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RESEARCH ARTICLE
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The Landscape of Vitamin A Deficiency Mitigation Efforts in Kenya

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Abstract:

Background: Vitamin A deficiency (VAD) remains a critical public health problem in Kenya, particularly among preschool-aged children. VAD is a leading cause of preventable childhood blindness, increases susceptibility to infections, and contributes to premature death. Kenya has implemented multiple interventions, including VA supplementation, food fortification, biofortification of staple crops, and the promotion of diversified diets. However, the effectiveness and equity of these measures require closer examination.

Methods: This study synthesizes evidence from three main sources: nationally representative data and policy documents, academic articles and working papers related to VAD in Kenya, and databases from international authoritative organizations. The evidence was analyzed to assess progress and identify policy and implementation gaps for improved VAD intervention in Kenya.

Results: Evidence shows that access to and coverage of Kenya's VAD interventions remain uneven. VA supplementation has achieved variable coverage, with rural and low-income households less likely to benefit. Food fortification of wheat flour, maize flour, and edible oils has been mandated since 2012, but compliance is inconsistent, particularly among small- and medium-scale millers. Cases of fraudulent practices and non-compliance highlight regulatory loopholes and weak enforcement. A biofortified crop, orange-fleshed sweet potato, has shown promising nutritional impact, whereas biofortified maize and cassava face sensory acceptance issues and market challenges. Consumer awareness of VAD and fortified foods remains low, resulting in insufficient demand.

Discussion: Policy gaps persist due to uneven access, weak enforcement, low consumer awareness, and reluctance toward adoption. Effective implementation requires stronger monitoring mechanisms and credible penalties for non-compliance, economic incentives for adopters, and intensive promotion of fortified foods and crops through nationwide sensitization campaigns.

Conclusion: Sustained and systematic data collection on VAD prevalence and intervention outcomes is essential for evidence-based policy formulation. Kenya should renew its political commitment to ensure more equitable, accountable, and sustainable VAD mitigation strategies.

Keywords: Biofortification, Food fortification, Hidden hunger, Kenya, Micronutrients, Vitamin A deficiency, Vitamin A supplementation.

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1. INTRODUCTION

Globally, Vitamin A deficiency (VAD) is one of the most prevalent micronutrient deficiencies, affecting 30% of preschool-aged children, mainly in developing countries [1]. It is a major cause of preventable childhood blindness and increases the severity of diseases such as measles and diarrhea. In severe cases, VAD can lead afflicted children to premature death [2]. The World Health Organization (WHO) states that VAD becomes a critical public health concern when its prevalence in children aged 6–59 months exceeds 20%, measured by a vitamin A (VA) serum level below 0.7 mol/L [1, 3]. VAD is typically caused by chronically insufficient consumption of VA [4], suboptimal absorption of the micronutrient, and frequent infections that deplete VA stored in the body [1].

To address VAD in children, international and national agencies have introduced multiple interventions, including the promotion of diversified diets with VA-rich foods, VA supplementation programs, mandatory food fortification, crop biofortification, and nutrition education campaigns. While effective implementation of these measures is essential for improving VA status, it is equally important to critically assess their current status. Without updated reviews, the adoption of overlapping VAD interventions may result in unsound policy choices, misinformed public health guidelines, and unnecessary financial burdens on governments. This study focuses on Kenya, one of the countries most affected by VAD.

VAD remains a serious public health concern in Kenya, particularly among preschool-aged children. An estimated 9.2% of children are VA deficient, and 52.6% are marginally deficient [2, 5]. Kenya also reports the lowest VA consumption among 12 East African countries: only 34% of respondents had adequate intake compared to a regional average of 63% [4]. Since 2000, Kenya has been a priority country for VA supplementation (VAS) supported by the United Nations Children's Fund (UNICEF) [6]. Additional measures, including mandatory food fortification and the release of VA-biofortified crops, have also been introduced. However, the presence of multiple interventions does not guarantee effective VAD reduction. Interventions may be concentrated in certain localities (coverage gaps), poorly regulated (enforcement issues), or insufficient in creating consumer demand (awareness gaps).

Against this backdrop, the study has two objectives: first, to examine the current landscape of VAD mitigation efforts in Kenya by synthesizing available evidence, and second, to identify policy gaps and opportunities for improving VA status among Kenyan children. The findings are intended to inform policy dialogues by providing an updated review of ongoing interventions. Such dialogues are critical for clarifying ambiguities, addressing shortcomings, and identifying opportunities in VAD reduction efforts. The remainder of the study is organized as follows: Section 2 describes the materials and methods, Section 3 presents and discusses results of the interventions implemented in Kenya, and in the last Section concludes with policy recommendations.

2. MATERIALS AND METHODS

This study draws mainly on three sources to analyze and synthesize empirical evidence on VAD mitigation efforts in Kenya. First, nationally representative data and policy documents were reviewed, including the Kenya Demographic and Health Surveys (2008, 2014, and 2022), nutrition-related policy documents, and agricultural production reports. Second, published academic articles and working papers directly and indirectly related to Kenya's VAD issues were examined for additional data and insights. Third, statistical information was collected from international databases maintained by UNICEF, WHO, and the Global Fortification Data Exchange.

3. RESULTS AND DISCUSSION

3.1. Vitamin A Supplementation

Children can develop VAD early in life due to habitual poor diets, frequent infectious diseases, and low VA levels in breastfeeding mothers. International organizations recommend that children aged 6–59 months in VAD-affected areas receive two high-dose VA supplements per year, typically four to six months apart [7]. These doses are delivered in soft gel capsules containing retinol, the most active form of VA [7, 8]. Since the 1990s, following evidence linking VAD to increased childhood mortality [1], VAS has become a widely adopted intervention. As of 2025, UNICEF supports VAS in 64 priority countries, including Kenya [6]. In sub-Saharan Africa, the primary delivery channel is semi-annual health campaigns, often integrated with polio vaccination programs [9]. However, critics argue that supplementation is not a sustainable solution. Many governments rely heavily on external funding, and achieving effective VAS coverage (at least 80% of the target population) is challenging. In addition, polio vaccination campaigns are being scaled back, limiting delivery channels, and the protective effect of a single dose lasts only three to four months [1, 9, 10].

Over the past two decades, the average two-dose VAS coverage in Kenya was 44%, with annual fluctuations ranging from 0% to 86% [6]. In earlier years, Kenyan children received supplementation through National Immunization Days for polio and measles, *i.e.*, door-to-door health campaigns conducted twice annually. In 2007, these campaigns were transitioned to a healthcare facility-based delivery system to reduce implementation costs [7]. Currently, VAS is provided through routine contacts at community health facilities, mainly *via* Malezi Bora campaigns. *Malezi Bora*, meaning "good nurturing," is a biannual maternal and child health event typically held in May and October over two weeks [2, 7]. This campaign represents a top-down, resource-intensive approach with strong community involvement. Consequently, coverage achieved through *Malezi Bora* campaigns is generally higher than that of routine facility-based supplementation [2].

Despite nationwide campaigns to deliver VA capsules, evidence shows that supplementation coverage remains uneven across geographic and socioeconomic groups (Table **1**) [6, 11-13]. Higher coverage rates are consistently associated with urban areas compared to rural areas, higher maternal education compared to no education, and higher wealth quantiles compared to the lowest [11-13]. This inequality in access to VAS is not unique to Kenya. Similar patterns have been reported in Ethiopia, where coverage was also higher in urban areas and among wealthier households [14]. Mothers in urban areas, with greater resources and higher education levels, are likely to have better access to VA-related information and a greater ability to understand and act on it. In Kenya, a study further indicated that VAS coverage is influenced by caretaker awareness of supplementation campaigns and by the costs of reaching each child. The per-child cost ranged from USD 1.81 to USD 11.13, reflecting differences in personnel and overhead expenses as well as logistical complexities in capsule distribution at the subnational level [7].

International donor funding plays a significant role in determining VAS coverage rates. Donors provide Kenya with substantial financial and technical support for supplementation supervision. Areas receiving higher levels of donor funding are able to conduct more intensive VA distribution campaigns compared to those with limited support [2, 7]. Although evidence links VAS to improved VA status in children [15], persistent inequities in coverage and access (particularly among less educated, rural, and low-income populations) remain a challenge. At the same time, some studies question the continued necessity and effectiveness of large-scale VA capsule provision. They cite declining infectious disease prevalence, rising child immunization rates, and expansion of food-based VAD interventions [14]. The next section examines these food-based interventions, often regarded as more sustainable and effective than VAS.

3.2. Food-based Vitamin A Deficiency Interventions

Food-based interventions to address VAD focus on ensuring sufficient VA intake through habitual diets. Different food sources provide different forms of VA, but only animal-based foods supply the most active form, known as preformed VA [3]. In contrast, plant-based foods provide pro-VA carotenoids, which must be metabolized into active VA before being utilized in the body [8]. Among these carotenoids, beta-carotene has the highest pro-VA activity, though its conversion efficiency is far lower than that of preformed VA: 1:1 for preformed VA (1 μg equals 1 μg Retinol Activity Equivalent) *versus* 12:1 for beta-carotene [3]. Because of this low conversion ratio, higher consumption of plant-based foods does not necessarily improve VA status [16]. In addition, absorption and utilization of VA are influenced by factors such as the food matrix, degree of processing, and the presence of dietary fat, since VA is fat-soluble.

A study indicates that children aged 6–23 months in sub-Saharan Africa consume low levels of animal-source foods, with the lowest consumption observed in East Africa. The proportion of children consuming animal-source foods was 23.7% in sub-Saharan Africa and 21.4% in East Africa [17]. Kenyan children similarly consume minimal amounts of animal-source foods, suggesting that their VA requirements must be met primarily through plant-based diets [8]. Only 34% of reproductive-aged Kenyan women reported adequate VA consumption, compared to an East African average of 63% [18]. Since the VA status of breastfeeding mothers directly affects their infants, this finding suggests that Kenyan infants are at an increased risk of developing VAD. Against this background, the following subsections examine food-based interventions, namely diet diversification, food fortification, and biofortification.

3.2.1. Diet Diversification

Promotion of dietary diversification encourages target populations to consume diets that naturally provide sufficient VA. The effectiveness of this approach depends on the availability and accessibility of VA-rich foods, prevailing dietary patterns, socioeconomic status and purchasing power, as well as nutrition knowledge and awareness of the importance of diversified diets [3]. Because animal-source foods are generally scarce in sub-Saharan Africa [17], alternative VA-rich foods include dark green leafy vegetables, carrots, and pumpkins [18]. In Kenya, these crops are not widely consumed, and the main staples, such as maize, Irish potatoes, beans, and sweet potatoes, contain little or no pro-VA carotenoids [19].

Table 1. Vitamin A supplementation coverage among Kenyan children by select demographic and socioeconomic factors, 2008-2022.

Survey Year	Total (%)	Locality		Wealth Quantile		Mother Education	
		Urban	Rural	Highest	Lowest	Secondary or Above	No Education
2008	29. 3	33. 8	28. 2	33. 4	28	33. 5	26. 4
2014	68. 7	72. 4	66. 7	73. 4	61. 3	72. 8	60
2022	60. 6	64. 9	61	66. 3	50. 4	66. 9	43. 3

Note: The National Demographic and Health Survey collected VA supplementation data in the last six months. Thus, differences exist in data sets between the National Demographic and Health Survey and UNICEF

Table 2. Consumption of VA-rich foods among Kenyan children aged 6-35 months, by socioeconomic and demographic factors.

Survey Year	Total	Locality		Region			Wealth Quantile		Mother Education	
		Urban	Rural	Nairobi	North Eastern	Central	Highest	Lowest	Secondary or Above	No Education
2008	74. 3	85	72. 4	81. 2	25. 9	88	82. 6	57. 8	83. 7	41. 9
2014	72	80. 7	62. 2	97	25	80. 7	83. 1	48. 6	80. 4	37. 2

Note 1: The National Demographic and Health Survey of 2022 did not separately collect VA-rich food consumption data.
Note 2: The National Demographic and Health Survey collected data on the VA-rich food consumption of children aged 6-35 months in the last 24 hours.

The Kenya National Demographic and Health Surveys reported that 77% of children aged 6–35 months consumed VA-rich foods in 2008, and 72% in 2014 (Table **2**). The 2022 survey did not separately collect data on VA-rich food consumption. In these two surveys, VA-rich foods included both animal-source and plant-based foods. Given the typical composition of Kenyan household diets, the VA-rich foods consumed by children were likely dominated by plant-based sources. As with VAS coverage, geography, maternal education, and household wealth quantile influenced children's consumption of VA-rich foods (Table **2**) [11, 12].

Children living in urban areas, particularly around the capital city, Nairobi, with well-educated mothers and in the highest wealth quantile consumed more VA-rich foods compared to those in rural or northeastern regions, with mothers lacking education, and in the lowest wealth quantile [11, 12]. Similarly, a study found that maternal education, household wealth, marital status, and media exposure were significant predictors of VA-rich animal-source food consumption among children aged 6–23 months in sub-Saharan Africa [17]. In East Africa, older, more educated, employed, wealthier, literate women with greater media exposure were also more likely to consume VA-rich foods than their counterparts [4]. These women may have better access to VA-rich foods and more resources to obtain and use VA-relevant information. In principle, promoting the consumption of VA-rich foods is an effective and sustainable strategy to reduce VAD. In practice, however, the primary target group, the less educated rural poor in remote areas, often lacks the means to do so. Therefore, these populations need social support, such as food vouchers and nutrition education, to improve access to diversified VA-rich diets in the Kenyan context.

3.2.2. Food Fortification

Food fortification refers to the practice of adding micronutrients to commonly consumed staples and condiments during processing to increase their nutritional value [20]. As of October 2024, 143 countries had mandated the fortification of at least one staple food, such as rice, maize flour, wheat flour, oil, sugar, or salt [3, 21]. Because it requires little change in habitual dietary patterns, food fortification is considered a low-cost, high-impact strategy for addressing VAD [22].

For fortification programs to be effective, several conditions must be met. First, there should be appropriate food vehicles, *i.e.*, widely consumed food items to which nutrients can be added [23]. Second, food distribution networks and processing industries must function effectively at scale [3]. Third, the majority of the population must purchase and consume processed foods, and fourth, well-established regulatory systems must be in place. In addition, the fortificant, the chemical form of the added micronutrient, must be safe, stable, sufficient, and effective for target groups [24]. Critics of fortification argue that uneven access to fortified foods, especially among VAD-vulnerable households in remote rural areas, undermines its effectiveness [9]. They also note that efficacy can only be assessed at the point of consumption because sufficient quantities of fortified foods must be consumed and the fortificant must remain adequately active [25].

In Kenya, food fortification began in 1972 with voluntary salt iodization [5]. Building on this success, the Government of Kenya expanded fortification programs over time. In 2005, the Kenya National Food Fortification Alliance (KNFFA) was established to coordinate efforts, bringing together the Ministry of Health, the Kenya Bureau of Standards, research institutions, development partners, industry associations, and consumer organizations [5]. By 2012, legislation mandated the fortification of maize flour, wheat flour, and edible oils. The Food, Drugs and Chemical Substances Act was amended in 2012 and 2015 to align standards and labeling requirements for fortified foods with East African Community regulations [5, 26]. Specifically for VA, the law required fortification of wheat flour, maize flour, and vegetable oil (Table **3**). These commodities were selected because of their wide consumption and affordability across all wealth quintiles in Kenya [24].

Compared to wheat flour, maize flour is fortified at a significantly lower rate (Table **3**). Maize is Kenya's most important staple, with annual per-capita consumption estimated at 98–100 kg [19, 27]. Large-scale mills, with daily processing capacities above 50 tons, dominate the maize flour market and account for 76% of total daily production. One study found that 51.4% of surveyed mills implemented mandatory fortification: all large-scale mills fortified 100% of their maize flour, whereas medium-scale mills fortified 45.8% and small-scale mills only 24.1% [27].

Reviews identified the weak engagement of small- and medium-scale mills as a major barrier to effective fortification [20]. Their limited participation is often attributed to financial constraints, lack of equipment, and insufficient technical capacity for quality assurance, all of which hinder consistent compliance with standards [15]. To encourage greater participation, financial incentives such as tax credits may be required.

Table 3. Kenya's mandatory Vitamin A fortification by commodity with coverage, quantities, and standards.

Contents / Target Commodity	Maize Flour	Wheat Flour	Oil
Fortification mandatory year	2012	2012	2012
Proportion fortified % #	46%	84%	Unavailable
Quantity fortified (MT) #	541222 tons	1676418 tons	Unavailable
VA as Retinyl Palmitate	0. 5 mg/kg §	2 mg/kg ʃ	30 mg/kg

Note: (Source) Global Fortification Data Exchange at https://www.fortificationdata.org, #: 2023 as reference year, §: 33% of WHO recommended level, ʃ: 34% of WHO recommended level.

Fortified maize flour in Kenya also shows high rates of non-compliance with legal standards. Evidence indicates that only one third of fortified maize flour samples met fortification requirements, with substantial regional variation: 29.6% compliance in Nairobi/Central compared with only 3.7% at the Coast [24]. These differences are partly explained by environmental conditions. The Nairobi/Central region is relatively dry, whereas the coastal region is hot and humid. Temperature and humidity affect micronutrient stability, including VA, leading to degradation and loss of VA in fortified foods [24].

Research on VA-fortified wheat flour in Kenya is limited. However, evidence from Nigeria shows that VA stability in wheat flour ranged from 21% to 61% of fortification standards, with compliance rates as low as 6% [25]. Given similar production and regulatory challenges, VA-fortified wheat flour in Kenya is likely to face comparable issues, including poor quality and low population coverage [15].

Furthermore, a study found that 10% of mills in Kenya using the food fortification logo did not actually fortify their products [27]. The logo, introduced in 2006, was intended to be displayed on the packaging of fortified foods [26]. This fraudulent practice may result from limited monitoring and surveillance and weak law enforcement. The Kenya Bureau of Standards and the Food Safety Unit of the Ministry of Health are the principal regulatory bodies; however, one study estimated that they conducted micronutrient analyses at only 37% of mills nationwide [27].

Ambiguities in penalties further contribute to non-compliance. Kenya's food fortification law does not specify clear penalties for violations; instead, penalties are left to the discretion of local officials [26]. This lack of clarity weakens enforcement, making it inconsistent and ineffective. Overall, available studies highlight major loopholes in Kenya's food fortification regulations and underscore the need for a comprehensive evaluation of VA fortification programs and related policies.

The success of VA fortification also depends on consumer participation, which requires adequate awareness and nutritional knowledge. However, awareness of food fortification in Kenya remains low; only 28% of surveyed respondents reported being aware of fortification [28]. Awareness was higher among women, older individuals, the more educated, and those in formal employment [28]. Other studies reported similar findings; only 27% of respondents knew how to identify fortified products in the market [26], and 26% were aware of the importance of VA in the diet [29]. Therefore, limited consumer awareness of fortified foods and their health benefits remains a significant barrier to generating sufficient market demand.

3.2.3. Biofortification

The WHO defines biofortification as the process of enhancing the nutritional quality of food crops through agronomic practices, conventional plant breeding, or modern biotechnology [3]. Compared to VAS and food fortification, biofortification is often viewed as a more sustainable approach to addressing VAD, particularly for populations in remote rural areas [30]. The rural poor, who rely heavily on subsistence farming, typically have limited access to VA supplements delivered through health facilities and to VA-fortified foods available in markets [20, 31]. Given the predominance of smallholder subsistence farming in Kenya, the adoption and consumption of VA-biofortified staple crops could play a critical role in improving VA status.

The success of VA-biofortified crops depends on their acceptance by both producers and consumers. Farmers adopt new varieties based on comparative agronomic advantages, while consumers focus on sensory attributes such as taste, color, and texture [18]. If VA-biofortified varieties do not perform as well as conventional crops, adoption is unlikely. Moreover, the efficacy of pro-VA carotenoids can be compromised by post-harvest handling, processing, and cooking. Owing to their highly unsaturated structure, carotenoids are vulnerable to degradation by heat, oxygen, and light [31]. For example, one study found that VA-biofortified cassava retained only 27–56% of VA after drying, whereas drying had minimal effects on VA-biofortified sweet potatoes. The same study reported that processed flours from VA-biofortified maize, cassava, and sweet potato retained as little as 20% of VA after up to four months of storage [31]. These findings indicate that the effectiveness of VA-biofortified crops can vary markedly at the point of consumption.

As of 2025, Kenya has officially released VA-biofortified sweet potato varieties, commonly known as orange-fleshed sweet potatoes (OFSP), while VA-biofortified maize and cassava varieties remain under testing prior to release [32]. The following sections focus on these three VA-biofortified crops most relevant to Kenya.

Sweet potatoes (*Ipomoea batatas*) are widely cultivated in Kenya for both household consumption and livelihoods, with an estimated annual yield of 0.87 million tons [33]. The crop can be harvested year-round and thrives across diverse agro-ecological zones [34]. Traditionally considered a women's crop, sweet potatoes are easily integrated into kitchen gardens [30, 35]. However, the dominant varieties grown in Kenya are white- and yellow-fleshed types, which contain low levels of pro-VA carotenoids. These characteristics made sweet potatoes a strategic target for VA-biofortification.

Two released OFSP varieties, Kabode and Vitaa, are rich in pro-VA carotenoids, and a daily intake of 100–125 g can meet the recommended daily VA requirement for children [33-35]. OFSP varieties also possess favorable agronomic traits, including faster maturation, higher yields, and suitability for value addition [18, 30]. Promotion strategies in Kenya have included distributing OFSP vines to households, establishing OFSP school gardens, and integrating OFSP into school feeding programs [30, 35].

In 2010, the Sweet Potato Action for Security and Health in Africa Project was launched in western Kenya as a proof of concept. The project engaged farmers as vine multipliers and extension officers as crop management supporters, while caretakers received vouchers for OFSP vines alongside sensitization campaigns. Findings showed that OFSP production and consumption increased, mothers' VA status improved, and children's stunting rates declined [9]. Despite the drastic color shift from white to orange, OFSP was generally well accepted due to its soft texture as well [36].

As a VAD-mitigation measure, the efficacy of OFSP depends on sustained consumption and high replanting rates [30]. Integrated, multi-channel campaigns involving both caretakers and children have been highly effective in promoting OFSP production and consumption [30, 35]. In contrast, single-channel campaigns did not significantly increase the likelihood of caregivers retaining OFSP on their farms after the initial distribution of planting material [30]. Despite promising outcomes, challenges persist. Market brokers who influence traded varieties often hold negative views of OFSP [37]. Some consumers believe that OFSP has contraceptive effects [10]. Additionally, rural households face high transaction costs when vine multipliers are not located nearby [9].

Maize (*Zea mays* L.) is a primary food source in Kenya, consumed by 85% of the population and contributing roughly 20% of national agricultural production [38]. Smallholder farmers produce more than 80% of maize, but the dominant varieties are white and low in pro-VA carotenoids [38]. This made maize an appropriate target for VA-biofortification, especially for subsistence farmers. VA-biofortified maize has a deep yellow to orange color due to carotenoid accumulation in the endosperm. However, unlike OFSP, this color change is a major barrier to acceptance, as yellow maize in sub-Saharan Africa is often associated with relief food or animal feed and is therefore perceived as "food for the poor." Overcoming this stigma is essential for improving acceptance of VA-biofortified maize [8].

Adoption is further constrained by farmer and market dynamics. Smallholders are often reluctant to adopt new varieties unless they align with their production priorities. Market prices also shape adoption decisions; if biofortified maize seeds are more expensive, or if the grain sells for less because of its orange color, farmers are unlikely to adopt them [8]. For these reasons, color stigma, reluctance to adopt unfamiliar varieties, and market uncertainty, the uptake of VA-biofortified maize in Kenya may be slow.

Concerns also exist regarding the efficacy of VA-biofortified maize. A study in Zambia found that routine consumption increased children's beta-carotene concentrations but did not improve VA status as measured by serum retinol. Limited conversion of beta-carotene to VA, likely due to high infection rates among children, was a probable explanation [39]. This issue may be relevant to Kenyan children, many of whom face infectious morbidities. Additionally, the instability of carotenoids means that storage conditions directly affect the efficacy of VA-biofortified maize [8].

Cassava (*Manihot esculenta* Crantz) is a starchy staple widely grown and consumed in Kenya. It serves as a food reserve when other crops fail, as it is well adapted to arid areas and nutrient-poor soils. The predominant varieties in Kenya have white roots with minimal pro-VA carotenoid content [40]. Similar to OFSP and VA-biofortified maize, VA-biofortification changes cassava root color from white to deep yellow due to increased beta-carotene. Some evidence suggests that higher pro-VA carotenoid levels may also affect cassava's taste because carotenoid accumulation is associated with lower dry matter content. However, unlike maize, the color change does not appear to hinder acceptance. In eastern Kenya, VA-biofortified cassava was perceived as favorable in both color and taste, with children preferring yellow over white varieties. Carotenoids may also reduce post-harvest physiological deterioration, potentially allowing longer storage of VA-biofortified cassava compared with white cassava [41]. A study in Nigeria similarly reported greater acceptance of VA-biofortified cassava products than white cassava, with the yellow color not perceived as a barrier [42].

Regarding efficacy, a study in Kenya found that daily consumption of boiled yellow cassava modestly increased serum retinol concentrations while substantially increasing beta-carotene levels. The modest rise in serum retinol, despite large increases in beta-carotene, suggests poor conversion of beta-carotene into active VA [40]. Another study in eastern Kenya showed that incorporating VA-biofortified cassava into school lunch programs improved dietary VA adequacy compared with lunches without cassava [43]. VA retention in VA-biofortified cassava varies by processing method; boiled cassava retained more than 90% of pro-VA carotenoids, whereas other preparation methods retained only 1–18% [44]. Beta-carotene retention ranged from 10–29.3% depending on storage duration and processing techniques [31]. As with other VA-biofortified crops, predictors of consumption include knowledge and awareness of pro-VA cassava, recognition of its health benefits, and recommendations from healthcare workers [41].

CONCLUSION

Kenya has implemented a broad set of interventions to address VAD, including VAS, food fortification, biofortification of staple crops, and the promotion of diversified diets. Although these measures have increased access to VA, their reach and impact remain uneven and fragmented. Children in rural and remote areas, particularly those from poorer households and with less educated mothers, continue to face limited access to VA supplements, fortified foods, and diversified diets. Addressing these inequities should remain central to Kenya's VA policy priorities.

VAS has long been a cornerstone of Kenya's VAD strategy, yet coverage remains inadequate. This strategy is also heavily reliant on external donor funding, and its delivery channels have weakened as polio campaigns are scaled back. For these reasons, VAS alone is unlikely to provide a sustainable, long-term solution. Food-based approaches offer more durable prospects but require overcoming persistent challenges related to enforcement, consumer perceptions, and market acceptance.

Food fortification, despite its promise as a low-cost and high-impact intervention, faces significant implementation challenges. A considerable share of VA-fortified maize flour on the market does not meet mandated standards, and some mills engage in fraudulent practices. Weak regulatory enforcement, particularly the lack of explicit legal penalties, further undermines program effectiveness. Strengthening regulatory oversight and establishing clear penalties for non-compliance are therefore essential. Equally important is expanding engagement with small- and medium-scale millers, who produce a substantial portion of Kenya's flour but often lack the financial and technical capacity needed to comply with fortification regulations. Financial incentives such as tax credits, subsidies, or equipment support could help offset compliance costs and encourage broader participation.

VA-biofortified crops such as OFSP, maize, and cassava show considerable potential, yet their adoption depends on addressing misconceptions, overcoming sensory barriers, and developing functioning markets. Sustained multi-channel promotion campaigns, school feeding programs, and agricultural extension support are needed to improve awareness, acceptance, and retention rates among both farmers and consumers. Low consumer awareness and weak demand remain major bottlenecks; many Kenyan households are unaware of fortified foods or do not understand the importance of VA in the diet. Renewed national sensitization and nutrition education campaigns, delivered through schools, health facilities, and mass media, are therefore necessary.

Finally, effective VA policy must be guided by accurate, timely, and comprehensive evidence on VAD prevalence and intervention performance. Reliance on outdated assumptions risks misinterpreting intervention outcomes and masking emerging challenges. For example, hyper-vitaminosis, overconsumption of VA, has been reported in countries implementing multiple overlapping VA interventions [45]. In Kenya, the evidence synthesized in this study indicates that hyper-vitaminosis is not currently an urgent public health concern. However, without up-to-date data, assessing the combined effects of VAS, fortification, and biofortification remains difficult. Systematic and sustained data collection along VAS delivery systems and VA food chains is therefore essential. Such monitoring would enable policymakers to evaluate program performance, detect non-compliance, and adjust strategies to safeguard public health, both by preventing VAD and avoiding the potential risks of hyper-vitaminosis.

AUTHOR'S CONTRIBUTION

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

LIST OF ABBREVIATIONS

KNFFA	=	Kenya National Food Fortification Alliance
OFSP	=	Orange-fleshed sweet potato
UNICEF	=	United Nations Children's Fund
VA	=	Vitamin A
VAD	=	Vitamin A deficiency
VAS	=	Vitamin A supplementation
WHO	=	World Health Organization

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

HUMAN AND ANIMAL RIGHTS

Not applicable.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available in the Kenya National Bureau of Statistics at https://www.knbs.or.ke/kenya-demographic-health-surveys/.

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CONFLICT OF INTEREST

The author declares no conflict of interest, financial or otherwise.

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