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Food-basket intervention to reduce micronutrient deficiencies among Maasai-pregnant women in Tanzania: a quasi-experimental study

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Abstract

Background: Micronutrients comprised of vitamin and mineral nutrients that are needed during pregnancy for foetal growth, development and maturation, as well as for reducing/preventing maternal complications. However, micronutrient-rich foods (vegetables and fruits) are lacking in the Ngorongoro Conservation Area as a result of restrictions on cultivation in conservation areas and the unavailability of vegetables and fruits in local markets. The present study introduced a food basket intervention and assessed the effectiveness of the food baskets with respect to addressing anaemia, vitamin A and iron deficiencies among pregnant Maasai women within the Ngorongoro Conservation Area.

Methods: The quasi-experimental study included Misigiyo ward as a control group (provided education only) and Olbalbal ward as an intervention group (provided food baskets and education). The study assessed haemoglobin, serum ferritin and retinol at baseline and during follow-up. Haemoglobin, serum ferritin and retinol were quantitatively (duplicate) measured with HemoCue™ (HemoCue AB, Ängelholm, Sweden), Maglumi 800 (Snibe Diagnostic, Shenzhen, China) and vitamin A enzyme-linked immunosorbent assay, respectively. Dependent and independent *t*-tests were used to compare the micronutrient blood levels between and within the groups.

Results: The present study found a statistically significant increase in serum retinol ($P < 0.001$) in the intervention group compared to the control group; moreover, baseline serum retinol was positively associated with the follow-up serum retinol, whereas baseline haemoglobin and serum ferritin were negatively associated.

Conclusions: The food basket intervention holds promise with repect to reducing micronutrient deficiency, especially in communities where micronutrient-rich foods are scarce.

Introduction

Micronutrient malnutrition is a prevalent global health problem, especially in mother–child dyads [(1)]. In developing countries, maternal micronutrient deficiencies have been associated with short- and long-term effects, such as miscarriage, low-birth weight, stillbirth, preterm birth, congenital disabilities, poor neurological development, delayed growth, decreased cognitive development, and infant and/or maternal death [(2–4)]. The present study focuses on vitamin A and iron as micronutrients of significant public health concern for pregnant women.

Vitamin A is a fat-soluble vitamin. It plays a major role in cell division, growth and maturation (foetal organ and skeletons), upkeep of the immune system to fight against infections, development of vision in the foetus, maintenance of maternal eye health and prevention of night blindness during pregnancy [5]. The prevalence of night blindness (a consequence of vitamin A deficiency) among pregnant women is approximately eight million worldwide [6]. In low- and middle-income countries, 15% of pregnant women have gross vitamin A deficiency, whereas 8% of pregnant women have vitamin A deficiency at a sufficient level to cause night blindness. Moreover, 39% of Tanzanian pregnant women were found to be vitamin A deficient [7].

Iron is a mineral found naturally in select foods. It plays a major role in formation of haemoglobin that aids in transportation of oxygen throughout the body [8]. When there is a chronic lack of iron in the diet, infection (parasitic infection) and infestation (worms), and iron-deficiency anaemia can result, contributing to maternal mortality and morbidity. Maternal mortality can be caused by increased blood loss during delivery, pre-eclampsia and miscarriage [9]. Iron-deficient mothers are at risk of delivering low birth weight, preterm and/or iron-deficient babies [10]. The prevalence of prenatal iron deficiency anaemia is 15%–20% worldwide and is estimated to be as high as 35%–75% in developing countries [11]. In Tanzania, 45% of women of reproductive age (15–49 years) are anaemic [7].

Maternal anaemia, as well as iron and vitamin A deficiencies, are increasing across the African continent as a result of poverty, lack of micronutrient knowledge and food insecurity [12]. To address this situation, the Food Agriculture Organization and the United Nations recommend micronutrient supplementation, fortification and food-based approaches as potential strategies for combating micronutrient deficiency [13]. Although this triad of solutions is noted, the food-based approach offers the most sustainable solution for both poverty and micronutrient malnutrition reduction in developing countries [13–16].

The food basket, as a food-based approach, consists of different foods gathered from local farmers specialising in the cultivation of certain foods. The purpose of the food basket intervention is to provide diverse micronutrient-rich foods to each individual or household depending on food aid/external needs, with the aim of improving nutrition status [17]. Little is known about the effectiveness of the food baskets with respect to combating maternal micronutrient deficiencies. The available studies have suggested that the food baskets are often aimed at providing the least costly array of foods without considering micronutrient density and cultural acceptability [18,19].

The food basket intervention consisted of micronutrient-rich foods (vegetables and fruits) that were supplied to pregnant women participants because this group is often identified as at risk for micronutrient deficiency. The food basket composition was based on the reported high prevalence of vitamin A deficiency (100%) and anaemia (29%) in this community [20]. High levels of vitamin A and iron deficiency were associated with the restrictions for cultivation in the Ngorongoro Conservation Area (NCA), cultural dietary restrictions, and inaccessibility/unavailability/unaffordability of fresh vegetables and fruits in local markets [21,22]. Previous work shows that this population had good knowledge about the need for iron in the diet; however, it also showed that this knowledge did not translate to good dietary practices (Mshanga N, Martin H & Petrucka P, Unpublished data).

The rationale of the present study was to consider the impact of the food basket intervention with respect to reducing micronutrient deficiency in a resource-poor setting, as well as the implications for the health status of the mother and unborn child. To achieve the stated objective, the study assessed the effectiveness of the food basket intervention with respect to reducing anaemia, vitamin A and iron deficiency by measuring the vitamin A and iron status of select Maasai pregnant women before and after a food basket intervention.

Materials and methods

Study area, participants and design

The study was conducted in NCA, comprising a unique protected area where the conservation of natural resources (animal and vegetation) is integrated with human activities. NCA is located 180 km west of Arusha in the crater highlands area of Tanzania. The majority of residents are Maasai pastoralists who have, in recent times, started to shift from animal-based diets to cereal-based diets because of the depletion of animal stocks as a result of diseases, droughts and famine.

The present study used a quasi-experimental (pre-post) design. Participants were recruited within two geographical locations, specifically in Misigiyo village (10 km from NCA gate) and Olbalbal village (42 km from the gate). Furthermore, Olbalbal ward was purposively selected as the ward where the Agri-health Cooperative project was implemented, whereas Misigiyo ward was selected based on its similar characteristics to the Olbalbal ward. To assess the effectiveness of the project implemented in Olbalbal ward, the Olbalbal group was categorised as an intervention group and Misigiyo as the control group. Thus, the intervention group received the food basket and nutrition education, whereas the control group received nutrition education only. Maasai pregnant women who were 1–12 weeks pregnant (to allow for follow-up) were recruited from antenatal and mobile clinics in both Olbalbal and Misigiyo wards, with those experiencing maternal complications being excluded from the study.

Nutrition education

Nutrition education was provided by the nutritionist to the intervention and control group. The lessons were explained in Swahili language and translated into Maa language by a research assistant used vegetable and fruit models. The participants were divided into two groups (containing either 12 or 13 participants), with one group first attending the nutrition education class when the other collected the food baskets and attended ANC clinics, then reversing the roles. Nutrition education was divided into three parts: (i) role of vegetables and fruits in our body and during pregnancy; (ii) good preparation, cooking and storage methods of vegetables and fruits; and (iii) foods that hinder or affect the absorption of certain micronutrients (e.g. tea and iron; zinc and iron). Furthermore, study participants from the intervention group were encouraged to diversify their diets (i.e. to consume at least three different vegetables per day) and all of the study participants (from control and intervention groups) were advised to continue consuming wild Indigenous vegetable (i.e. African nightshade).

To preserve the vegetables and fruits (i.e. because refrigeration is not an option), participants who had clay pots (large and small) in their households were advised to put the smaller pot in the larger pot and put sand in the space between the two pots. Furthermore, they were instructed to keep the sand moist by adding water (daily), when placing the vegetables (packed in plastic bags) in the smaller pot. Both pots were then covered with a wet sack to keep the produce cool. For those who did not have clay pots, they were advised to sprinkle the vegetables with water and put them in a plastic bag. With the clay method, the green leafy vegetables stayed fresh for 4–6 days, whereas those using the plastic bag method found that freshness was retained for 3–4 days. The storage lessons were adopted from the Technical Centre for Agriculture and Rural Cooperation [23].

Food basket intervention

Traditional birth attendants (TBAs) were responsible to distribute the food basket for the project primarily as a result of their cultural role as influencers of pregnant women with respect to the consumption of vegetables and fruits. We recognise that there are both formal and informal providers within the health sector and, within the communities of interest, the cultural and/or traditional practices often dominate. The vegetables and fruits contained in the food basket were cultivated in Karatu district (a nearby district) and transported to Olbalbal (intervention group). The food basket contents and micronutrient contributions are shown in Table 1. The food basket contents were selected based on the participants' preferences, existing micronutrient deficiencies identified during baseline testing, plus the nutritional quality and quantity of the available vegetables and fruits. The nutritional content of the vegetables and fruits in the food basket was obtained from previous studies [24–28].

One food basket contained the core elements of one bunch of sweet potato leaves, amaranth, pumpkin leaves, onions, oranges, carrots and pumpkins. Dependent on availability, Chinese cabbage (*Brassica rapa*) was added to one supply, and spinach was supplied in the next distribution followed by saro because these were highly preferred vegetables in the community, although they were difficult to obtain on a consistent basis.

As a result of the dispersed settlement patterns in these two communities, the food baskets (four or five food baskets for each participant) were provided twice per month, on market days, because there was reliable public transport that enabled the target population to go to the market, visit the antenatal clinic and collect their food baskets. More importantly, the study was conducted during the rainy season, which enabled the participants to continue consuming wild vegetables (African nightshade) as reported in a prior study (Mshanga N, Martin H & Petrucka P, Unpublished data). The food baskets were provided for a period of 6 months.

Recruitment

At the beginning of the study, in the intervention group, the TBAs announced the presence of this study during religious gatherings, village meetings and markets, as well as to their neighbours. Interested participants were instructed to contact any TBA who would then take the participant to the clinic for the recruitment process. There were no mobile clinics at the intervention area as a result of the presence of markets, which resulted in participants relying on public transport to reach the clinic. At the control group site, announcements were made at church gatherings by the health personnel and village leaders also made announcements to each household, instructing interested participants to attend the clinic, as well as mobile clinics as a result of a lack of markets in this community. Upon recruitment, standard measurements, such as last normal menstruation calculations and positive results for pregnancy testing, confirmed pregnancy, whereas fundal height measurement estimated pregnancy age in weeks.

At the beginning of the study, all of the recruited participants to both the control and intervention groups

Table 1 Micronutrient content of vegetables present in one food basket

Vegetable	Botanical names	Fe (mg)	Vitamin A	Retinol equivalent	Vitamin C	Zn (mg)
Sweet potato (20 leaves)	*Ipomoea batatas* (L)	152	5340	455	436	12
Amaranth (12 leaves)	*Amaranthus*	157.2	2052	171	534	7.2
Pumpkin (12 leaves)	*Cucurbita pepo* (L)	78	4992	416	294	19.2
Onion (20)	*Allium cepa* (shallot)	4	0	0	148	4
Orange (10)	*Citrus aurantium*	1	80	6.6	530	1
Pumpkin (3)	*Cucurbita*	2.4	603	50.25	15	0.6
Carrots (10 pieces)	*Daucus carota*	3	8410	700.8	59	2
Spinach (12 leaves)	*Spinacia oleracea*	32.4	9828	819	120	9.6
Chinese cabbage (12 leaves)	*Brassica rapa* (bok choy)	3.6	1440	120	300	2.4
Saro (12 leaves)	NA	151.2	22.92	1.91	241.2	7.2
African nightshade (12 leaves)	*Solonumnigrum*	190.8	47.64	3.97	20	3.4
WHO recommended daily intake during pregnancy.	NA	31–61	-	600	50	20

Sources: Lyimo *et al.* [24]; Weinberger and Msuya [25]; Lukmanji *et al.* [26]; WHO [30]; Kamga *et al.* [27]; Mamboleo *et al.* [28]. NA, not applicable.

were tested for malaria (and this was repeated on every clinic visit for food basket collection/nutrition education) and provided with long lasting insecticide nets for the prevention of malaria. For the participants who were diagnosed with malaria, they were prescribed with malaria tablets (quinine plus clindamycin) for 7 days. Furthermore, participants were given deworming tables (mebendazole) on their next clinic visit (after 2 weeks) and this treatment was repeated every 3 months. Moreover, sulphadoxine-pyrimethamine was given twice, at week 20 of pregnancy and, again, 4 weeks after the first dose as an intermittent preventive treatment for malaria. In addition, participants were physically assessed for any symptoms of infection and advised to practice good water, hygiene and sanitation (WASH) practices, such as avoiding unpasteurised foods, aiming to prevent infections. All medications were provided free of charge.

Follow-up

During the study period, each TBA was responsible for attending two to three participants based on their residential proximity. TBAs and the researcher filled the baskets with the selected vegetables and fruits and each TBA distributed the food baskets to the pregnant women who they were attending. For those women who were unable to visit the clinic on each occasion, the responsible TBAs supplied the food basket to their home place.

After supplying food baskets, the TBAs made unscheduled home visits to evaluate compliance on the dietary intake of vegetables and fruits supplied in the food basket and to encourage the participants to continue attending their ANC appointments to access the next food supplies. Attendance at ANC clinic was not a prerequisite for them to receive the food basket but comprised a convenient way of meeting the study participants.

Data collection and laboratory analysis

A qualified and experienced nurse collected blood samples from each participant during baseline and follow-up in the study. A 5-mL syringe was used to draw blood from the median cubital vein. A few drops were used for haemoglobin analysis on a HemoCue™ (HemoCue AB, Ängelholm, Sweden) machine and the remaining blood was stored in a vacutainer tube and left to clot for 30 min. Afterwards, the blood was centrifuged at a spin rate of 145–202 × ***g*** for 15 min. The serum was pipetted from the clotted blood and stored in a 2-mL Eppendorf tube. Then, the serum was transported in a liquid nitrogen jar to the laboratory where it was stored at −40 °C until analysis.

Laboratory analysis was conducted at the Safe Focus Laboratory in Arusha, Tanzania, where serum ferritin and retinol blood serums were quantitatively analysed in duplicate using the Maglumi 800™ machine (Snibe Diagnostic, Shenzhen, China) (employing a chemo-luminescence immunoassay system) and the Human Reader™ (HUMAN Diagnostics, Magdeburg, Germany) machine (via a vitamin A enzyme-linked immunosorbent assay). Serum ferritin is an iron store that releases its iron when there is iron depletion [29]; therefore, low levels of serum ferritin confirm iron deficiency. Serum retinol is the predominant circulating form of vitamin A, with vitamin A deficiency being diagnosed when the serum retinol count is less than 0.07 μmol L^{-1} [30].The analysis of serum retinol by enzyme-linked immunosorbent assay and serum ferritin by a chemo-luminescence immunoassay was based on techniques previously described by Yalow & Benson [31] and Woodhead & Weeks [32], respectively.

Statistical analysis

Descriptive statistics, such as frequency distribution, were used to assess the socio-demographic characteristic data of the study participants. The chi-squared test was used to compare the categorical variables, such as vitamin A deficiency, anaemia status (haemoglobin < 11 g dL^{-1}) and iron depletion status (ferritin < 12 ng L^{-1}) between groups (control and intervention). A dependent *t*-test was computed to determine changes in the continuous variables, such as serum retinol, ferritin and haemoglobin concentrations, which occurred within control and intervention groups. An independent *t*-test was used to determine the changes in serum retinol, ferritin and haemoglobin between the groups from baseline and after intervention. Lastly, stepwise multiple regression analysis was carried out to identify factors associated with serum retinol increase at the end of the study. SPSS, version 25 (IBM Corp., Armonk, NY, USA)™ and PRISM, version 7 (GraphPad Software Inc., San Diego, CA, USA) were used to perform statistical analysis. $P < 0.05$ was considered statistically significant.

Ethical approval

Ethical clearance from National Institute for Medical Research (NIMR/HQ/R. 8a/Vol. 1X/2708) was obtained along with a permit from NCA Authority. The ethical committee approved a written consent, parental/guardian assent forms (for minor participants) and the use of verbal consent for the case of illiteracy. After explanation to the study participants, those willing to participate signed informed consent forms. For the participants who did not know how to read and write, consent was provided orally in Maa with an impartial (nonresearch associated) witness to acknowledge the individual's verbal consent, and a thumb print signature was used.

Results

Socio-demographic characteristics of the study participants

There were 77 participants who volunteered to join the study and, based on the inclusion and exclusion criteria, 50 participants (25 in the control and in the intervention group) were eligible and consented to participate in the study (Fig. 1). Of those enrolled participants, two mothers delivered before follow-up and one miscarried; therefore, 47 participants remained at follow-up assessment. Over half (64% and 56% in the intervention and control groups, respectively) of the study participants were between 25 and 29 years of age. Most of the participants (92% and 96% in the intervention and control groups respectively) reported being married, and 72% listed their mothers-in-law as the nearest female supporter (Table 2).

Haemoglobin and anaemia

During baseline, study participants had a mean haemoglobin level of 12 and 11 g dL^{-1} in the intervention and control groups, respectively, showing no statistical difference of the haemoglobin levels between the groups ($P = 0.74$) (Fig. 2). There was no significant difference in the level of haemoglobin after 6 months between the intervention and control groups ($P = 0.06$). Moreover, 76.2% of the participants were anaemic during baseline with no significant difference between the groups ($P = 0.27$); however, there was a significant decrease in the proportion of anaemic women in the intervention group ($P < 0.02$) compared to the control group at follow-up.

Serum ferritin and iron deficiency

At the beginning of the study, participants across both groups had a mean ferritin of <7 ng mL^{-1}. However, after the food basket intervention, the ferritin levels were seen to slightly increase in the intervention group and further decrease in the control group (Fig. 3), whereas there was no statistical difference of pre- and post-intervention ferritin ($P = 0.10$). Although there was no significant difference in the proportion of iron-deficient women in both groups ($P = 0.44$) at the beginning and end of the study, the control group had a higher prevalence of iron-deficient women than the intervention group at the end of the study.

Serum retinol and vitamin A deficiency

Both groups had a serum retinol of less than 0.70 μmol L^{-1} during baseline and the difference was statistically insignificant between the groups ($P = 0.32$). After 6 months of the food basket intervention, there was a significant increase of serum retinol of 20 μmol L^{-1} in the intervention group ($P < 0.001$), whereas there was an insignificant increase of 3 μmol L^{-1} in the control group ($P = 0.07$) (Fig. 4). All of the study participants were vitamin A deficient and there was no statistically significant difference between the two groups at baseline ($P = 0.28$). Both groups experienced a decrease in the proportion of vitamin A deficient women over the course of the study, although the control group remained with a higher proportion of vitamin A deficient women after 6 months.

A stepwise multivariable analysis was performed to calculate the contributions made by the geographic location (ward), baseline haemoglobin, serum ferritin and serum retinol changes. The findings showed that, at baseline, vitamin A status of the participants was positively

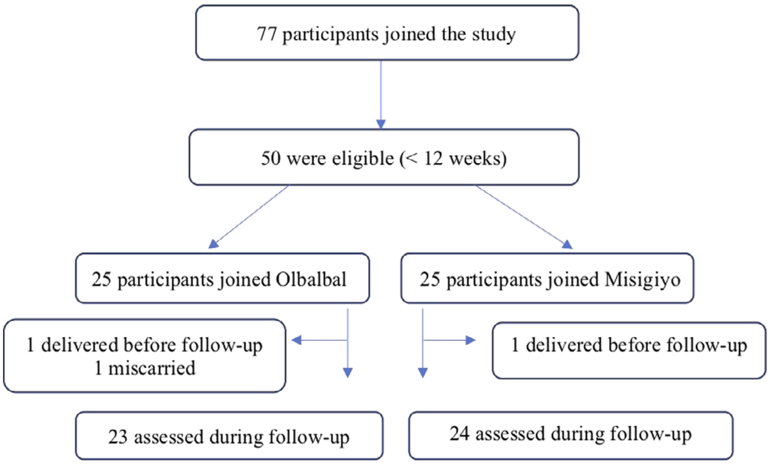

Figure 1 Distribution of study participants and loss to follow-up. At the beginning of the study, 77 participants joined the study but only 50 (25 each ward) were eligible for enrolment. At the end of the study, there were three dropouts caused by miscarriage and early delivery (before 6 months of intervention).

associated with the increase of serum retinol during follow-up. Conversely, wards, baseline haemoglobin and serum ferritin were negatively associated with serum retinol levels (Table 3). In addition, independent variables were able to predict 69% of the serum retinol changes.

Discussion

The food basket, together with nutrition education interventions, significantly increased serum retinol in pregnant women in the intervention group; however, there was an insignificant increase of serum retinol in the education only group (control). The present study is one of only a few showing the usefulness of fruits and vegetables with respect to reducing maternal vitamin A and iron deficiency, especially in pastoral societies.

The significant increase of serum retinol may be associated with the dietary intake of vegetables and fruits present in the food basket. These findings were in contrast to the findings of Mulokozi *et al.* [33] who found no significant difference between vegetable intake and retinol status of Tanzanian pregnant women. The difference between the results of the present study and those of Mulokozi *et al.* [33] may be attributed to the different study designs because the latter study assessed the participants' retinol level and related it to the vegetable intake, whereas the present study measured the retinol levels of vegetable intake and nonvegetable intake participants for a period of time. Moreover, the reason for this shift may relate to the findings of the study by Tanumihardjo *et al.* [34], who reported that supplying vitamin A rich foods to deficient patients results in high cleavage rates of provitamin A, which contributes to the increased bio-efficacy of serum retinol.

The presence of small amounts of zinc in the food supplied may have contributed to the increase of serum retinol. Hess *et al.* [35] reported that zinc acts as a cofactor of β,β-carotene 15-15′- dioxygenase 1 (BCO1) enzyme, which plays an important role in breaking the provitamin A from plant foods to the form that is easily absorbed (retinol) in the body. Dietary intake of wild vegetables (i.e. African nightshade), as reported in a previous study, may have contributed to the small increase of serum retinol in the control group (Mshanga N, Martin H & Petrucka P, Unpublished data). Moreover, the nutrition/health education provided during the present study might have contributed to the increase of serum retinol in both groups. As suggested by Howson *et al.* [16], providing nutrition education together with food interventions improves dietary intake because the educated population would have acquired a certain knowledge (e.g. green leafy vegetable intake prevents night blindness) that influences their dietary practices. The results were similar to the quasi-experimental findings of Kidala *et al.* [36] reporting a high increase of serum retinol in Tanzanian mothers who received nutrition education.

Arinola *et al.* [37] suggested an intake of deworming pills to reduce micronutrient deficiency among pregnant women; therefore, the increase of serum retinol in both groups may be attributed to the intake of deworming pills, malaria prevention interventions and the provision of WASH education. The findings of the present study are similar to a study carried out in Benin, which found an increase in haemoglobin after the provision of sulphadoxine-pyrimethamine and deworming tables to pregnant women who had low haemoglobin at the beginning of the study [38]. All of the participants were given the same care regarding the prevention of diseases (parasitic, infectious and infestation), controlling for artefacts in haemoglobin and serum ferritin levels. Hence, the changes seen in the present study may be attributable to the impact of the food baskets as a result of diversification and micronutrient redress. As suggested by Thompson and Amoroso [13], a combination of different sources of micronutrient rich foods (i.e. different vegetables per

Table 2 Socio-demographic characteristics of study participants

Variable	Intervention group *n*	Intervention group %	Control group *n*	Control group %
Number of participants				
Baseline	25	100	25	100
Follow-up	23	92	24	96
Age (years)				
15–20	2	8	1	4
21–24	1	4	2	8
25–29	16	64	14	56
≥30	6	24	8	32
Nearest female supporter				
Mother in law	17	68	19	76
Co-wife	5	20	2	8
Mother	3	12	4	16
Marital status				
Single	2	8	1	4
Married	23	92	24	96
Education status				
No formal education	8	32	6	24
Primary	12	48	16	64
Secondary	5	20	2	8
Gravidity				
0	0	0	0	0
1–3	14	56	17	68
4–6	3	12	7	28
≥7	8	32	1	4
Parity				
0	5	20	4	16
1–3	12	48	16	64
4–6	3	12	5	20
≥7	5	20	0	0
Occupation				
Pastoralist	23	92	24	96
Business women	2	8	1	4

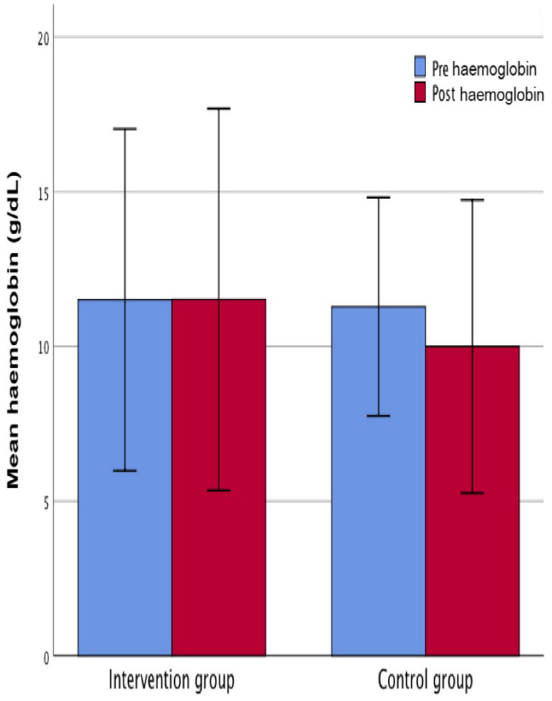

Figure 2 Pre- and post-haemoglobin. The study participants from both wards had a mean haemoglobin of less than 11 g dL^{-1} at the beginning of the study, whereas the haemoglobin level dropped in the control group and remained constant in the intervention group. The results were obtained from independent and dependent *t*-tests.

meal) may help to reduce and prevent different types of micronutrient deficiencies.

Although this is a pastoralist society, pregnant women were restricted in their consumption of milk, animal protein, rice and other carbohydrates, protein and fat foods [22], and there was also a lack of micronutrient supplements in NCA health centres [39]. The different vegetables provided contained a nonhaeme iron (low absorbable iron). This situation may explain the statistically insignificant increase of haemoglobin and ferritin after food basket intervention, which may be attributed by the supply of nonhaeme-rich vegetables and highly perishable vegetables (i.e. they cannot store for longer periods of time). Moreover, the small increase of serum ferritin and haemoglobin may be attributed to the haemo-dilution (increase of blood volume (approximately 1.5 L) that occurs in the last trimester, hence clinically reducing the amount of ferritin and haemoglobin [40,41].

Furthermore, the minor increase of serum ferritin may be triggered by the increased use of ferritin (stored iron) in haemoglobin synthesis. These findings are similar to those of the study by Milman [42], who found a decrease in ferritin when haemoglobin increases and associated this with the increased use of ferritin during haemoglobin formation. These results are in line with a study conducted by Makola *et al.* [43], which reported low ferritin levels after an 8-week supply of dietary supplements in Tanzanian pregnant women. The increase of haemoglobin and ferritin may be attributed to the reduced consumption of calcium-rich foods (i.e. milk) as one of their cultural restricted foods during pregnancy because calcium tends to hinder the absorption of iron in the body. A study by Bivolarska *et al.* [44] found a significant reduction in maternal serum ferritin with dietary intake of fish and cow's milk.

Study limitations included a failure to control consumption by the target participants, although the TBAs undertook intermittent home-based visits to evaluate dietary intake and to advise the study participants to continue using the vegetables and fruits. Although the study participants used traditional storage methods (i.e. clay pots), some of the green leafy vegetables could not survive the 2-week period because of a lack of power and/or cold storage

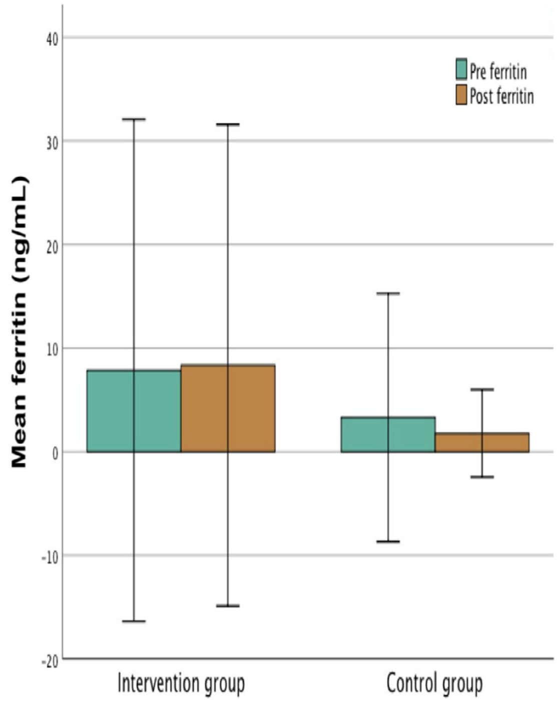

Figure 3 Pre- and post-ferritin. At the beginning of the study, participants across both groups had a mean ferritin of <7 ng mL^{-1}. However, after the food basket supply, the ferritin levels were seen to slightly increase in the intervention group and further decrease in the control group. The results were obtained from independent and dependent *t*-tests.

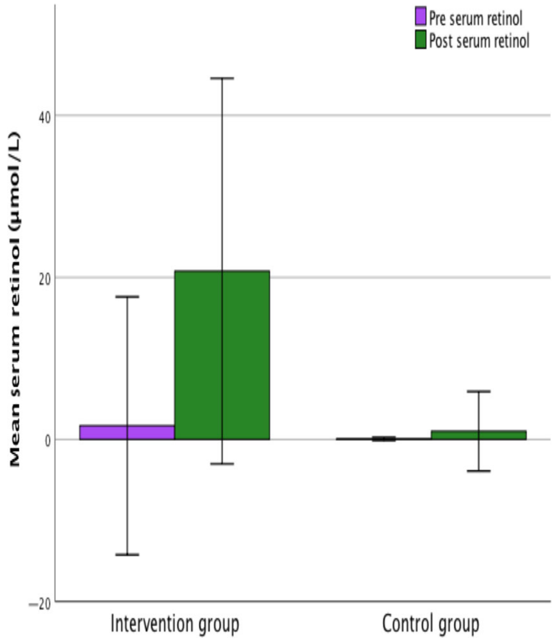

Figure 4 Pre- and post-serum retinol. Both groups had a serum retinol of less than 1 µmol L^{-1} during baseline, whereas, after 6 months of the food basket intervention, there was an increase of mean serum retinol of 20 mcg dL^{-1} in the intervention group and 3 mcg dL^{-1} in the control group. The results were obtained from independent and dependent *t*-tests.

in this community which was the resuilt of a lack of electricity in the conservation area. Because of budget constraints, the study failed to assess creatinine levels for detecting infection among participants; however, the study participants were advised to practice WASH and other hygienic practices (i.e. food pasteurisation) to prevent infections. Lastly, the majority of study participants joined the study during weeks 6–12 of pregnancy, and so we may have missed a crucial period where there is high need for micronutrients (such as folic acid, which is highly needed before conception and during the first trimester).

Overall, the evidence obtained from the present study indicates that, when used together, food basket and nutrition education interventions may reduce micronutrient deficiency amongst pregnant women in developing contexts. Moreover, the present study shows the importance of treating vitamin A deficiency by advocating for the consumption of vegetables and fruits, especially in pregnant women, because they are being advised to consume provitamin A (β-carotene) as a result of its low likelihood of causing vitamin A toxicity. Therefore, the NCA could allocate farming areas in nearby districts to enable the availability of vegetables and fruits. Furthermore, the community/traditional/religious leaders (e.g. Laigwanan, elders) should be trained and advised on the importance of the intake of vegetables/fruits among pregnant, lactating women, as well as women of reproductive age, because they are the most influential persons in the community.

Table 3 Factors predicting the vitamin A levels during follow-up

	β^2	*P*	Confidence interval
Constant	49.18, 8.31	0.000	32.40 to 65.95
Wards	−19.78, 2.330	0.000	−24.49 to −15.08
Pre-haemoglobin (g dL^{-1})	−0.15, 0.62	0.805	−1.41 to 1.10
Pre-ferritin (ng mL^{-1})	−0.21, 0.15	0.166	−0.52 to 0.09
Pre-serum retinol (µmol L^{-1})	0.578, 0.21	0.009	0.15 to 1.007

$r = 0.83$, $r^2 = 0.69$, adjusted $r^2 = 0.65$.

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Conflict of interests, source of funding and authorship

The authors declare that they have no conflicts of interest.

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NM and PP were responsible for conceiving the study. NM was responsible for data curation, formal analysis, methodology and writing the original draft. PP was responsible for resources. HM and PP were responsible for study supervision. NM, HM and PP were responsible for writing, reviewing and editing. All authors critically reviewed the manuscript and approved the final version submitted for publication.

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with CONSORT guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned [National Institute of Medical Research (NIMR/HQ/R. 8a/Vol. 1X/2708)] have been explained.

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