ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 22 No. 3
April 2022
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2022; 22(3): 19929-19944 https://doi.org/10.18697/ajfand.108.21735

THE STATUS OF UGANDA'S FOOD-BASED VITAMIN A DEFICIENCY MITIGATION STRATEGIES

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Volume 22 No. 3
April 2022
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ABSTRACT

Vitamin A deficiency (VAD) threatens public health especially among children in developing countries. Various interventions and their efficacy have been much discussed at a global level to alleviate VAD. Yet, studies indicate individual countries afflicted with VAD may be running relevant programs without adequately updated data or evidence from situational analyses. This study takes Uganda as a case to examine the status of its existing VAD mitigation programs, focusing on food-based interventions. To review the VAD mitigation programs, nationally representative data from the Ugandan public institutions, policy documents from the government and VAD-relevant data from the United Nations agencies were mainly examined. Also analyzed in detail were published studies and working papers directly or indirectly related to Uganda's VAD and/or VA issues. The results from the review pointed to some evidence on the existing issues with the country's VAD mitigation strategies. First, gauging a temporal trend of VAD prevalence in the target population was not possible due to changes and inconsistencies in the survey formats and methodologies. This implies the present VAD interventions might rely on unsynchronized VAD assessments in the first place. Second, of the ongoing food-based VAD interventions, effectiveness of food fortification with VA seemed constrained by questionable food vehicle choices, reluctant food industries, low stakeholder engagement, and weak public supervision. Third, for biofortification, wide adoption/utilization of the VA-biofortified orange sweet potato appeared to be complicated by farmer and consumer preferences, social factors, and immature value chains of the crop. But adoption/utilization of the genetically modified VA-biofortified banana seems to have been even more complicated by additional issues around the relevant biotechnology law of the country and public concerns about the genetic modification. Collectively, these VAD interventions in Uganda appeared to be continued without sufficiently updated documents and monitoring frameworks. This suggests that Uganda should review its current VAD interventions for more effective and efficient VAD mitigation.

Key words: Biofortification, Food fortification, Public health, Vitamin A deficiency, Uganda

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INTRODUCTION

Vitamin A deficiency (VAD) threatens public health especially in preschool-aged children in developing countries. In 2013, the estimated prevalence of VAD was 29% among children aged 6 to 59 months in low- and middle-income countries, decreased from 39% in 1991 [1]. Yet, the prevalence in many parts of sub-Saharan Africa still remained high, ranging from 25% to 75% among the children [2]. Vitamin A is required for multiple biological processes including the visual system, maintenance of cell function for growth, and immunity. Accordingly, VAD is associated with increased vulnerability to preventable blindness and other illnesses, which can lead to higher morbidity and mortality in children [1, 2].

Thus, to alleviate VAD, international and national entities have been implementing various interventions such as VA supplementation (VAS), food fortification, crop biofortification, micronutrient powder, dietary diversification, and nutrition campaigns [3, 4]. While these interventions are key to mitigate VAD, limited documents on VAD and VA programs often prevent countries from making timely informed decisions for more effective application of their VAD strategies [3, 5]. Wirth *et al.* [3] examined data from 82 developing countries and found most countries ran VAS and other VA programs without accurate or updated VAD data [3]. Therefore, attention needs to be paid to individual countries under the VAD burden to identify what available evidence in the previous studies indicates about their VAD mitigation strategies and what obstacles they face for more effective VAD reduction.

This study focuses on Uganda for three reasons, among the countries in sub-Saharan Africa where the heaviest VAD burden exists [2]. First, Uganda is a priority country for the United Nations Children's Fund (UNICEF)'s VAS support as a VAD-heavy country among the children [2, 6]. Second, the country implements food fortification and crop biofortification as part of its VAD mitigation strategies; Uganda mandated VA-fortified foods and released conventionally bred VA-biofortified crops to increase VA intake. Third, Uganda is about to release a genetically modified (GM) VA-biofortified banana while the countrywide debates around GM products continue. This study aims to explore the current situation with the country's VAD programs, focusing on food-based interventions and identify issues associated with them. Findings may offer circumstantial evidence for a dialog point among the Ugandan stakeholders for better VAD mitigation strategies.

MATERIALS AND METHODS

This study attempts to review the status of the VAD-relevant situations and the mitigation strategies of Uganda. The timeframe for the review was set between early 2000s and 2020 during which statistical data on Uganda's VA and VAD were largely available. Since a systemic review was little possible due to scarcely available literature on the subject, the review mainly relied on the three sources. First, nationally representative data and policy documents were searched and examined. They included, but not limited to, the Uganda Demographic Health Surveys (UDHS) between 2001

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and 2016 (the 2021 version is yet to be published) and the Annual Health Sector Performance Reports of Uganda (AHSPR) [7-10]. Second, published studies, which were directly or indirectly related to Uganda's VA or VAD issues were analyzed for the details and the discussions. Third, working papers, reports from international organizations, and databases such as the United Nations Children's Fund (UNICEF) Global VAS Coverage Database and the World Health Organization (WHO) Vitamin and Mineral Nutrition Information System were examined and referred to if they provided reliable information. For additional evidence, personal communications were carried out with stakeholders.

RESULTS AND DISCUSSION

Status of vitamin A deficiency of Ugandan children

Presently, the most nationally representative source of the VAD status may be UDHS, conducted every five years [7]. Since 2001, UDHS has estimated VAD prevalence in children aged 6-59 months as part of measuring their nutritional status. Infants younger than 6 months are generally excluded because breastfeeding can reduce their vulnerability to VAD although poor breastfeeding practices or maternal VA statuses can affect VAD risks in infants [7].

The overall VAD prevalence in 2001 was 27.9% with the cut-off serum retinol concentration of 0.7 μML^{-1} in the blood samples of children (Table 1) [8]. Living in rural areas and being male appeared to make the children more prone to VAD risks (Table 1). The survey estimated that 57.5% of the children consumed foods rich in VA whereas consumption quantities were not provided [8]. In 2006, the VAD prevalence decreased to 20.4% (Table 1). However, the two periods were not comparable due to methodological changes. The new method in 2006 measured a concentration of Retinol-Binding Protein (RBP) because it is known to be more stable than a serum retinol concentration [9].

In 2011, the VAD prevalence was 32.6%, which was adjusted for infection/inflammation; the unadjusted prevalence was 38% [10]. This adjustment was introduced in 2011 since infection/inflammation is known to depress RBP [3, 5]. The 32.6% was a substantial increase in VAD (Table 1). This increase was difficult to explain, yet partially attributed to the problems linked to the blood sample collection, storage, and transportation during the heavy rainy season in 2011. They could have adversely affected the quality of the blood samples [10]. In 2016, the adjusted and unadjusted VAD prevalence was 8.9% and 15.1% respectively (Table 1) [7]. This was a noticeable decrease but reasons for the positive change were not specified.

Overall, it was not possible to identify a temporal trend in the VAD prevalence among the Ugandan children due to the various changes. Nonetheless, two trends appeared consistent: being male and living in rural areas increased likelihood to suffer from VAD. Exact reasons for the higher VAD in male children were unknown, yet according to AHSPR, VAS coverage tended to be slightly lower in male children, suggesting possible associations with parental behaviors. For rural areas, they may have more

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ISSN 1684 5374

restricted access to food choices, healthcare, and nutritional information. Also, remote rural areas are likely missed for VAD interventions by logistical complexities.

Food-based approaches for vitamin A deficiency mitigation
Greiner [11], while disputing effectiveness of VAS, endorsed food-based approaches to address VAD for their sustainability, safety, reachability, and other health benefits [11]. Of the approaches, dietary diversification can improve VAD by promoting increased intakes of VA-rich foods. However, it is often difficult to change established dietary behaviors and maintain such diet in resource-poor settings [4]. Other food-based approaches include food fortification and biofortification.

Food fortification with vitamin A
Food fortification is a practice of deliberately increasing target micronutrients in processed foods [12]. It is likely effective when: good food vehicles exist, that carry a target level of the nutrient, the nutrient remains at an adequate level when consumed, the target population has easy access to fortified foods for regular consumption and fortification costs are reasonable as a public health measure [4, 12]. Simultaneously, food fortification requires sufficiently developed food industries with national regulatory frameworks in place [4].

Uganda prioritized food fortification in the early 1990s. The Ministry of Health issued the Food and Drugs (Control of Quality) Regulations 1997, which mandated universal salt-iodine fortification [13]. The Ministry developed the National Working Group for Food Fortification for coordinated supervision over fortification in 2002 and the National Bureau of Standards was mandated to set the food fortification standards and monitor compliance with the regulation [14]. Uganda expanded its fortification program to additional food vehicles under the Food and Drugs (Food Fortification) Regulations 2005, which called for industries producing wheat flour, maize flour, edible oil, and fat to fortify their products. The Ministry further issued the amended Food and Drugs (Food Fortification) Regulations 2011 to mandate other food fortifications [13]. For VA, the Global Fortification Data Exchange shows that in Uganda, edible oil, maize flour, and wheat flour are mandated to be fortified with retinyl palmitate.

To effectively raise VA intake among the Ugandan children, a national survey suggested a combination of VA-fortified oil and sugar while cautioning sugar could be a risk factor for excessive VA intake [15]. Hypervitaminosis A was reported in Zambian children who were exposed to both VAS and VA-fortified sugar [16]. However, in the Ugandan context, VA-fortified sugar might benefit poor rural households likely at higher VAD risks [17]. As of 2021, sugar is not VA-fortified in the country. Other than the potential risk for excessive VA intake, a speculative reason for excluding sugar was the Ugandan sugar industry's hesitation with uncertainty about market demands and costs. Compared to oil, a cost for sugar fortification was estimated 4.8 times higher [17].

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In 2020, the population coverage of VA-fortified products remained low: 54.4% for oil, 8.5% for wheat flour and 6.5% for maize flour reported by the Global Fortification Data Exchange. The higher coverage of oil, in comparison to wheat flour and maize flour, was attributable to the characteristics of the Ugandan oil industry. It is dominated by a few oil processors and the leading processors voluntarily fortified their products early on in 2004 [14]. Yet, for the oil fortification quality, a nationwide survey with 278 samples estimated 58% of them complied with the national standard, which was 20-40 mg Retinol Equivalents/kg oil [18].

Despite the importance of maize in the Ugandan diet (about 92% of the households consume maize flour), VA-fortified maize flour had the lowest coverage (6.5%). The amended Food and Drugs (Food Fortification) Regulations 2011 mandated maize mills with a daily production capacity of 20 tons or more to fortify their products. However, most of the qualified millers did not comply and a study identified several issues linked to the industrywide low compliance [13]. First, some millers assumed fortification was mandatory for those who actually produced 20 tons or more per day, not the production capacity. Second, two different standards for maize fortification existed, one for the Uganda Standard/East Africa Fortification Standards (US: EAS 768) and the other for humanitarian agencies, which purchased over 89% of the total fortified maize flour with the biggest buyer being the World Food Programme (WFP). Applying the two standards may be impractical for the millers when one market is dominant. Third, the fortified maize flour was sold at the same or even lower price than the unfortified, due to lack of consumer awareness of nutritional benefits. This is a critical issue as the millers would not make unviable business decisions. Fourth, the Ugandan milling sector is largely dominated by small (below 10 ton per day) and medium (10-20 ton) scale millers, which became the policy loophole itself. Finally, the majority of the millers required to fortify by law rarely face consequences without compliance [13].

Wheat flour appeared to be the least effective food vehicle to improve VA intake in Uganda. The population coverage of wheat flour was only 11.2%, compared to 92% of maize flour as indicated on the Global Fortification Data Exchange. Thus, the low coverage of wheat flour makes it a doubtful VA vehicle. Given the existing circumstances with the VA-fortified foods, these findings suggest the government should examine its VA fortification markets, and regulatory mechanisms to check the loopholes and better engage stakeholders with policy clarification for compliance.

Biofortification with pro-vitamin A

Biofortification differs from food fortification in that it intends to increase target micronutrients in edible parts of crops during their growth. Biofortification can be achieved by applying nutrient-rich fertilizers, conventional breeding, and transgenic methods [4]. Ultimately, successes of biofortification rely on target households substituting conventional varieties for biofortified ones [19]. However, acceptance rates of VA-biofortified varieties may be low if they show distinct agronomic and sensory traits deviated from their conventional counterparts. Farmers can perceive them as production risks and consumers may prefer familiar varieties [20]. Of the VA-

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biofortified crops, orange fleshed sweet potato (OSP) is probably the most well-known in Uganda.

Conventionally bred orange fleshed sweet potato with pro-vitamin A

Sweet potato (*Ipomoea batatas*, L.) is a key food crop in sub-Saharan Africa although its relative importance varies by sub-region [21]. Conventionally, the crop is considered easy to grow and drought tolerant. Colors of its root flesh range from white, yellow, orange to purple, and the dominant varieties are white and yellow. While the dominant varieties contain little pro-vitamin A carotenoids (pVAC), the orange roots provide high levels of beta-carotene; the darker the orange color, the more beta-carotene is present [21]. For its efficacy as a VA source, studies suggested a daily consumption of 50-125g of OSP may provide children with sufficient VA to meet their needs, depending on varieties, cooking methods, farming conditions or child growth stages [19, 21, 22]. Thus, the logic was that introduction of adoptable OSP varieties to VAD-afflicted communities could increase VA intake without substantial changes in cropping systems and dietary patterns [20].

In Uganda, sweet potato is a primary staple along with banana, cassava, and maize and the leading varieties are white-yellow roots [23]. National efforts to breed OSP with high pVAC started in 1991 and the first OSP variety was released in 1999. Later in 2007, two OSP varieties, Kabode and Vita were released with moderate virus resistance and higher dry matter and utilized for the Reaching End Users project (REU) in Uganda. From 2007 to 2009, 10,000 members of selected farmer groups received free OSP vines and necessary support including nutrition trainings through REU [21]. The project evaluation indicated REU contributed to increased probability in OSP adoption, and improved VA intake among children and women in a highly cost-effective manner. These findings offered convincing evidence for scaling up OSP distribution as a VAD mitigation strategy [20, 21]. Subsequently, between 2012 and 2016, 409,711 Ugandan households received OPS vines under the Developing and Delivering Biofortified Crops project to identify best strategies for wide OSP adoption and consumption [24]. Although the results from REU were encouraging, a question was whether farmers would continue cultivating OSP.

In fact, during the first season of REU, the adoption rate was very high (91.6%), but gradually declined with district-specific patterns. Some reasons for OSP dis-adoption included unavailable vines, labor shortage, and general dislike of the variety [19]. Other studies also suggested reasons for dis-adoption, including vine costs, drastic color change, dry matter contents and low preference for the taste. Currently, scarce data exist on comprehensive OSP cultivation and consumption with the available OSP cultivars across Uganda. The HarvestPlus, the flagship program for OPS development acknowledged difficulties obtaining accurate OSP data since adoption and dis-adoption occur simultaneously with multiple organizations distributing the crop (personal communication with HarvestPlus Uganda).

Ndaula *et al*. [24] hypothesized that OSP acceptance and adoption at a household level may be first affected by a perceived VAD risk [24]. They tested the hypothesis in

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Uganda with two other factors: perceived effectiveness of control measures and household dynamics. Their results implied the perceived VAD risk could motivate OSP adoption and perceived effectiveness of risk control measures might sustain OSP cultivation. This suggested campaign messages for OSP promotion should emphasize the linkage between the reduced VAD risk and OSP's nutritional value as an effective risk control measure [24].

In Eastern, Central and Southern Africa including Uganda, women dominate sweet potato production, and can play key roles in OSP adoption and social exchange of vines [21]. Gilligan *et al*. [19] assessed intra-household decision making between women and men in OSP adoption and diffusion in Uganda. Their findings indicated probability to adopt OSP and share its vine was affected by the degree of bargaining power of women over land control for OSP adoption and over household non-land resources for vine sharing [19]. Gender dynamics in OSP adoption in Uganda was also identified in a different study [25]. Yet bargaining power of women did not influence dietary VA intake of children because both parents could have the same preference regarding the nutritional status of their children [19].

For the Ugandan urban consumers, the current immature OSP value chain may limit their access to OSP [26]. Ugandan farmers grow sweet potatoes mainly for subsistence, which could explain why OSP marketability was not found associated with the adoption decision [25]. Additionally, few price incentives existed with OSP due to its undervalued nutritional quality that in turn discouraged the value chain development [26]. Instead, the urban consumers more likely benefit from OSP-based products such as composite flour available at the market. However, processing OSP could result in changes or losses in pVAC as it is known to be highly sensitive [27]. These imply that quantification of OSP contribution to VAD alleviation can be considerably complex.

Genetically modified golden banana with provitamin A

Banana (*Musa* spp.) is an economically important fruit crop and food staple. The most cultivated edible *Musa* spp. include dessert bananas, plantains, East African Highland Bananas (EAHB) and other cooking types, whose relative importance varies by region [28, 29]. In Uganda, banana is one of the most important food crops with an annual per-capita consumption of 220-250kg, one of the highest in the world, and the crop provides 30% of the Ugandan daily caloric intake [28, 29]. Of the banana sub-groups, EAHB, locally known as *matooke* is the most dominant [30]. According to the Uganda Data Portal, the total production of EAHB was 6.5 million ton in 2018 whereas the sweet banana was 0.2 million ton. However, most EAHB cultivars contain negligible levels of pVAC, thus diet primarily based on EAHB can increase VAD risks. Additionally, Mbabazi *et al*. [30] cited that UDHS [9] observed the highest VAD incidence occurred in regions where banana was the principal source of carbohydrate [30].

With its importance in the Ugandan diet, efforts to increase pVAC in EAHB started in 2005 via GM methods under the Banana 21, a collaborative project between Australia and Uganda. The goal of the project was to develop GM EAHB lines that could provide

50% of the Estimated Average Requirement of VA with a daily per-capita consumption of 300g [29]. The project justified the utilization of GM methods with difficulties in banana conventional breeding, and GM EAHB would be irrelevant to international GM-product regulations since most EAHB is consumed domestically [28, 31]. Also, vegetative reproduction of banana could allow farmers to own the offspring under favorable intellectual property regimes [28].

The project identified orange-pulped GM EAHB lines (called Golden Bananas) with the target pVAC level, showing no other phenotypic alterations. Furthermore, a preliminary sensory test indicated positive results with the lines [29]. Yet, studies observed other factors that affected pVAC in EAHB. For instance, storage up to 14 days increased beta-carotene equivalent in EAHB cultivars and they retained higher beta-carotene equivalent after being steamed and boiled, compared to the plantain [30]. These findings were encouraging for GM EAHB development because typical Ugandan households purchase EAHB by bunch, store and consume by steaming and boiling [3, 30].

Technically, the final step to release GM EAHB is its clearance with Ugandan GM regulations. The existing laboratory and field experiments with GM crops in Uganda are regulated under the Act of the National Council of Science and Technology 1990 as the country currently lacks the biotechnology law, which is yet to be passed as of 2021 [32]. Uganda is a signatory of the Cartagena Protocol of Biosafety on the Convention on Biological Diversity of 2000, which only allows countries with a biotechnology law to release GM materials [33]. Thus, the present status of the law (waiting to be signed) does not allow Uganda to release GM EAHB.

Uganda recognized the value of biotechnology in the late 1990s while formulating the Poverty Eradication Plan and the Plan for Modernization of Agriculture to address challenges in agricultural production. With the continued high political interest in biotechnology, Uganda adopted the National Biotechnology and Biosafety Policy in 2008, which identified biotechnology as a strategic tool for agriculture. The Policy under the Section 5.4 required the government to develop legislative instruments to regulate biotechnology applications. In 2012, the Cabinet approved the National Biotechnology and Biosafety Bill that proposed an institutional framework, consisting of the competent authority (Uganda National Council for Science and Technology), national focal point, national biosafety committee, and institutional biosafety committee [34]. Yet, Schnurr and Gore [32] argued the regulatory and legislative framework was tailored towards eventual endorsement of GM crops since the key agencies in the regulatory system were also those with invested interest in biotechnology [32]. Along the process, the Bill was turned down twice; the president demanded gene banks be established to protect native species and GM crops be grown only in greenhouses to prevent contamination. In 2017, the parliament passed the Bill as the Biosafety Bill that arguably favored science more, then in 2018 it changed to the Genetic Engineering Regulatory Bill. The 2018 version included liability clauses for any danger from biotechnology applications, which was less preferred by the Ugandan science community [33]. The slow progress of the Bill was also attributable to the cautious parliament, aware of the debates around the technology. One of the debating points was that biotechnology applications were mostly supply-driven while farmers' perspectives were less considered [35, 36]. As the end users of the technology, farmers should consider it suitable for their farming and economic realities.

Regarding Ugandan farmer perceptions of GM EAHB, Schnurr and Addison [28] indicated multiple factors influenced the adoption decision including region, membership to farmer organization, farm size and access to extension service [28]. For regional differences, farmers in the Eastern and Southwestern region held more positive attitudes towards GM EAHB than ones in the Central region. A speculation was that historical factors contributed to the contrasting regional views on GM EAHB. The central region is the historic and cultural core of EAHB, which is an integral part of the region's social events, thus expressed negative views on GM EAHB. In comparison, it has less such significance in the East and Southwest where EAHB is primarily grown for commercial purposes [28].

Another important aspect for GM EAHB adoption is its match to the agronomic and economic priorities of EAHB growers. A study showed the banana growers did not highly rank the nutritional value in EAHB (11th of the 15 characteristics) compared to other crop characteristics; top-ranked characteristics included a banana bunch size, drought tolerance, and resistance to pests and diseases [36]. This suggested the farmers prioritized agronomic and marketing traits over nutrition because a bunch size mostly determined its price. Furthermore, weakness of the formal seed system of Uganda and a potential for higher prices of GM EAHB plantlets could restrict its cultivation. During the initial adoption process, farmers may have to purchase tissue-cultured plantlets of GM EAHB with relatively higher prices through the formal seed system. The current formal system carries issues in trust and transparency while most farmers obtain EAHB planting materials from neighbors or save their own [36]. These findings indicate potential obstacles to GM EAHB adoption and possible needs to develop effective delivery systems of the plantlets.

Preference of Ugandan consumers about GM crops should not be ignored. Some studies with GM bananas, not specifically for nutritional traits, showed Ugandan consumers would purchase GM bananas at the same price as non-GM counterparts with quality benefits. And the rural poor (both producers and consumers) were more likely to accept GM bananas if they provided tangible benefits such as high yields [37]. Yet, GM EAHB may be different from the GM bananas with improved agronomic traits because its orange color may deter consumers despite the nutritional value. Additionally, controversies around the GM EAHB human trials that involved students at Iowa State University in the United States may not help build positive views on the GM banana in Uganda and elsewhere, affirming strong influences exerted by the media and non-government organizations on GM crops [38].

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April 2022
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ISSN 1684 5374

CONCLUSION

Vitamin A deficiency is a public health threat to Uganda, particularly to the children. Accordingly, much effort has been made by the Ugandan government and international agencies to ameliorate VAD with the multiple interventions. Nonetheless, insufficiency of reliable VAD-relevant data/documents makes it difficult to identify evidential grounds for VAD interventions and gauge their progresses. This is not a unique challenge to Uganda among the VAD-afflicted countries as the data collection and the situational analysis require substantial resources. For the VAD status of the Ugandan children, it was unclear if any positive/negative changes occurred over the years. What appeared clear though was living in rural areas and being male consistently increased VAD risks (Table 1). The most recent 2016 data hinted a positive change in VAD. If the trend is confirmed and continues, the Ugandan children may fall into the mild category in VAD severity. Then the questions would be what caused the positive change and what further actions need to be done with the existing VAD interventions.

Each of the current food-based interventions in Uganda carried different advantages and programmatic issues, demanding comprehensive reviews of the VAD mitigation policy. Ideally, maximized impacts on VAD reduction can manifest themselves when appropriate combinations of the VAD mitigation strategies are in place, specific to the target groups. Such planning and implementation are especially challenging in resource-poor countries. In addition, there are many other factors affecting efficacy of the VAD interventions. For instance, many children with VAD suffer from overall malnutrition and VA is fat-soluble, requiring co-consumption of fat and other nutrients for VA utilization. Also, infectious diseases are known to overlap and exacerbate VAD, therefore prevalent infections would likely undermine the intervention impacts.

Uganda already expressed its strong political commitment to address VAD by the mandatory fortification legislation, the long-term investment in biofortified crop development and the efforts for enacting the biotechnology law. However, the political commitment in and of itself does not lead to improved VAD without continued investment in gathering VAD-relevant data and strengthening intervention monitoring mechanisms.

While the findings from this study offer valid circumstantial evidence for the existing issues across the VAD mitigation interventions, limitations exist. First, this study utilized the nationally representative and officially published data and documents. Yet, the Ugandan policy makers may have access to internal VAD-relevant data for policy formulation. Second, sufficient literature specific to the Ugandan context was unavailable. Nonetheless, the findings strongly suggest that the Ugandan government examine and monitor its overall VA programs.

Funding
No funding for this review is provided.

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Table 1: Prevalence in vitamin A deficiency among Ugandan children

Year	Overall (%)	Region (%)		Gender (%)		VA rich food consumption c
		Rural	Urban	Male	Female	
2001a	27.9	29.1	15.9	29.7	26.1	57.5 (under 36 months only)
2006	20.4	21.1	14.9	22.4	18.5	61.8 (6-35 months only)
2011b	32.6	34.0	26.4	34.4	30.9	61.2 (6-23 months only)
2016	8.9	9.4	6.7	9.1	8.6	66.5 (6-23 months only)

a: VAD cutoff was retinol concentration 0.7 μML^{-1} while all other years, retinol-binding protein 0.825 μML^{-1}

b: Adjusted VAD prevalence was adopted in 2011 and 2016

c: Only 2001 adopted '7 days preceding survey' while all other years, 'past 24 hours'

(Data source) Uganda Demographic Health Survey

https://doi.org/10.18697/ajfand.108.21735

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 22 No. 3 April 2022 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

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