Effect	Null Model (Empty)	Model I	Model II	Model III
AOR	0.3636(0.2976.4443)			
P-value	***	***	***	***
ICC	0.34006	0.1299576	0.0372283	2.65E-02
LR test	166.43	39.3	1.74	0.03
<b>Model Fit Statistics</b>				
AIC	3425.643	3214.267	3075.518	2972.16
BIC	3437.522	3321.179	3188.369	3180.043
DIC (-2loglikelihood)	-1710.8213	-1589.1336	-1518.7591	-1451.0798

**Notes:** \*\*\* p<0.001.

**Abbreviations:** AOR, Adjusted Odds Ratio; ICC, Intra-class Correlation Coefficient; LR test, Likelihood Ratio Test; AIC, Akaike's Information Criterion; BIC, Bayesian Information Criterion; DIC, Deviance Information Criterion.



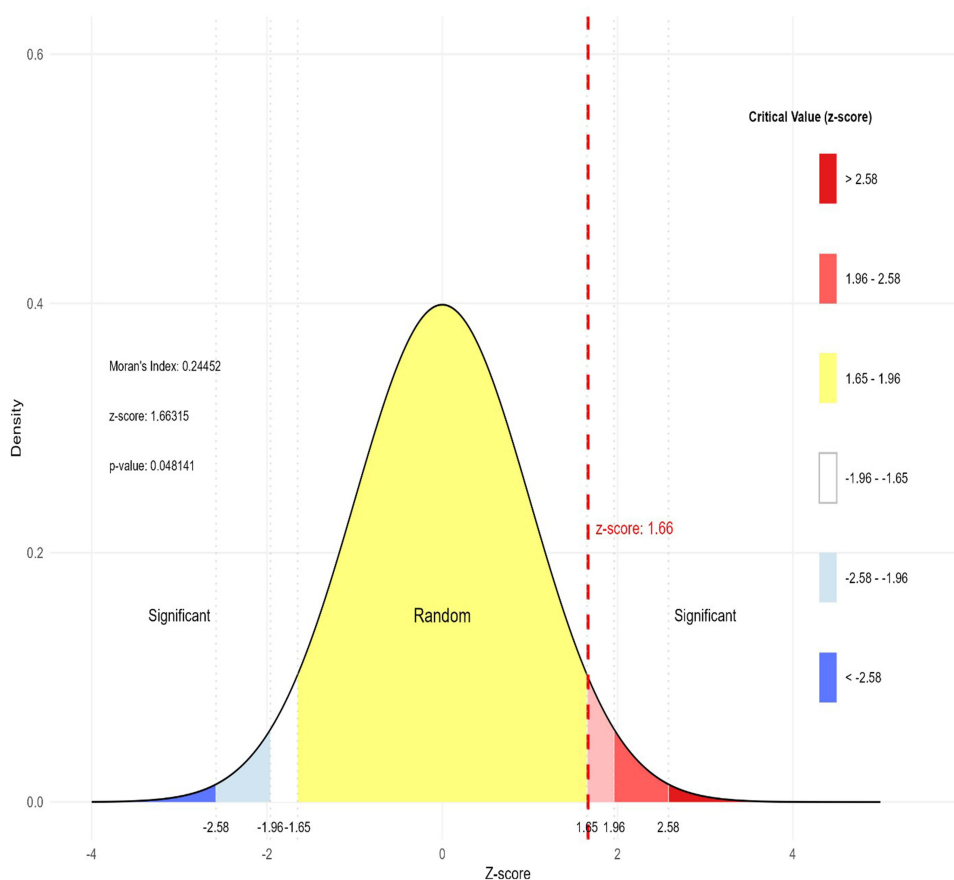
**Figure 4** Spatial Distribution of Vitamin A-rich food consumption among children (SDHS 2020).

observed in the northwestern areas of Awdal and Woqooyi Galbeed, as well as in the southern regions of Bay and Shabeellaha Dhexe. In contrast, the lowest consumption rates (0.155–0.259) were noted in Sanaag and Jubbada Hoose, suggesting that these populations are more susceptible to Vitamin A deficiency. Other regions, including Sool, Bakool, and Galguduud, exhibit relatively low consumption, whereas areas such as Togdheer, Mudug, and Hiiraan show moderate-to-high levels. This distinct geographical pattern underscores the necessity of localised public health strategies to effectively tackle nutritional deficiencies throughout the country.

(Table 5) The Global Moran's I test was employed to evaluate the spatial autocorrelation in the intake of Vitamin A-rich foods among children in Somalia. The figure demonstrates that the findings indicate a statistically moderate and significant positive spatial autocorrelation (Moran's I = 0.24, z-score = 1.66, p = 0.048). This suggests that regions with similar consumption levels, whether high or low, tend to cluster. This result supports the rejection of the null hypothesis of random spatial distribution, confirming that the pattern of Vitamin A-rich food consumption is not random but exhibits distinct geographic areas with similar consumption rates (Figure 5).

**Table 5** Global Moran's I Spatial Autocorrelation

Statistic	Moran's I Statistic	Z-Score	P-Value
Value	0.24452	1.66315	0.048



**Figure 5** Normal distribution curve of Vitamin A rich food consumption.

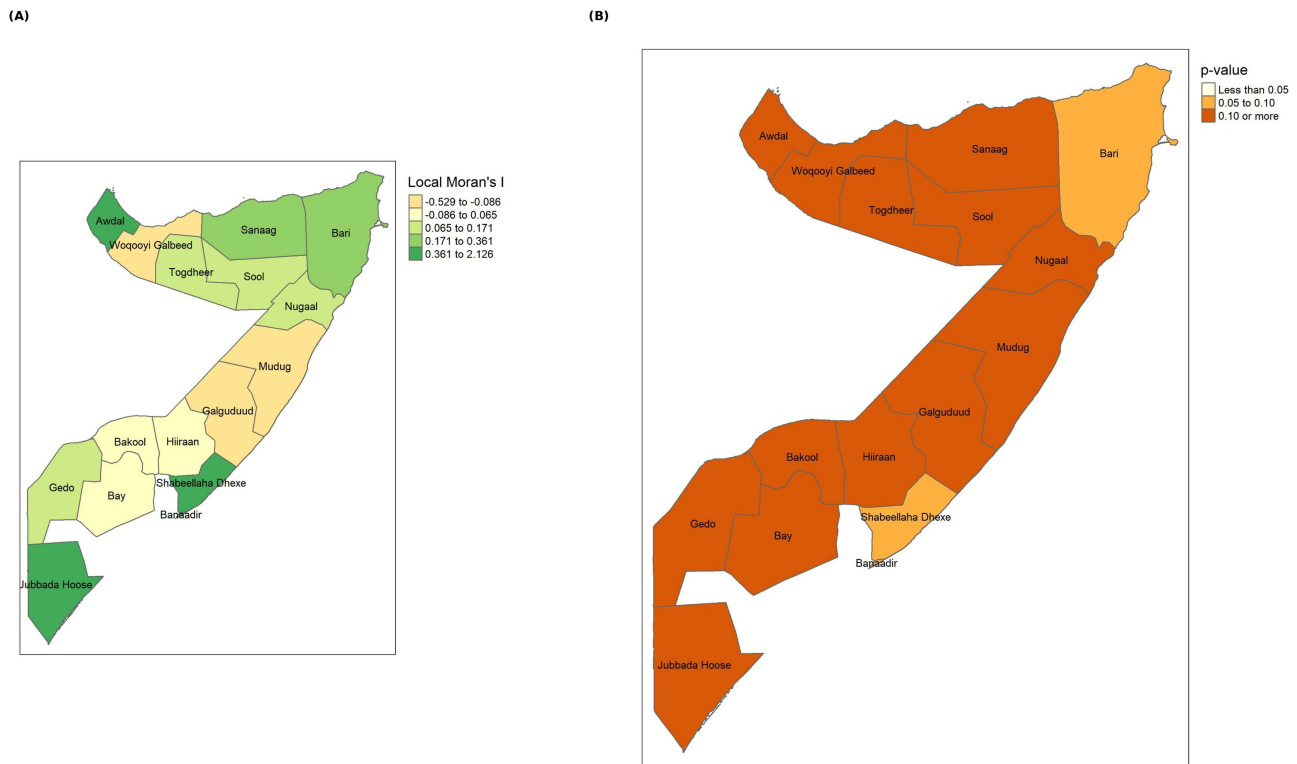
## Local Moran's I Spatial Autocorrelation

Figure 6 expanding on global spatial autocorrelation patterns, Local Moran's I analysis offers a more nuanced understanding of the localised clustering effects related to vitamin A-rich food consumption. The Local Moran's I map reveals significant spatial clustering of similar consumption levels in areas like Jubbada Hoose, Awdal, and Shabeellaha Dhexe, which show high positive Moran's I values ranging from 0.361 to 2.126. These regions highlighted areas with strong local spatial autocorrelation, indicating consistent consumption patterns within the clusters. In contrast, regions such as Woqooyi Galbeed, Sool, Mudug, and Galguduud exhibited low or negative Moran's I values between  $-0.529$  and  $0.065$ , indicating spatial heterogeneity and variability in consumption levels.

The p-value map enhances this analysis by emphasising the statistical significance of spatial patterns. In most regions, such as the high-clustering areas of Jubbada Hoose and Awdal, the p-values were below 0.1, indicating statistically significant spatial patterns of clustering. In contrast, Bari and Shabeellaha Dhexe, with p-values of 0.1 or higher, showed patterns that lacked statistical significance, suggesting that their observed clustering or dispersion may have resulted from random variation. Collectively, these findings highlight the spatial disparities in the consumption of Vitamin A-rich foods, with some regions exhibiting statistically significant clustering, while others show heterogeneity or insignificant patterns. This underscores the need for targeted, region-specific interventions to address the localised disparities across Somalia.

## Hotspots and Coldspots Analysis (Getis-Ord $G_i^*$ )

Figure 7 illustrates that the Getis-Ord  $G_i^*$  statistic identifies both hotspots and cold spots, indicating areas with significantly high or low consumption of Vitamin A-rich foods, respectively. Regions such as Awdal, Galguduud, and Shabeellaha Dhexe exhibited high positive  $G_i^*$  values ( $0.565$ – $1.362$ ), designating them as notable hotspots with



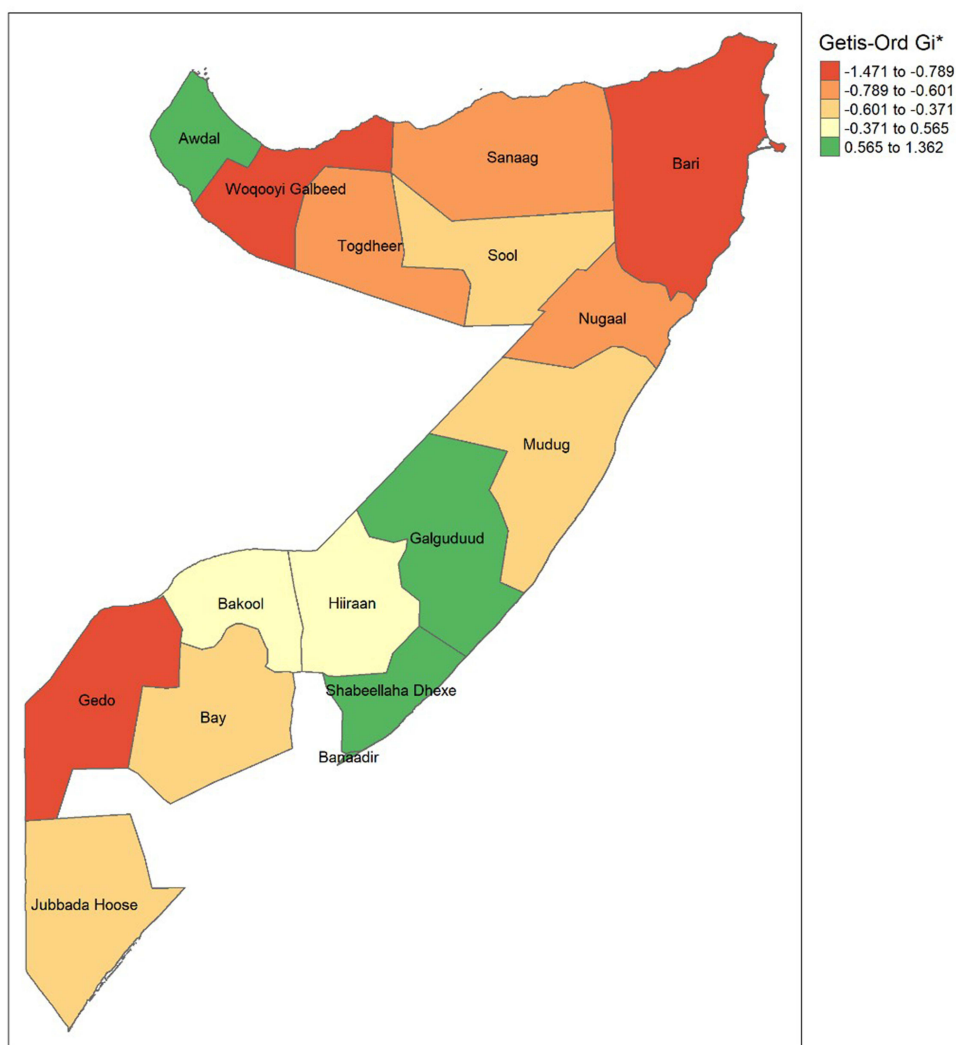
**Figure 6** Local Moran's I spatial autocorrelation (SDH,S 2020).

concentrated higher consumption. These areas, shown in green, may suggest improved dietary diversity or better access to specific foods. Conversely, regions such as Bari, Gedo, and Woqooyi Galbeed displayed strong negative  $G_i^*$  values ( $-1.471$  to  $-0.789$ ), marking them as significant cold spots with lower consumption clustering. These areas, highlighted in red, are priority zones that may require targeted nutritional interventions and public health initiatives. These findings underscore the considerable spatial variations in Vitamin A-rich food consumption and highlight the need for geographically focused, evidence-based public health strategies to address nutritional deficiencies throughout Somalia.

## Discussion

This research offers an in-depth evaluation of the consumption of Vitamin A-rich foods among children aged 6 to 23 months in Somalia, showing a low prevalence rate of 33.75%. Through multilevel analysis, it was determined that community-level factors contributed to 34.0% of the variation in consumption, with Model III emerging as the most suitable model. Important individual-level predictors included the child's age, the mother's education, media exposure, and household wealth, while community-level factors such as the region and place of residence were also significant. Additionally, spatial analysis revealed notable geographical clustering (Moran's  $I = 0.24$ ), pinpointing specific consumption hotspots in Awdal and Shabeellaha Dhexe and critical coldspots in Bari, Gedo, and Woqooyi Galbeed. These results emphasize the complex nature of nutritional deprivation in Somalia and highlight the necessity for interventions that tackle both sociodemographic and geographic disparities.

The proportion of infants and young children who met the recommended intake of vitamin A-rich foods was similarly low, with only 34% reaching the required consumption levels. The results of this study are higher than those of other studies conducted in Burundi (16%), Rwanda (23%),<sup>27</sup> Ethiopia (13.3%–24%),<sup>28</sup> and Wolaita Sodo, Ethiopia (18%).<sup>29</sup> However, these figures are lower than those reported in studies from other regions, such as India (58.1%),<sup>30</sup> Ghana (52%),<sup>9</sup> Malawi (79.1%),<sup>31</sup> and Bangladesh (72%).<sup>32</sup> These differences can be attributed to variations in socioeconomic



**Figure 7** Hotspot and Coldspot Analysis (Getis-Ord  $G_i^*$ ) (SDHS 2020).

status, access to various foods and levels of maternal education. Additionally, the study design, sample size, and measurement tools may have contributed to these discrepancies.

The research indicated that children aged 12–23 months were much more likely to eat foods rich in vitamin A than those aged 6–11 months, aligning with findings from studies conducted in Ethiopia.<sup>33–35</sup> This could be attributed to older children's greater exposure to family meals, enhanced chewing and digestion capabilities, and the tendency for many women to introduce weaning at a later stage in the child's development.<sup>36,37</sup>

Maternal education was positively associated with the consumption of foods rich in vitamin A, as evidenced by studies conducted in 91 low- and middle-income countries, including India.<sup>38–40</sup> Mothers with education tend to possess greater nutritional knowledge, access health-related information more effectively, and implement better feeding practices, which, in turn, improves their children's dietary quality.<sup>41,42</sup>

Exposure to media had a notably positive impact, consistent with research conducted in various regions of Ethiopia.<sup>43–45</sup> Mothers with access to media are more likely to obtain information related to nutrition, which can affect feeding practices and enhance dietary diversity. Children from more affluent families were more inclined to eat vitamin A-rich foods, which is consistent with studies from Ethiopia, India, Mexico, and Kenya.<sup>46–48</sup> A higher socioeconomic status provides better access to a variety of foods, including animal sources, fruits, and vegetables that are high in vitamin A.

Notable regional differences were identified at the community level in the study. Children residing in Banadir were more likely to consume vitamin A-rich foods, whereas those in Sool, Sanaag, Bari, Galgaduud, Hiraan, Bay, Bakool, Gedo, and Lower Juba had considerably lower chances of consuming vitamin A-rich foods.<sup>48–50</sup> These discrepancies may stem from variations in agricultural output, market accessibility and public health infrastructure. Additionally, children in rural and nomadic regions were less inclined to fulfil vitamin A intake guidelines than their urban counterparts,<sup>51–53</sup> likely due to restricted access to markets, healthcare services, and a variety of food sources.

Spatial analysis revealed notable clustering in consumption patterns, identifying hotspots in Awdal and Shabellaha Dhexe, while cold spots were identified in Bari, Gedo, and Wogooyi Galbeed. This highlights the importance of geographically focused interventions to address localised nutritional deficiencies.

While this study provides a comprehensive analysis using a large, nationally representative dataset, it is important to recognize several limitations. Firstly, the cross-sectional nature of the SDHS prevents the determination of causal links between the identified factors and Vitamin A consumption. Future investigations should utilize longitudinal or prospective cohort studies to observe dietary changes over time and verify the direction of these relationships. Secondly, the reliance on maternal 24-hour recall is prone to recall bias and may not accurately represent long-term dietary habits. To address this in future evaluations, researchers should consider employing multiple-day food records or validating recall data with biochemical markers like serum retinol or retinol-binding protein (RBP) levels. Thirdly, the survey did not provide quantitative data on the amount of food consumed, which limits our ability to assess whether the intake meets the complete physiological needs for Vitamin A. Future nutritional surveys in Somalia should include weighed food records or portion-size estimation tools to offer a more detailed view of nutrient adequacy. Lastly, the dataset lacked variables such as household food security status, local market prices, and cultural feeding taboos. Future studies should aim to connect DHS data with market price monitoring systems (eg., FSNAU) and qualitative ethnographic research to gain a better understanding of the economic and cultural obstacles to accessing Vitamin A-rich foods in nomadic and rural communities.

## Conclusion

This study highlights the low prevalence of vitamin A-rich food consumption among Somali children aged 6–23 months, with significant disparities driven by socio-demographic and geographic factors. Multilevel analysis revealed that both individual- and community-level factors substantially contributed to these results. Key determinants included the child's age, maternal education, media exposure, household wealth, region, and residence. The spatial clustering of consumption patterns further emphasises the need for context-specific multisectoral interventions. Strategies should focus on improving maternal education, enhancing access to health services and information, addressing economic inequalities, and implementing regionally tailored programs to improve vitamin A intake and reduce micronutrient deficiencies in Somalia. Given that Vitamin A deficiency is a major driver of preventable blindness and immune dysfunction, the public health significance of this study is underscored by its contribution to the evidence base needed to achieve Sustainable Development Goals related to ending “hidden hunger” and ensuring healthy lives for all Somali children.

## Abbreviations

VAD: Vitamin A Deficiency; IYC: Infant and Young Child. SDHS, Somali Demography and Health Survey; SDG, Sustainable Development Goals; SSA, Sub-Saharan Africa; WHO, World Health Organization.

## Data Sharing Statement

Data is available online using this link on free access Somalia - Somali Health and Demographic Survey 2020 (nbs.gov.so).<sup>15</sup>

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors report no competing interest in this work.

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