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Research

Maternal risk factors and vitamin A deficiency among pregnant mothers in Mbeya region, Tanzania: A cross-sectional study

Ray M. Masumo[1,*], Patrick Codjia[3], Kaunara Azizi[1], Tedson Lukindo[1], Heavenlight A. Paulo[2], Adam Hancy[1], Geofrey Mchau[1], Rose Msaki[1], Samira J. Spilloh[1], Esther M. Nkuba[1], Julieth Shine[1], Erick Killel[1], Geoffrey Chiduo[1], Abraham Sanga[3], Ramadhani S. Mwiru[3], Germana H. Leyna[1, 2]

[1] Tanzania Food and Nutrition Centre (TFNC), 22 Barack Obama Drive, P.O. Box 977, Dar es Salaam, Tanzania; [2] Department of Epidemiology and Biostatistics, Muhimbili University of Health and Allied Sciences (MUHAS), P.O. Box 65001, Dar es Salaam, Tanzania; [3] The United Nations Children's Fund (UNICEF) Tanzania, P.O. Box 4076, Dar es Salaam, Tanzania

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Background
Vitamin A deficiency (VAD) among pregnant women is a public health concern and is widespread in developing countries.

Objective
The present study aimed to assess the prevalence of VAD and associated factors among pregnant women in the Mbeya region of Tanzania.

Methods
A cross-sectional study was conducted among 420 pregnant women in seven district councils in the Mbeya region of Tanzania. Serum retinol concentration was determined by high-performance liquid chromatography (HPLC). Assessment of anthropometric, food consumption and other socio-economic characteristics were performed and clinical information obtained on participants. A multivariate regression analysis was conducted to determine the independent predictors of VAD.

Results
46.1% suffered from any form of VAD and 9.8% from severe VAD. Those pregnant women who belonged to the lowest socioeconomic status, who were anaemic, and who consumed low dietary diversity scores were more likely to have any VAD (ARR = 2.84; 95% CI: 1.58, 5.12), (ARR = 1.73; CI: 1.03, 2.92) and (ARR=1.59; 95%CI: 1.01, 2.51), respectively. Any VAD was more likely among those who resided in Kyela district (largely rural) compared with Mbeya city (ARR = 0.32; 95%CI: 0.11, 0.92). Their marital status, occupation, and education levels were not statistically associated with VAD. Younger women were more likely to have severe VAD (ARR=0.29; 95%CI: 0.10, 0.84).

Conclusions
VAD among pregnant women in the Mbeya region of Tanzania is a mild public health concern according to the WHO's categorization. Additionally, VAD was significantly associated with low socio-economic status, anaemia, and low maternal dietary diversity scores.

INTRODUCTION
Vitamin A Deficiency (VAD) is a public health problem affecting approximately six percent of all pregnant women worldwide (Eyeberu et al. 2023; Bastos Maia et al. 2019). It may increase mortality by raising women's susceptibility to pregnancy- related infections and other conditions that can result in death (Wolde et al. 2023). VAD occurs especially during the last trimester of pregnancy when demand by both the mother and foetus is highest, particularly in poor communities (Panth et al. 1990; Wallingford et al. 1987). During the third trimester of pregnancy and postnatally, the

* Corresponding author: rmasumo@yahoo.com

foetus accumulates vitamin A Colostrum and early milk are usually rich in vitamin A, and even the milk of a mild malnourished mother may meet the physiological needs of the newborn during the first weeks (Imdad et al. 2017; Wolde et al. 2023). However, pregnant women with VAD have a lower content of vitamin A in their breast milk, which in turn predisposes to the earlier onset of deficiency among infants (Bastos Maia et al. 2019), with severe consequences for the child's health and wellbeing (Strobel et al. 2007).

WHO defines sub-clinical VAD as a public health concern when the prevalence of pregnant women with a serum retinol level below 0.70μmol/L exceeds 20% of pregnant women; moderate when affecting between 10% and 20%; and mild when between 2% and 10% (World Health Organization.2009). According to most recent estimates in developing countries, more than 7.2 million pregnant women suffer from severe VAD (serum retinol < 0.70μmol /L), and another 13.5 million have any VAD (<1.049μmol/L) and with over six million experiencing night blindness annually (World Health Organization. 1996). VAD is particularly widespread in South Asia and Sub-Saharan Africa (Wolde et al. 2023; Eyeberu et al. 2023).

In population surveys, the assessment of VAD can be classified as either clinical or sub-clinical. The clinical VAD involves the assessment of eye signs, such as night blindness and Bitot's spots. The sub-clinical VAD is biochemically determined via the concentration of retinol in serum (Bastos Maia et al. 2019). High-performance liquid chromatography (HPLC) is commonly used to assess serum retinol (Zhao et al. 2020). HPLC is preferred over other methods due to its simplicity, cost-effectiveness, and accuracy (Zhao et al. 2020). Previous studies have shown that in population studies, HPLC can detect a serum retinol concentration of <0.70μmol/L with adequate precision, which is not achievable with other methods (Zhao et al. 2020).

A Tanzania Demographic and Health Survey and Micronutrient Survey (TDHS-MNS) found that 39.0% of pregnant women had VAD, based on serum retinol-binding protein (RBP) concentration measured using a spectrophotometric method, which is less sensitive compared to HPLC (ICF Macro. 2011; Chaudhary-Webb et al. 2019). In addition, more recent data on sub-clinical VAD among pregnant women in Tanzania are limited. Therefore, the present study was conducted to assess the prevalence of VAD and associated factors among pregnant women in one region of Tanzania (Mbeya).

METHODS

STUDY DESIGN AND SETTING

This community-based cross-sectional study was conducted among pregnant women in seven districts of the Mbeya region. Mbeya region has a population of 2,343,754 comprising 1,123,828 males and 1,219,926 females, with 605,647 women falling within the reproductive age category (Rugeiyamu 2022).The region has 17 hospitals, 23 health centres, and 278 dispensaries, of which 251 (79.0%) offer reproductive and child health (RCH) services. Of these 42 were randomly selected across the seven districts of the Mbeya region, allocated per district according to probability proportional to size. Each of the selected RCH clinics typically serve approximately 1,000 pregnant women annually (Rugeiyamu 2022).

STUDY POPULATION AND SAMPLING PROCEDURE

Based on previous research, the proportion of women of reproductive age with any VAD was estimated at 39.0%, with a margin error of 5.0%, a confidence level of 95.0%, and a design effect of 1.5. Another 10.0% was added to the sample size to account for non-response (Lemeshow 1991), arriving at a required sample size of 420. All pregnant women showing no signs of sickness aged between 15 and 49 years at less than 28 weeks of gestation attending antenatal care in the selected RCH clinics from September to December 2022 were invited to participate in the study. We invited 574, continuing until we reached 420 agreeing to participate (response rate of 73.0%). The missing data relates to pregnant women who were ill or facing communication and transportation difficulties. (Thus our sample may have been biased toward women living closer to the health centers.)

DATA COLLECTION

LABORATORY INVESTIGATIONS

A trained nurse collected approximately 8 ml of blood samples via vein puncture from each participant who provided informed consent for the study. One portion of the blood, approximately 3 ml, was transferred into a vacutainer tube containing EDTA anticoagulant and mixed thoroughly. This sample was utilized for malaria testing through a rapid diagnostic test and for the assessment of hemoglobin levels using the HemoCue 201+ device (Abdallah et al. 2022). The remaining 5 ml was drawn into a plain vacutainer tube without anticoagulant (designated with a red top) for the measurement of serum retinol concentration. Immediately following blood collection, this vacutainer tube was placed in a dark, cool location at room temperature for 15 to 30 minutes to facilitate clotting. Subsequently, all vacutainer tubes were relocated for 4-8 hours to a dark container maintained at a temperature of 2 to 8ºC and transported for to a designated temporary field laboratory for processing and storage. Upon arrival at the temporary laboratory, the samples were separated into serum and clotted pellets through centrifugation. Following centrifugation, the serum from the red top vacutainer was carefully aliquoted into cryovial tubes and stored in a dark container at −20ºC until further analysis. The measurement of serum retinol concentration was conducted using HPLC (Shimadzu, Japan), adhering to the US Centers for Disease Control and Prevention protocol. A C18 normal phase column and ultraviolet detector were employed for this procedure (Furr. 2004; Chaudhary-Webb et al. 2019). Further, the measurement of inflammation markers, i.e., C-reactive protein (CRP), and alpha-1 acid glycoprotein (AGP), was performed with a Roche Cobas Integra 400 Plus analyser (Roche Diagnostics GmbH, German) to adjust serum retinol values for inflammation (Young et al. 2022; Larson et al. 2018).

SOCIO-DEMOGRAPHIC AND ECONOMIC STATUS

A standard socio-economic status questionnaire was developed and pretested. Socioeconomic status was assessed by household ownership of durable assets using simple questions to avoid recall bias or social desirability bias (such as ownership of a car, motorcycle, bicycle, cart, refrigerator, television, radio, etc.), housing characteristics (such as the material of dwelling floor and roof, toilet facilities, etc.), and access to basic services (such as electricity supply, source of drinking water) (Abdallah et al. 2022). Principal Components Analysis was used to create a wealth index, assessing each item as (1) "available and in working condition" or (0) "not available and/or not in working condition". The first principal component was used to categorize households into three approximate groups, i.e. highest, middle and lowest socioeconomic groups.

MATERNAL ANTHROPOMETRY

Maternal nutritional status was assessed by anthropometric measurement. Weight was measured to the nearest 0.1 kg with a battery-powered electronic scale (Seca, Hamburg, Germany), and height was measured to the nearest 0.1 cm with a height model. Height and weight were measured without shoes or a head covering. Mid upper arm circumference (MUAC) was assessed using standard MUAC tapes on the left arm while held straight (Okereke et al. 2013). All anthropometric measurements were taken in duplicate and the average recorded.

MATERNAL DIETARY DIVERSITY

The dietary diversity score (MDD-W) was computed using a modified Prime Screen Questionnaire which contains 21 food items. The questionnaire used 24-hour recalls that reflected food consumption from the previous morning to the morning of the interview. The food items asked were: dark green leafy vegetables, cruciferous vegetables, dark orange vegetables and fruits, other vegetables, citrus fruits, other fruits, legumes, nuts and seeds, poultry, fish, whole grains, vegetable liquid oils, white roots and tubers, red meat as a main dish, processed meats, refined grains and baked products, sugar-sweetened beverages, fried foods away from home, sweets and ice cream, low-fat dairy. The responses were 0= No, 1= Yes. The MDD-W was computed by collapsing the 21 food items into 10 food group items as recommended by FAO, which are: starchy staples; beans and peas; nuts and seeds; dairy; flesh foods (meat, fish); eggs; vitamin A−-rich dark green vegetables; other vitamin A rich fruits and vegetables; other vegetables; and other fruits (Islam et al. 2024). The total score was categorized as "low" and "high" if they reported to have consumed less than 5 and more than 5 food groups, respectively.

DATA ANALYSIS

The data were analyzed by using SPSS version 25. Vitamin A deficiency was assessed as a categorical variable using the WHO cut-off values for severe (<0.70μmol/L) and any (<1.24μmol/L) (World Health Organization 1994).

The strengths of the associations between the dependent and independent variables in bivariate analysis were tested using the Pearson chi-square tests because all variables were categorical. The Wald test, based on bivariate log-binomial models with a p-value less than 0.2, was utilized in constructing the multivariable model. The log-binomial multivariable regression model was used to identify independent predictors of VAD among the study population. All tests were two-tailed, and the significance level was set at 0.05.

ETHICS STATEMENT

The study protocol was approved by the National Health Research Ethics Committee (NaTHREC) of the National Institute for Medical Research with the reference number SZEC-24239/R. A/V.1/151 issued on 12th August 2022. Written informed consent was obtained from all participants or the parents/guardians of participants less than 18 years of age. All procedures were per the Helsinki Declaration of 1975, including confidentiality and authors had no access to information that could identify individual participants during or after data collection.

RESULTS

RELIABILITY

The agreement between the interviews and the gold standard on the dietary diversity- index was Cohen's kappa 0.62. Thus, acceptable levels of intra-interview agreement (kappa >0.60) were obtained. Duplicate interviews were performed with 60 pregnant women two days apart. Test-retest reliability in terms of Cronbach's alpha and intra-class correlation coefficient was 0.72 (95% CI 0.64 – 0.78).

SOCIO- DEMOGRAPHIC CHARACTERISTICS

A total of 420 pregnant women participated in the study. Their mean age was 25.49 ± (6.37 SD) years. As shown in Table 1, 8% of the study participants had not attended any formal education and, 75% (n=316) were multigravida. 26% (n=110) were in the first trimester (<12 weeks), 37% (n=155) did not receive iron and folic acid supplementation and, 33% (n=141) fell under the category of lowest socioeconomic status. 25% (n=107) were diagnosed with anaemia, 66 (16%) had a haemoglobin of range between 10.0 to 10.9 g/dl (that representing mild anaemia) and only one had severe anaemia (haemoglobin of less than 7.0g/dl) and was referred to the nearby health facility.

Table 1. Socio-demographic characteristics of study participants in Mbeya region, Tanzania (n=420)

Variables	Category	*%(n)*
Age group (years)	15-19	19.5 (82)
	20-24	31.6 (133)
	25-29	23.5 (99)
	≥30	25.2 (106)
Marital Status	Married	56.2 (238)
	Cohabit	31.8 (134)
	Single/ Divorced	11.6 (49)
Occupation	Formal employment	3.6 (15)
	Self-employed	84.6 (356)
	Not employed	11.9 (50)
Household wealth index	Lowest – poorest	33.5 (141)
	Middle	33.0 (139)
	Highest – richest	33.3 (140)
Education Status	No education	8.1 (34)
	Primary	71.7 (302)
	Secondary and above	20.2 (85)
District councils	Chunya	10.7 (45)
	Mbeya	23.0 (97)
	Mbarali	22.1 (93)
	Kyela	11.9 (50)
	Rungwe	16.4 (69)
	Busekelo	7.8 (33)
	Mbeya city	8.1 (34)
Number of pregnancies	Primigravida	24.7 (104)
	Multigravida	75.1 (316)
Trimester	Less than 12 weeks	26.1 (110)
	12-26 weeks	73.9 (311)

Table 1. *Continued*

Variables	Category	%(n)
Mid arm circumference (MUAC)	MUAC<23cm	3.8 (16)
	MUAC≥23 - <33cms	91.0 (383)
	MUAC≥33cms	5.0 (21)
Visits to ANC care	First visit	39.0 (164)
	2-3 Visits	53.7 (226)
	>3 Visits	7.4 (31)
Received Iron/folic acid	No	36.8 (155)
	Yes	62.9 (265)
Drinking alcohol	No	83.1 (350)
	Yes	16.6 (70)
Malaria infection	No	95.7 (403)
	Yes	4.3 (18)
Anaemia	Anaemic	25.4 (107)
	Not Anaemic	73.9 (311)
Dietary diversity score	low	54.6 (230)
	high	45.1 (190)

Table 2. Food groups consumed by study participants in Mbeya region, Tanzania (n=420)

Food Groups	Food Items	%(n)
Starch Staples	Unrefined corn, millet, cassava, plantain, banana, yams, potato, maize porridge, rice buns, refined pastry	98.6 (415)
Beans and Peas	Beans, Peas, Lentils (i.e. red lentil, brown lentil, yellow lentil, other)	38.5 (162)
Nuts and Seeds	Peanut, Bambara nut, groundnut,	34.4 (145)
Dairy	Low-fat milk, low-fat or skim yoghurt or kefir, low-fat cottage or fresh cheese	16.9 (71)
Fleshy Foods	Oily fish, White fish, Beef, veal, Lamb, goat, Pork, Chicken, Turkey, Duck, Pigeon	58.0 (244)
Eggs	Eggs	17.3 (73)
Vitamin A Dark Green Vegetables	Spinach, Amaranth, Sweet potato leaves, Cowpea leaves, Cassava leaves, Pumpkin leaves	66.0 (278)
Other Vitamin A Vegetables and Fruits	Carrot, Pumpkin, Mango, Papaya, Cantaloupe, Apricot	37.5 (158)
Other Vegetables	Eggplant, Tomato, Paprika/pepper, Okra, Cucumber. Cabbage, Broccoli, Cauliflower	40.9 (172)
Other Fruits	Apple, Pear, Peach, Plum, Prune, Grapes, Berries, Guava, Avocado and Melon	32.5 (137)

FOOD GROUPS CONSUMED BY PREGNANT WOMEN

Table 2 shows the food groups consumed by participating women in the previous 24 hours. Nearly all (n=415) reported consuming starch staples while only 16.9% (n=71) had consumed diary products. 66% (n=278) and 38% (n= 158) reported consuming vitamin A dark green vegetables and other vitamin A vegetables and fruits, respectively. Table 1 shows that 54.6% (n= 230) did not attain the minimum required dietary diversity score (lower MDD-W).

UNIVARIATE ANALYSIS: VAD BY SOCIO-DEMOGRAPHIC CHARACTERISTICS

Linear regression was conducted to determine the effects of the inflammatory markers i.e., AGP and CRP with VAD. The results indicated a non-significant effect i.e. [r=-0.092; 95%CI=-0.274, 0.026; p=0.104] and [r=0.014; 95%CI=-0.039, 0.051; p=0.790], respectively. Similarly, for severe VAD the results indicated a non-significant effect i.e. [r=-0.011; 95%CI=-0.093, 0.076; p=0.8842] and [r=0.087, 95%CI=-0.002, 0.048; p=0.077], respectively. Hence the adjustment of VAD and severe VAD to inflammatory markers in this study group was not warranted according to step three of BRINDA (Larson et al. 2018).

The prevalence of any VAD (serum retinol concentration <1.24µmol/L) was 46.1% and, severe VAD (≤0.70µmol/L) was 9.8%. As shown in Table 3, any vitamin A deficiency was significantly associated with pregnant women with the lowest socioeconomic status (CRR = 2.38; 95% CI: 1.42, 4.01) and, those who did not attain minimum maternal dietary diversity (CRR = 1.36; 95% CI: 1.00, 2.07). Any VAD was also significantly associated with primigravida women and participants who were not anaemic (CRR = 0.51; 95% CI: 0.32, 0.81) and (CRR = 1.92; 95% CI: 1.19, 3.09), respectively. Severe VAD was associated with the 20-24 age group and those who were not anaemic (CRR = 0.31; 95% CI: 0.11, 0.88) and (CRR = 2.01; 95% CI: 1.02, 3.93), respectively.

MULTIVARIATE ANALYSIS: FACTORS ASSOCIATED WITH VAD

Independent variables included in the multivariable regression model were selected based on a P-value of ⩽0.05 from the univariate analysis. As shown in Table 4, sample women who belonged to the lowest socioeconomic status, who were anaemic, and who consumed low dietary diversity scores were more likely to have any vitamin A deficiency (ARR = 2.84; 95% CI: 1.58, 5.12), (ARR = 1.73; CI: 1.03, 2.92) and (ARR=1.59; 95%CI: 1.01, 2.51), respectively. Any VAD was more likely among those who resided in Kyela district (largely rural) compared with Mbeya city (ARR = 0.32; 95%CI: 0.11, 0.92). Severe VAD was only associated with not being in the younger age group, 20-24 (ARR=0.29; 95%CI: 0.10, 0.84).

Table 3. Maternal related and nutrition characteristics of pregnant women with Vitamin A deficiency in Mbeya region, Tanzania (n=420)

		Any VAD (<1.24µmol/L)			Severe VAD (<0.70µmol/L)		
		No	Yes	Crude Risk Ratio, CRR (95% CI)	No	Yes	Crude Risk Ratio, CRR (95% CI)
Variables	Category	%(n)	%(n)		%(n)	%(n)	
Age group (years)	15-19	50.0 (38)	50.0 (38)	0.60(0.33-1.10)	92.7 (76)	7.3 (6)	0.62(0.18-2.13)
	20-24	63.5 (73)	36.5 (42)	1.04(0.60-1.58)	86.5 (115)	13.5 (18)	**0.31(0.11-0.88)***
	25-29	59.3 (51)	40.7 (35)	0.87(0.48-1.58)	87.8 (86)	12.2 (12)	0.35(0.12-1.04)
	⩾30	62.4 (63)	37.6 (38)	1	95.3 (101)	4.7 (5)	1

Table 3. *Continued*

Household wealth index	Lowest - poorest	72.1 (93)	27.9 (36)	**2.38(1.42-4.01)****	91.5 (129)	8.5 (12)	1.10(0.48-2.50)
	Middle	54.5 (67)	45.5 (56)	1.10(0.67-1.81)	88.5 (123)	11.5 (16)	0.78(0.36-1.70)
	Highest - richest	52.0 (66)	48.0 (61)	1	90.7 (127)	9.3 (13)	1
Marital Status	Married	63.1 (137)	36.9 (80)	1.25(0.65-2.40)	91.2 (217)	8.8 (21)	0.91(0.30-2.80)
	Cohabit	53.8 (63)	46.2 (54)	0.85(0.42-1.70)	88.0 (117)	12.0 (16)	0.65(0.20-2.04)
	Single/ Divorced	57.8 (26)	42.2 (19)	1	91.8 (45)	8.4 (4)	1
Occupation	Formal employment	58.3 (7)	41.7 (5)	1.08(0.30-3.92)	80.0 (12)	20.0 (3)	0.16(0.02-1.11)
	Self-employed	60.2 (192)	39.8 (127)	1.17(0.63-2.17)	89.9 (319)	10.1 (36)	0.36(0.08-1.58)
	Not employed	56.3 (27)	43.8 (21)	1	96.0 (48)	4.0 (2)	1
Education Status	No education	65.5 (19)	34.5 (10)	1.54(0.63-3.75)	85.3 (29)	14.7 (5)	0.52(0.15-1.77)
	Primary	60.3 (164)	39.7 (108)	1.23(0.74-2.05)	90.4 (272)	9.6 (29)	0.84(0.35-1.99)
	Secondary and above	55.1 (43)	44.9 (35)	1	91.8 (78)	8.2 (7)	1
District councils	Chunya	51.4 (18)	48.6 (17)	0.52(0.19-1.45)	77.8 (35)	22.2 (10)	0.46(0.13-1.64)
	Mbeya	65.6 (59)	34.4 (31)	0.95(0.39-2.28)	92.8 (90)	7.2 (7)	1.71(0.46-6.26)
	Mbarali	57.1 (48)	42.9 (36)	0.66(0.27-1.59)	90.3 (84)	9.7 (9)	1.24(0.35-4.34)
	Kyela	43.5 (20)	56.5 (26)	**0.38(0.14-1.00)***	92.0 (46)	8.0 (4)	1.53(0.35-6.60)
	Rungwe	61.3 (38)	38.7 (24)	0.79(0.31-1.97)	91.2 (62)	8.8 (6)	1.37(0.36-5.25)
	Busekelo	71.9 (23)	28.1 (9)	1.27(0.43-3.76)	97.0 (32)	3.0 (1)	4.26(0.45-40.36)
	Mbeya city	66.7 (20)	33.3 (10)	1	88.2 (30)	11.8 (4)	1
Number of pregnancies	Primigravida	47.4 (45)	52.6 (50)	**0.51(0.32-0.81)****	91.3 (95)	8.7 (9)	1.18(0.54-2.58)
	Multigravida	63.7 (181)	36.3 (103)	1	89.9 (284)	10.1 (32)	1
Trimester	Less than 12 weeks	60.8 (62)	39.2 (40)	1.06(0.67-1.69)	92.7 (102)	7.3 (8)	1.51(0.67-3.39)
	12-26 weeks	59.2 (164)	40.8 (113)	1	89.4 (277)	10.6 (33)	1
Mid arm circumferen (MUAC)	MUAC<23cm	61.5 (8)	38.5 (5)	0.93(0.21-3.99)	81.3 (13)	18.8 (3)	0.45(0.06-3.12)
	MUAC≥23 - <33cms	59.4 (206)	40.6 (141)	0.85(0.32-2.21)	90.6 (347)	9.4 (36)	1.01(0.22-4.53)
	MUAC≥33cms	63.2 (12)	36.8 (7)	1	90.5 (19)	9.5 (2)	1
Visits to ANC care	First visit	59.2 (87)	40.8 (60)	1.02(0.45-2.29)	90.2 (147)	9.8 (16)	0.63(0.13-2.90)
	2-3 Visits	60.1 (122)	39.9 (81)	1.06(0.48-2.34)	89.8 (203)	10.2 (23)	0.60(0.13-2.71)
	>3 Visits	58.6 (17)	41.4 (12)	1	93.5 (29)	6.5 (2)	1
Received Iron/folic acid	No	57.6 (80)	42.4 (59)	0.87(0.57-1.33)	89.7 (139)	10.3 (16)	0.90 (0.46-1.73)
	Yes	60.8 (146)	39.2 (94)	1	90.6 (240)	9.4 (25)	1
Drinking alcohol	No	58.8 (184)	41.2 (129)	0.81(0.47-1.41)	89.4 (313)	10.6 (37)	0.51(0.17-1.48)
	Yes	63.6 (42)	36.4 (24)	1	94.3 (66)	5.7 (4)	1
Malaria infection	No	59.1 (214)	40.9 (148)	0.60(0.20-1.74)	90.0 (362)	10.0 (40)	0.53(0.06-4.10)
	Yes	70.6 (12)	29.4 (5)	1	94.4 (17)	5.6 (1)	1
Anaemia	Anaemic	63.3 (181)	36.7 (105)	**1.92(1.19-3.09)****	92.0 (286)	8.0 (25)	**2.01(1.02-3.93)***
	Not Anaemic	47.3 (43)	52.7 (48)	1	85.0 (91)	15.0 (16)	1
Dietary diversity score	low	63.7 (109)	36.3 (62)	**1.36(1.00-2.07)***	90.0 (171)	10.0 (19)	0.95(0.49-1.81)
	high	56.3 (117)	43.8 (91)	1	90.4 (208)	9.6 (22)	1

Log-binomial univariate regression; 95%CI; **P-value <0.001; *P-value<0.05

Table 4. Factors associated with Vitamin A deficiency among pregnant in Mbeya region, Tanzania (n=420)

Variables	**Category**	**Any VAD** (<1.24µmol/L)	**Severe VAD** (<0.70µmol/L)
		Adjusted Risk Ratio, ARR (95% Confidence Interval)	*Adjusted Risk Ratio, ARR (95% Confidence Interval)*
Age group (years)	15-19	0.73 (0.36- 1.49)	0.61 (0.16- 2.29)
	20-24	1.18 (0.65- 2.16)	**0.29 (0.10- 0.84)***
	25-29	0.85 (0.45- 1.60)	0.35 (0.11- 1.08)
	≥30	1	1
Household wealth index	Lowest - poorest	**2.84 (1.58- 5.12)****	0.79 (0.32- 1.98)
	Middle	1.38 (0.80- 2.38)	0.71 (0.31- 1.62)
	Highest - richest	1	1
District councils	Chunya	0.58 (0.20- 1.73)	0.60 (0.15- 2.29)
	Mbeya	0.78 (0.30- 2.00)	1.76 (0.44- 7.01)
	Mbarali	0.63 (0.24- 1.62)	1.51 (0.39- 5.81)
	Kyela	**0.32 (0.11- 0.92)***	1.67 (0.35-7.98)
	Rungwe	0.77 (0.29- 2.33)	1.67 (0.41- 6.77)
	Busekelo	0.77 (0.23- 2.55)	5.01 (0.49- 50.97)
	Mbeya city	1	1
Number of pregnancies	Primigravida	0.58 (0.33- 1.01)	1.25 (0.52- 3.00)
	Multigravida	1	1
Anaemia	Anaemic	**1.73(1.03-2.92)***	1.94(0.94- 4.00)
	Not Anaemic	1	1
Dietary diversity score	Low	**1.59 (1.01- 2.51)***	0.98 (0.48- 1.96)
	High	1	1

Log-binomial multivariate regression; 95%CI; **P-value <0.001; *P-value<0.05

DISCUSSION

We found that about 10% of our sample of pregnant women in the Mbeya region of Tanzania had serum retinol levels below 0.70µmol/L, which revealed that the prevalence of severe VAD in the Mbeya region of Tanzania falls in the category of mild public health concern according to the WHO classification (World Health Organization. 1994). WHO recommended vitamin A supplementation for preventing night blindness in young children, but not in pregnant women; indeed, routine high-dose supplementation should be avoided in all women (World Health Organization. 2012).

46.1% had either mild or severe VAD, similar to findings in Ethiopia, Kenya, Nigeria, and South Africa, where the prevalence of VAD ranged from 21% to 48% (Harika et al. 2017). However, a careful interpretation is needed as most VAD studies in developing countries estimate VAD based on the clinical assessment of night blindness and Bitot's spots (Sommer et al. 2002; Akhtar et al. 2013; Underwood et al. 1996).

We found an association between any vitamin A deficiency among the pregnant women in our sample with socio-economic status and residents in the more rural Kyela district of the Mbeya region. Previous studies from sub-Saharan African countries have documented the protective link between higher socio-economic statuses and malnutrition (Christian & Dake 2022; Kosaka et al. 2017; Bastos Maia et al. 2019). In Tanzania, from 2007 to 2016, the poverty rate fell from 60.0% to 47.0%, respectively (Evans et al. 2014). However, about 12 million Tanzanians are living below local the poverty line, earning less than US$1.0 per day (Evans et al. 2014). Inconsistent with previous studies, our data could not establish an association between maternal levels of education or occupation status with VAD (Kosaka et al. 2017; Bastos Maia et al. 2017). VAD is more prevalent not only among pregnant women in poor resources countries and underserved communities affected by inequalities in income and education, but also is associated with gestational age, smoking, alcohol consumption and poor access to health services (Yang et al. 2015; Larson et al. 2018; Lee et al. 2008).

Hence, concerted efforts are needed to ensure that pregnant women of low socio-economic status are carefully targeted in any activities aimed at improving household income or dietary intake.

Sample women with VAD exhibited a higher likelihood of being anaemic. These findings are consistent with prior research conducted in Bangladesh, which demonstrated that pregnant women with VAD faced approximately double the risk of developing anaemia (Ahmed et al. 2003). VAD may disrupt iron metabolism, contributing to poor pregnancy and lactating outcomes (Kosaka et al. 2017; Bastos Maia et al. 2019; Ishaq et al. 2024). Over a decade ago, the TDHS found that close to half of pregnant women in Tanzania suffered from both anaemia and VAD (ICF Macro. 2011).

Sample women with VAD had a higher likelihood of poor diversity dietary intake scores (MDD-W). This finding aligns with other studies showing that a higher dietary diversity score correlates with improved nutritional indicators (Shrestha et al. 2021). VAD has for example been found to occur with the chronic consumption of diets that are limited in dairy products and carotene-rich vegetables and fruit (Bastos Maia et al. 2019), though some studies have failed to establish an association between dietary diversity and the actual consumption of Vitamin A-rich foods (Okello et al. 2013). Various methods are utilized to assess dietary diversity as indicators of micronutrient intake, and the interpretation of these findings requires particular attention.

Limitations of this study include the weakness of cross-sectional studies in establishing causal relationships. Our findings may not be applicable to pregnant women receiving antenatal care throughout mainland Tanzania, though the socio-demographic distribution of our study participants was typical for the country.

CONCLUSION

Vitamin A deficiency among pregnant women in the Mbeya region of Tanzania is a mild public health concern according to the WHO classification. VAD was significantly associated with younger women, low socio-economic status, anaemia, and low maternal dietary diversity scores. We believe this highlights the importance of proper nutrition education promoting the consumption of low-cost, locally available nutrient-dense foods to support healthy pregnancies.

AUTHOR CONTRIBUTIONS

RMM, GM, HAP, RM, SS, EMN, AH, JS, PC, AS and, EK participated in the conceptualization and design of the study, collected and analysed data and prepared the first draft. KA and TL participated in prepared and analysed laboratory data. RSM, RMM and GHL participated in project administration and supervision. RMM, KA, TL, GC, AS, RM, SS, GM, EK, RSM, PC and, GHL participated in reviewing and editing the final draft of the manuscript. All authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

TRANSPARENCY DECLARATION

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

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REFERENCES

Abdallah F., John S.E., Hancy A., Paulo H.A., Sanga A., Noor R., Lankoande F., Chimanya K., Masumo R.M. and Leyna G.H. 2022. Prevalence and factors associated with anaemia among pregnant women attending reproductive and child health clinics in Mbeya region, Tanzania. *PLOS Global Public Health*, *2*(10), e0000280. https://doi.org/10.1371/journal.pgph.0000280

Ahmed F., Mahmuda I., Sattar A., & Akhtaruzzaman M. 2003. Anaemia and vitamin A deficiency in poor urban pregnant women of Bangladesh. *Asia Pacific Journal of Clinical Nutrition*, *12*(4), 460-466.

Akhtar S., Ahmed A., Randhawa M.A., Atukorala S., Arlappa N., Ismail T., & Ali Z. 2013. Prevalence of vitamin A deficiency in South Asia: causes, outcomes, and possible remedies. *Journal of Health, Population, and Nutrition*, *31*(4), 413-423. https://doi.org/10.3329/jhpn.v31i4.19975

Bastos Maia S., Rolland Souza A. S., Costa Caminha M. D. F., Lins da Silva S., Callou Cruz R. D. S. B. L., Carvalho dos Santos C., & Batista Filho M. 2019. Vitamin A and pregnancy: a narrative review. *Nutrients*, *11*(3), 681-699. https://doi.org/10.3390/nu11030681

Chaudhary-Webb M., Schleicher R.L., Erhardt J.G., Pendergrast, E. C., & Pfeiffer, C. M. 2019. An HPLC ultraviolet method using low sample volume and protein precipitation for the measurement of retinol in human serum suitable for laboratories in low-and middle-income countries. *The Journal of Applied Laboratory Medicine*, *4*(1), 101-107.

Christian A.K., & Dake F.A. 2022. Profiling household double and triple burden of malnutrition in sub-Saharan Africa: prevalence and influencing household factors. *Public Health Nutrition*, *25*(6), 1563-1576. https://doi.org/10.1017/S1368980021001750

Evans D., Hausladen S., Kosec K., & Reese N. (2014). *Community-based conditional cash transfers in Tanzania: Results from a randomized trial*. World Bank Publications. https://documents1.worldbank.org/curated/en/789981468133177841/pdf/Community-based-conditional-cash-transfers-in-Tanzania-results-from-a-randomized-trial.pdf

Eyeberu A., Getachew T., Tiruye G., Balis B., Tamiru D., Bekele H., Abdurke M., Alemu A., Dessie Y., Shiferaw K. & Debela A. 2023. Vitamin A deficiency among pregnant women in Ethiopia: A systematic review and meta-analysis. *International Health*, *15*(6), 630-643.

Furr H. C. 2004. Analysis of retinoids and carotenoids: problems resolved and unsolved. *The Journal of Nutrition*, *134*(1), 281S-285S. https://doi.org/10.1093/jn/134.1.281S

Harika R., Faber M., Samuel F., Kimiywe J., Mulugeta A., & Eilander A. 2017. Micronutrient status and dietary intake of iron, vitamin A, iodine, folate and zinc in women of reproductive age and pregnant women in Ethiopia, Kenya, Nigeria and South Africa: a systematic review of data from 2005 to 2015. *Nutrients*, *9*(10), 1096-1119. https://doi.org/10.3390/nu9101096

ICF Macro. 2011. Micronutrients: Results of the 2010 Tanzania demographic and health survey. https://dhsprogram.com/pubs/pdf/NUT5/NUT5.pdf

Imdad A., Mayo-Wilson E., Herzer K., & Bhutta Z.A. 2017. Vitamin A supplementation for preventing morbidity and mortality in children from six months to five years of age. *Cochrane Database of Systematic Reviews*, 3(3), CD008524. https://doi.org/10.1002/14651858.CD008524.pub3

Ishaq M.U., Kunwar D., Qadeer A., Komel A., Safi A., Malik A., Malik L. and Akbar A. 2024. Effect of vitamin A on maternal, fetal, and neonatal outcomes: An overview of deficiency, excessive intake, and intake recommendations. *Nutrition in Clinical Practice*, *39*(2), 373-384. https://doi.org/10.1002/ncp.11096

Islam M.H., Nayan M. M., Jubayer A., & Amin M. R. 2024. A review of the dietary diversity and micronutrient adequacy among the women of reproductive age in low- and middle-income countries. *Food Science & Nutrition*, *12*(3), 1367-1379. https://doi.org/10.1002/fsn3.3855

Kosaka S., & Umezaki M. 2017. A systematic review of the prevalence and predictors of the double burden of malnutrition within households. *British Journal of Nutrition*, *117*(8), 1118-1127. https://doi.org/10.1017/S0007114517000812

Larson L.M., Guo J., Williams A. M., Young M. F., Ismaily S., Addo O. Y., Thurnham D., Tanumihardjo S.A., Suchdev P.S. and Northrop-Clewes C.A. 2018. Approaches to assess vitamin A status in settings of inflammation: Biomarkers Reflecting Inflammation and Nutritional Determinants of Anaemia (BRINDA) project. *Nutrients*, *10*(8), 1100-11. https://doi.org/10.3390/nu10081100

Lee V., Ahmed F., Wada S., Ahmed T., Ahmed A.S., Banu C. P., & Akhter N. 2008. Extent of vitamin A deficiency among rural pregnant women in Bangladesh. *Public Health Nutrition*, *11*(12), 1326-1331. https://doi.org/10.1017/S1368980008002723

Lemeshow S. 1991. *Sample size determination in health studies: a practical manual*. World Health Organization. https://tbrieder.org/publications/books_english/lemeshow_samplesize.pdf

Okello J. J., Sindi K., Low J., & Shikuku K.M. 2013. Hidden hunger or knowledge hunger? Nutritional knowledge, diet diversity and micronutrient intake in Rwanda: The case of Vitamin A. *African Association of Agricultural Economists Conference, Tunisia,* 1-25. http://ageconsearch.umn.edu

Okereke C.E., Anyaehie U.B., Dim C.C., Iyare E E., & Nwagha U.I. 2013. Evaluation of some anthropometric indices for the diagnosis of obesity in pregnancy in Nigeria: a cross-sectional study. *African Health Sciences*, *13*(4), 1034-1040. https://doi.org/10.4314/ahs.v13i4.25

Panth M., Shatrugna V., Yasodhara P., & Sivakumar B. 1990. Effect of vitamin A supplementation on haemoglobin and vitamin A levels during pregnancy. *British Journal of Nutrition*, *64*(2), 351-358. https://doi.org/10.1079/bjn19900037

Rugeiyamu R. 2022. The Tanzania housing and population census 2022: A panacea for local service delivery and development drawbacks. *Local Administration*

Journal, *15*(1), 1-13.

Shrestha V., Paudel R., Sunuwar D.R., Lyman A.L.T., Manohar, S. & Amatya A. 2021. Factors associated with dietary diversity among pregnant women in the western hill region of Nepal: A community based cross-sectional study. *PloS one*, *16*(4), e0247085. https://doi.org/10.1371/journal.pone.0247085

Sommer A., & Davidson F.R. 2002. Assessment and control of vitamin A deficiency: The Annecy Accords. *The Journal of Nutrition*, *132*(9), 2845S-2850S. https://doi.org/10.1093/jn/132.9.2845S

Strobel M., Tinz J., & Biesalski H. K. 2007. The importance of β-carotene as a source of vitamin A with special regard to pregnant and breastfeeding women. *European Journal of Nutrition*, *46*, 1-20. https://doi.org/10.1007/s00394-007-1001-z

Underwood B.A., & Arthur P.A.U.L. 1996. The contribution of vitamin A to public health. *The FASEB Journal*, *10*(9), 1040-1048.

Wallingford J.C., & Underwood B.A. 1987. Vitamin A status needed to maintain vitamin A concentrations in nonhepatic tissues of the pregnant rat. *The Journal of Nutrition*, *117*(8), 1410-1415. https://doi.org/10.1093/jn/117.8.1410

WHO. Indicators for Assessing Vitamin A deficiency and their application in monitoring and evaluating intervention programmes; World Health Organization: Geneve, Switzerland, 1996.

Wolde M., & Tessema Z.T. 2023. Determinants of good vitamin A consumption in the 12 East Africa Countries using recent Demographic and health survey. *PLoS One*, *18*(2), e0281681. https://doi.org/10.1371/journal.pone.0281681

World Health Organization. 2012. WHO Guideline: Vitamin A supplementation in pregnant women. Geneva: WHO, 2011; WHO Guideline: Vitamin A supplementation in postpartum women. Geneva: WHO, 2011. *Advances in Nutrition*, *3*(2), 215-216. https://doi.org/10.3945/an.111.001701

World Health Organization. 1994. Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. *Report of a WHO/UNICEF Consultation, Geneva, 9-11 November 1992*. https://www.who.int/publications/i/item/WHO-NUT-96.10"

World Health Organization. 2009. Global prevalence of vitamin A deficiency in populations at risk 1995-2005: WHO global database on vitamin A deficiency.

Yang C., Chen J., Liu Z., Yun C., Piao J., & Yang X. 2015. Prevalence and influence factors of vitamin A deficiency of Chinese pregnant women. *Nutrition Journal*, *15*, 1-7. https://doi.org/10.1186/s12937-016-0131-7

Young M. F., & Suchdev P. S. 2022. Effects of inflammation on micronutrient biomarkers associated with anemia. In *Nutritional Anaemia* (pp. 63-73). Cham: Springer International Publishing.

Zhao Y., Hu J., Zhao J., & Yin D. 2020. Determination of vitamin A and vitamin E in human serum by high performance liquid chromatography with fluorescence detection. *Wei Sheng yan jiu= Journal of Hygiene Research*, *49*(4), 585-590. https://doi.org/10.19813/j.cnki.weishengyanjiu.2020.04.011