The effect of a combination of nutrition education, soy and vegetable gardening, and food preparation skill training interventions on dietary intake and diversity in women: a case study from Qwa-Qwa

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Abstract

Objective: The objective of the study was to determine if an integrated food and nutrition intervention, including home gardening, nutrition education and recipe development and training, would improve dietary diversity in women.

Design: This was a single-system case study.

Setting: The study setting was peri-urban Qwa-Qwa, Free State province, South Africa.

Subjects: Fifty randomly selected women were included in the study from three purposively selected tribes.

Outcome measures: Three 24-hour recall questionnaires were used to determine dietary intake and nutrient adequacy, a dietary diversity questionnaire to calculate the dietary diversity scores (DDSs), and the Radimer-Cornell Hunger Scale questionnaire to ascertain food insecurity.

Results: The median food variety score (FVS) was 23 at baseline, and improved significantly (p-value 0.002) to 29 at follow-up. Micronutrient intake was consistently low, despite the median adequacy ratio (MAR) improving significantly (p-value 0.002) from 0.49 to 0.63 at follow-up. Despite a significantly improved MAR at follow-up, the nutrient adequacy ratio (NAR) for only three nutrients met 100% at follow-up, namely dietary iron, phosphate and vitamin B_3. A strong significant positive correlation existed between FVS and the food group diversity score ($r = 0.617$, p-value 0.000). The FVS and DDS were higher in the food-secure group ($n = 16$, 32%) than in the food-insecure group ($n = 34$, 68%), but not significantly. Although most food groups were consumed by the women, limited foods from each group were included.

Conclusion: Women in this resource-poor community lacked a variety of food in their diet, despite a high overall DDS. Thus, they had inadequate micronutrient intake and adequacy. A combination of nutrition education, soy and vegetable gardening, and food preparation skill training interventions, seemed to positively influence the nutrient adequacy and overall dietary diversity of the women participating in this study.

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Introduction

At present, food and nutrition security is an important global issue[1] as an estimated 805 million people suffered from chronic under nutrition between 2012 and 2014. Thus, one in every nine people globally do not have sufficient food required for an active and healthy life. The majority of undernourished people live in developing countries. The highest prevalence of any region, i.e. one in four people (24%) in the world, is in sub-Saharan Africa.[2] Although malnutrition is caused by many factors, such as infectious diseases (tuberculosis, and human immunodeficiency virus/acquired immune deficiency syndrome, an inadequate intake is one of the immediate causes of malnutrition. Thus, chronic undernutrition is often the result of hunger or household food insecurity. Food security is defined as a situation "when all people at all times have access to sufficient, safe and nutritious food to maintain a healthy and active life".[3] Twenty-six per cent of the population is food insecure in South Africa,[4] meaning that they have inadequate food availability and access,[5] while 28.3% are at risk of hunger. Furthermore, black Africans have the highest rate of food insecurity (30%).[4]

Research has proved that food insecurity in resource-poor adults is associated with chronic diseases of lifestyle, such as cardiovascular disease, diabetes, and overweight and obesity. For instance, it was proven in other countries that people who live in resource-poor conditions often have no choice other than to consume a low-quality, monotonous, nutrient-deprived diet.[6] However, the essential nutrients to meet nutritional needs and to prevent micronutrient deficiencies are not found in one single food item, but rather in a diverse diet, derived from different foods and food groups. Also, food insecurity is adversely associated with dietary quality and dietary intake.[5] Therefore, the implication is that dietary diversification is important with regard to nutrient diversity for human well-being.[1,6] Furthermore, a whole-diet approach is necessary when examining relationships between nutrition and health,[1] but a paucity of information still exists regarding women's micronutrient adequacy and diet quality.[7]

This study was undertaken in the peri-urban Thabo Mufatsanyane District (Qwa-Qwa), the largest in Free State province, with a population of 766 754. This district is severely impoverished. Seventy-three per cent of the population live below the poverty line for South Africa,[8] and 32% and 29% of the population are at risk of hunger and food insecurity, respectively.[4] Poverty, household food insecurity, an inadequate habitual dietary intake[9] and poor dietary diversity[10] were found in female caregivers in previous studies on the same community. Dietary diversification is sustainable and central to all food-based strategies when food insecurity and malnutrition are being addressed, and includes an increase in and the diversification of food production. This can be achieved by home gardening in two ways,[11] i.e. primarily through the production of food crops which can be consumed by the household, and also by selling the produce to complement the household income for food procurement and consumption. Thus, it is possible that diversified agricultural production could result in a more diverse diet in households that consume almost everything they produce.[12] Few studies have been performed which link home gardening to dietary diversity.[11,12] The objective of this study was to expand the limited evidence by determining if an integrated food and nutrition intervention, including home gardening, nutrition education and recipe development and training, would improve the dietary diversity of women resident in peri-urban Qwa-Qwa.

Method

The study protocol complied with the World Medical Association Declaration of Helsinki and the South African Medical Research Council's guidelines for research on human beings. The University of the Witwatersrand's Medical Ethics Committee for Research on Human Beings approved the study (M080931), which was conducted between March 2008 and November 2012.

Sampling

The sampling was calculated using a power calculation,[13] based on 80% power, 95% significance and a change of 15% (estimated) in the food frequency score, with a standard deviation (SD) of 2.[12] A total of 40 respondents was needed to obtain statistically representative data for this study. The local community leader purposively chose three tribes who met the inclusion criteria (those in a peri-urban area, with a monthly household income < R2 000, who were Sotho-speaking women, aged 19-75 years), from whom a random sample was selected, using a location map for each of the tribal areas. Every fourth household was selected until the sample size was obtained. Ten extra respondents were recruited to make provision for withdrawals during the intervention. The women signed informed consent forms for voluntarily participation after the project objectives and procedures had been explained to them.

Study design

A single-system design was used for this case study as the researchers had been studying the same community on a repetitive basis for four years.[14] The implemented project constituted a community-centre integrated food and nutrition approach to support the alleviation of malnutrition through improved household food security in three rural communities.

The project included three phases:

- Situation analysis and strategy planning, from 2008-2009.
- Intervention studies, from 2010-2012.
- Impact evaluation, in 2013.

Applied interventions included vegetable and soy gardening at household level; nutrition education,[15,16] specifically the use of vegetables and soy beans in meal planning for human health; the development of compatible recipes, tested and adjusted for sensory and cultural acceptance,[17] and published in recipe book format;[9,17] and food preparation training projects. Dietary intake, dietary diversity and food security measurements were taken at baseline (2008) and follow-up (2012), after all the interventions were complete.

The measurements were obtained during the month of February in the different years. Thus, seasonality could not have influenced the results.

Measurements

A four-stage, multiple-pass interviewing procedure[18] was used to complete the 24-hour recall questionnaires in one-on-one interviews with the assistance of trained fieldworkers. Based on the fact that dietary intake measurements are not reliable, three (two week days, and one weekend day) 24-hour recall questionnaires were completed for each of the respondents over a period of three days. Trained fieldworkers used food models and household utensils to assist the respondents with estimating portion sizes.

An adapted validated dietary diversity questionnaire (DDQ)[19] was used to collect data on dietary diversity indices for a reference period of seven days.[20] The DDQ was a printed list of foods, categorised according to the nine nutritious food groups, recommended by the United Nations Food and Agriculture Organization (FAO).[21] Household food insecurity was assessed by the validated Radimer-Cornell Hunger Scale questionnaire, developed by Kendall and et al.[22]

Data analysis

After completing the fieldwork, the questionnaires were sorted and checked for completeness, accuracy and usability by the researchers. A complete dataset for 85 women was subject to statistical analysis using SPSS® version 22. A p-value of < 0.05 was considered to be significant. A normal probability plot and Kolmogorov-Smirnov *test* were used to test the normal distribution of variables. Most were not normally distributed. Therefore, medians with interquartile range (25^{th} and 75^{th} percentiles), instead of means and SD were calculated. The 24-hour recall data were captured and analysed under the supervision of a registered nutritionist, using FoodFinder® version 3, a dietary analysis programme developed by the Medical Research Council, and based on the South African food consumption tables.[23]

A median intake of three days was calculated for macro- and micronutrient intake variables. Frequencies were used to determine the percentage of the total number of participants with a nutrient intake below 100% of the estimate average requirement (EAR) or adequate intake (AI) when the EAR was not available, taking into consideration the different EAR for the age groups 19-30, 31-50 and 51-70 years.[24-27] The reported micronutrients were chosen from a range of micronutrients, based on those mainly represented by the nine nutritious food groups used for the dietary diversity scores (DDSs).

The nutrient adequacy ratio (NAR) was calculated for 18 micronutrients. The NAR for a given nutrient was calculated by dividing the respondent's actual intake of a nutrient by the current dietary reference intake for her sex and age category.[28] The EAR value was mainly used as it is recommended as the standard to be used to estimate the prevalence of inadequate intake within a group.[24-27] The recommended dietary allowance and AI levels were used for those nutrients without an EAR. The median adequacy ratio (MAR) was calculated by the sum of NAR for micronutrients, divided by the number of nutrients (n = 18). This served as a measure of the adequacy of the overall diet. A value of 1 for both NAR and MAR was the ideal, indicating that the intake equalled the requirement.[28]

The DDQ data were captured on a Microsoft® Excel® spreadsheet. The nine nutritious food groups recommended by the FAO were used to measure food intake.[21] The DDQ was used to determine the food variety score (FVS) and the food group diversity score (FGDS) for each of the nine nutritious food groups. The FVS consisted of a simple count of single foods within the nine nutritional food groups.[29] The DDS was defined as the number of food groups consumed during the seven day-period.[20] Thus, the DDS was based on the following groups: meat, poultry and fish; eggs; dairy; cereal, roots and tubers; legumes and nuts; vitamin A-rich vegetables and fruit; other fruit; other vegetables; and fats and oils. Other foods, not included in these groups, were not used to calculate the DDS. A cut-off point for dietary diversity indicators in adult women has not yet been finalised in the literature.[30] Thus, the cut-off points developed by Matla[19] in a South African study were used for this study. Therefore, the cut-off points for a low, medium and high DDS and FVS were as follows: 0-3 food groups and < 30 individual foods, 4-5 food groups and 30-60 individual foods, and 6-9 food groups and > 60 individual foods, respectively. The DDSs were statistically analysed for descriptive statistics (frequencies, medians and quartiles).

The food security questionnaire was analysed and a score calculated for the positive answers ("Yes") to the 10 questions. Respondents with a score > 5 were classified as food insecure, and those with a score ≤ 5 were classified as food secure. Independent t-tests were applied to determine significant differences between the selected variables for the food-secure and -insecure groups.

Paired t-tests were used to determine any significant differences between dietary intake and FVS and DDS at baseline and follow-up.

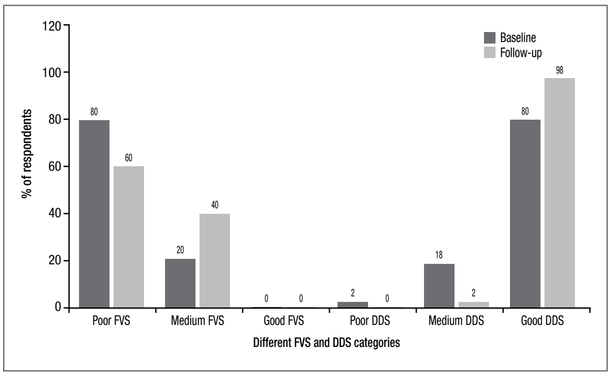
Using Pearson's product-moment correlation coefficients, correlations were drawn between the NAR of the 18 micronutrients and the DDS and FVS, as well correlations between with the MAR and the DDS and FVS, to determine any significant relationships.

Results

Detailed baseline characteristics have been reported previously.[9] This study included 50 women who completed the baseline and follow-up measurements and who participated in all of the implemented interventions over a period of four years. The respondents were black women, aged 23-70 years, with a mean ± SD age of 47 ± 13 years. Sixty-eight per cent of the respondents were classified as food insecure, and their mean ± SD age was 49 ± 13 years, compared to 46 ± 14 years for the food-secure group. In total, 83 different foods were consumed by the respondents during the seven-day period. However, the maximum different food items consumed by an individual during this period at baseline were 46. This increased slightly to a total of 88 food items consumed by the respondents, and 60 different food items being consumed by just one individual, during the seven-day measurement period at follow-up. The median FVS at baseline was 23, and although the FVS improved significantly (p-value 0.002) to 29 at follow-up, this still reflected poor food variety (0-30 different food items).[19] The results in Figure 1 show that a poor FVS was recorded in the majority of the women (80%). A medium FVS was recorded in 20%, and a good FVS at baseline in none of them. This improved after the interventions to reflect a poor and medium FVS of 60% and 40%, respectively (Figure 1).

A summary of the food variety within the food groups (the FGDS) is presented in Table I. The highest median FGDS of 6 was recorded for the cereal group, followed by the other vegetables and meat, poultry and fish food groups, with a median FGDS of 5 and 3, respectively, at baseline. Similarly, the highest FGDS was recorded in the same three food groups at follow-up with the same ranking. The FGDS of the dairy, legumes and nuts, and other fruit groups, improved significantly at follow-up from 1 to 2, 1 to 2, and 2 to 2, respectively. At follow-up, the range of food items consumed within a food group improved from baseline in the meat, poultry and fish, dairy, legumes and nuts, other fruit, other vegetables, and fats and oils groups.

The majority of respondents (80% at baseline and 98% at follow-up) could be classified as having a high DDS (i.e. consuming food from 6-9 groups)[20] (Figure 1). This was reflected in the median DDS of 8 and significantly (p-value 0.002) improved DDS of 9 at baseline and follow-up, respectively.



DDS: dietary diversity score, FVS: food variety score

Figure 1: The distribution of the respondents in the various dietary diversity categories

Table I: The number of food items consumed per group during the seven-day collection period

Food groups	Baseline		Follow-up		p-value*
	Median FGDS (IQR)	Range (min to max)	Median FGDS (IQR)	Range (min to max)	
Meat, poultry and fish	3.5 (2.8-5.0)	0-7	4.0 (3.0-6.3)	0-9	0.062
Eggs	1.0 (1.0-1.0)	1-1	1.0 (1.0-1.0)	1-1	1.000
Dairy	1.0 (1.0-2.3)	0-5	2.0 (1.0-3.0)	0-6	0.014
Cereals, roots and tubers	6.0 (5.0-7.3)	0-11	6.0 (5.0-8.0)	0-11	0.721
Legumes and nuts	1.0 (0.0-2.0)	0-4	2.0 (1.0-3.0)	0-5	0.001
Vitamin A-rich vegetables and fruit	3.0 (2.0-4.0)	0-6	3.0 (2.0-4.0)	0-5	0.946
Other fruit	2.0 (0.0-3.0)	0-7	2.0 (1.0-5.0)	0-10	0.013
Other vegetables	5.0 (3.8-5.0)	0-9	4.0 (2.0-6.0)	0-11	0.407
Fats and oils	2.0 (1.0-3.0)	0-3	2.0 (1.0-2.0)	0-4	0.607
Food variety score	23.0 (18.8-29.3)	6-46	29.0 (20.8-38.0)	10-60	0.002
Dietary diversity score	8.0 (7.0-9.0)	6-9	9.0 (7.8-9.0)	6-9	0.002

* The significant difference between baseline and follow-up
FGDS: food group diversity score, IQR: interquartile range (25th, 75th percentiles), max: maximum, min: minimum

Table II: The nutrient adequacy ratio, as measured by the three 24-hour recalls (n = 50)

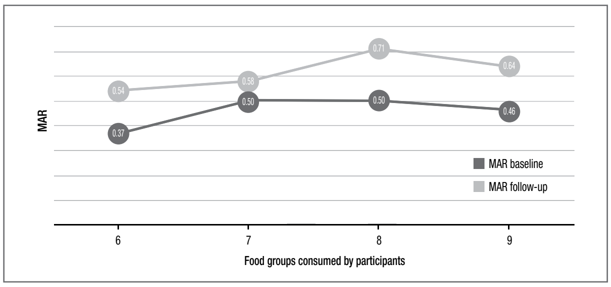
Dietary intake variable	Baseline		Follow-up	
	Median NAR (IQR)	Range of nutrient intake	Median NAR (IQR)	Range of nutrient intake
Total protein intake (g)	0.9 (0.5-1.5)	4.0-80.0	13 (5-38)	14.0-86.0
Carbohydrate (g)	0.9 (0.6-1.3)*	24.0-356.0	1.5 (1.1-1.9)*	64.0-311.0
Calcium (mg)	0.1 (0.1-0.2)*	2.6-523.3	0.3 (0.2-0.5)*	24.8-1 089.6
Iron (mg)	1.0 (0.5-1.2)*	1.1-24.2	1.3 (0.9-1.8)*	3.0-23.6
Magnesium (mg)	0.5 (0.3-0.7)*	38.0-666.0	0.6 (0.5-1.0)*	78.0-469.0
Phosphate (mg)	0.7 (0.5-1.1)*	93.6-1 714.8	1.1 (0.7-1.4)*	208.4-1 406.6
Zinc (mg)	0.6 (0.3-1.0)	1.0-1 361.3	0.7 (0.6-1.1)	2.1-16.7
Copper (mg)	0.0 (0.0-0.0)	0.1-7.6	0.0 (0.0-0.0)	0.1-1.7
Selenium (µg)	0.2 (0.0-0.4)*	0.0-48.5	0.3 (0.2-0.6)*	1.1-117.5
Iodine (µg)	0.1 (0.0-0.2)*	0.6-2 083.2	0.1 (0.1-0.2)*	1.5-160.6
Vitamin A (µg) (RE)	0.4 (0.2-0.7)*	37.5-719.5	0.8 (0.5-1.3)*	22.5-7 937.3
Vitamin B_1 (mg)	0.5 (0.3-0.7)*	0.1-3.0	0.7 (0.5-1.1)*	0.2-2.0
Vitamin B_2 (mg)	0.4 (0.3-0.7)*	0.1-1.2	0.8 (0.5-1.1)*	0.2-3.6
Vitamin B_3 (mg)	0.7 (0.3-1.6)	1.0-31.7	1.0 (05-1.4)	2.5-26.4
Vitamin B_6 (mg)	0.5 (0.3-0.7)*	0.1-2.3	0.6 (0.5-1.0)*	0.4-8.1
Folate (µg)	0.5 (0.3-0.8)*	10.2-445.1	0.7 (0.5-1.0)*	45.7-1 563.1
Vitamin B_{12} (µg)	0.2 (0.0-0.6)*	0.1-2.2	0.6 (0.2-1.3)*	0.2-30.9
Vitamin C (mg)	0.2 (0.0-0.3)*	0.2-167.5	0.3 (0.1-0.5)*	0.7-192.4
Vitamin D (µg)	0.0 (0.0-0.1)*	0.0-8.4	0.1 (0.0-0.2)*	0.0-20.5
Vitamin E (mg)	0.1 (0.1-0.6)	0.4-20.3	0.2 (0.1-0.6)	0.2-39.4
Median adequacy ratio	0.49 (0.29-0.67)*	0.1-12.9	0.6 (0.47-0.8)*	0.3-2.5

IQR: interquartile range (25th, 75th percentiles, NAR: nutrient adequacy ratio
*Indicate a significant difference in variables between baseline and follow-up

The NARs are summarised in Table II. An adequacy ratio of 1 was not reported for any of the nutrients at baseline, except iron. Thus, the EAR for this specific nutrient was met in the group of women. The nutrients with a MAR of ≥ 0.6 (within one third lower than recommended) included phosphate, zinc and vitamin B_3. A low median NAR of < 0.6 was noted for the majority of the nutrients. This was reflected in a MAR of 0.49 for the 18 micronutrients. At follow-up, the median MAR significantly (p-value 0.002) improved to 0.63, but was still low as the dietary intake did not meet two thirds of the EAR for all the micronutrients. There was a significant improvement at follow-up in the NAR for all of the micronutrients, except copper, zinc, vitamins B_3 and E. Despite a significantly improved MAR at follow-up, NARs at follow-up were reported for only three nutrients, namely dietary iron, phosphate and vitamin B_3. These poor nutrient intakes are reflected in the poor FVS at both baseline and follow-up.

Statistically significant relationships were not demonstrated between the NAR of the 18 micronutrients and the FVS and DDS, or MAR, using Pearson's product-moment correlation coefficient. Nevertheless, the relationship between the MAR and DDS is shown in Figure 2. The MAR was significantly higher at follow-up at DDS levels 6 (p-value 0.000), 7 (p-value 0.034), 8 (p-value 0.001) and 9 (p-value 0.002). A strong significant positive correlation existed between FVS and FGDS (r = 0.617, p-value 0.000).

The women were classified as being either food secure (n = 16, 32.0%) or food insecure (n = 34, 68.0%) (Table III). A significantly higher FGDS for the legume and nuts, and other fruit groups, as well as the FVS, was observed in the food-secure group at follow-up. Similarly, a higher FVS and DDS, as well as FGDS, for the legume and nut, other vegetables, and fats and oils groups, respectively, was observed. However, a significantly lower FGDS was reported for the cereals, roots and tubers food group in the food-insecure group at follow-up. Although it seems as if there was a higher median FGDS for the different food groups in the food-secure group, significant differences between the FGDS of the different food groups were not observed between the food-secure and -insecure groups at baseline and follow-up, except for the other fruit, and fats and oils groups. A significantly higher median FGDS



MAR: mean adequacy ratio

Figure 2: The mean adequacy ratio at different levels of the dietary diversity score

was recorded for the other fruit and fats and oils groups at follow-up in the food-secure group. Overall, the FVS and DDS was higher than those in the food-insecure group, but this was not significant.

Significant differences in the various NARs were observed between baseline and follow-up in both the food-secure and -insecure groups, but the MAR did not improve significantly in either group. Furthermore, significant differences in the NAR for the majority of the nutrients and the MAR did not exist between the food-secure and food-insecure groups. There was a significantly NAR for vitamin A at baseline, and for selenium and vitamin E at follow-up in the food-secure group.

Discussion

The effect of multiple food and nutrition interventions (i.e. combining nutrition education, soy and vegetable gardening and food preparation skills training) on dietary diversity has not previously been studied. Food insecurity was previously viewed as a country's inability to produce an adequate agricultural food supply, but more recently, it is regarded as a household's inability to access food by producing and/or procuring it with its own assets.[31] Food security has four pillars, namely food availability, access, utilisation and stability.[32] The term "nutrition security" emerged in the mid-1990s and focuses on utilisation, i.e. food consumption by a household or individual, and how food is utilised by the body. Thus, the broad definition of food security embodies key determinants of good nutrition. More recently, the term "food and nutrition security" has been used to combine the two concepts. Food security is a precondition to adequate nutrition, and embedding "nutrition" between "food" and "security" emphasises that raising the level of nutrition is the ultimate goal of any programme that addresses food security.[33]

Dietary diversity is acknowledged as a good measure of household food access,[34] and Faber et al recommended that nutrition education and other intervention programmes should focus on both the quantity and quality of foods eaten, and hence micronutrients obtained .[35] Furthermore, dietary quality, including dietary diversity, is important for women as a woman's nutritional status before conception and during pregnancy directly affects her own health and well-being, as well as that of her child. It is well known that a low micronutrient intake in women is common, but very little data are available on this aspect of women's diet quality.[30]

Thus, we hypothesised that poverty and food insecurity, identified in this group of women,[9] resulted in limited food access, with restricted

Table III: A comparison of the variables between the food-secure and food-insecure groups

Variable	Food secure (n = 16, 32.0%)		Food insecure (n = 34, 68.0%)	
	Baseline	Follow-up	Baseline	Follow-up
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
FGDS				
Meat, poultry and fish	3.0 (2.0-3.8)	5.0 (4.0-7.0)	4.0 (3.0-4.8)	4.0 (3.0- 6.0)
Eggs	1.1 (1.0-1.0)	1.1 (1.0-1.0	1.1 (1.0-1.0	1.1 (1.0-1.0)
Dairy	1.0 (1.0-2.8)	2.0 (0.3-3.0)	1.0 (1.0-2.0)	2.0 (1.0-3.0)
Cereals, roots and tubers	5.0 (3.3-6.8)	6.5 (5.3-8.8)	6.0 (5.0-7.8)^{a}	5.5 (4.3-7.5)^{a}
Legumes and nuts group	1.0 (0.0-1.0)^{a}	2.5 (2.0-3.8)^{a}	1.0 (0.0-2.0)^{b}	2.0 (0.3-3.0)^{b}
Vitamin A-rich vegetables and fruit	3.0 (2.0-4.0)	3.0 (2.3-5.0)	3.0 (2.0-4.0)	3.0 (2.0-4.0)
Other fruit	1.0^{a,b} (0.0-2.8)	4.5^{a,c} (2.0-6.0)	2.0^{b} (0.0-3.0)	2.0^{c} (1.0-4.8)
Other vegetables	4.0 (4.0-5.0)	4.5 (3.3-6.8)	5.0 (3.3-6.0)^{a}	4.0 (2.0-5.0)^{a}
Fats and oils	2.0 (0.1-2.0)	2.0^{a} (2.0-2.0)	2.0^{b} (1.0-2.0)	1.0^{a,b} (1.0-2.0)
FVS	20.0 (17.3-26.3)^{a}	32.0 (27.5-43.0)^{a}	25.0 (19.0-30.0)^{b}	25.5 (18.3-34.8)^{b}
DDS	8.0 (6.3-8.8)	9.0 (8.0-9.0)	7.0 (7.0-9.0)*	9.0 (7.3-9.0)*
NAR				
Calcium	0.2 (0.0-0.5)^{a}	0.4 (0.2-0.6)^{a}	0.1 (0.1-0.2)	0.2 (0.1-0.5)
Iron	1.0 (0.6-1.2)	1.0 (0.7-1.8)	0.9 (0.4-1.2)^{a}	0.7 (0.5-1.1)^{a}
Magnesium	0.6 (0.4-0.8)	0.6 (0.5-0.9)	0.5 (0.2-0.6)	0.7 (0.5-1.1)
Phosphate	0.9 (0.6-1.3)^{a}	1.2 (0.9-0.5)^{a}	0.6 (0.5-1.0)	1.0 (0.7-1.4)
Zinc	0.8 (0.4-1.5)	0.7 (0.6-1.3)	0.5 (0.3-0.9)	0.7 (0.6-1.0)
Copper	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Selenium	0.2 (0.1-0.4)^{a}	0.3 (0.2-1.1)^{a,b}	0.2 (0.0-0.5)	0.2 (0.1-0.5)^{b}
Iodine	0.1 (0.1-0.2)	0.2 (0.1-0.3)	0.1 (0.0-0.2)	0.1 (0.0-0.2)
Vitamin A	0.6 (0.4-0.9)^{a}	0.8 (0.5-1.3)	0.3 (0.2-0.7)^{a}	0.74 (0.5-1.4)
Vitamin B_1	0.6 (0.3-0.8)	0.6 (0.4-1.2)	0.4 (0.3-0.6)	0.7 (0.5-1.2)
Vitamin B_2	0.6 (0.3-0.9)^{a}	0.96 (0.7-1.3)^{a}	0.4 (0.2-0.6)	0.8 (0.5-1.0)
Vitamin B_3	1.2 (0.4-1.7)	1.2 (0.6-1.6)	0.7 (0.3-1.5)	0.9 (0.5-1.4)
Vitamin B_6	0.5 (0.4-0.8)	0.7 (0.5-1.0)	0.5 (0.3-0.6)	0.6 (0.5-1.0)
Folate	0.6 (0.3-0.7)	0.7 (0.5-1.0)	0.5 (0.3-0.9)	0.7 (0.5-1.0)
Vitamin B_{12}	0.4 (0.0-0.8)	0.9 (0.5-2.5)^{a}	0.2 (0.1-0.6)	0.5 (0.1-1.1)^{a}
Vitamin C	0.1 (0.0-0.3)	0.3 (0.1-0.4)	0.2 (0.0-0.3)^{a}	0.3 (0.1-0.6)^{a}
Vitamin D	0.0 (0.0-0.1)^{a}	0.1 (0.0-0.5)^{a}	0.0 (0.0-0.1)	0.1 (0.0-0.1)
Vitamin E	0.1 (0.1-0.6)	0.5(0.2-1.0)^{a}	0.1 (0.1-0.5)	0.2 (0.1-0.4)^{a}
MAR	0.6 (0.3-0.8)	0.6 (0.6-0.9)	0.4 (0.3-0.6)	0.6 (0.5-0.8)

DDS: dietary diversity score, FVS: food variety score, FGDS: food group diversity score, IQR: interquartile range (25^{th}, 75^{th} percentiles, MAR: median adequacy ratio, NAR: nutrient adequacy ratio

a, b: significant difference in the same row dietary choices; and that dietary diversity in terms of low food variety and low FGDS scores, would be improved by nutrition education, and agricultural and food preparation skills training programmes.

Overall, a significantly greater variety was observed after the intervention with respect to both the FVS and the DDS. A trend was observed that a higher DDS meant a better MAR at both baseline and follow-up. More respondents were classified with medium FVS, and less with poor FVS, at follow-up, further showing an improved FVS. A similar trend was observed for the DDS. Less respondents were classified with poor and medium DDS, and more with high DDS, after the intervention. The results revealed contradictions in that the DDS indicated high dietary diversity, and the FVS low dietary variety, at both baseline and follow-up. This shows that although most food groups were consumed by the women, limited foods from each group were included. Therefore, the consumption of one or two foods from each of the nine groups did not constitute a varied intake. These findings are similar to those of other South African studies on women[10] and the elderly.[36]

There were few differences between the food groups consumed at baseline and follow-up. The exception was that there was a significantly improved FGDS in the dairy, legumes and nuts, and other fruit groups. Furthermore, more diversity was seen with respect to the range of food items included in the nine nutritious food groups at follow-up, with the exception of the cereals, roots and tubers group, which remained the same as at baseline. However, it is unclear if all the home-grown vegetables were consumed, or if some were sold to purchase other food items, such as dairy and other fruit. The highest FGDS was recorded in the cereals, roots and tubers group, which also reflected the most variety in terms of range of foods, in this study. This is consistent with the findings of other South African studies on adults,[10] the elderly[36] and children,[35] as well as those in other countries.[6,37] A low intake of vegetables and fruit has been positively linked to food insecurity[5,38] as vegetables and fruit are usually more expensive than food from other food groups, and are not always available in lower-income communities.[5] Interestingly, the food groups ranking second and third after the cereals, roots and tubers group in this study, were the other vegetables and other fruit groups. However, the median FGDS of these groups was low, despite the other vegetables group ranking second in terms of FGDS at both baseline and follow-up. Only three different vitamin A-rich vegetables or fruit, two other fruit, and five other different vegetables were consumed over a period of seven days by any one individual. The legumes and nuts group typically consists of cheaper food sources, such as dried beans, peas and soy, but reflected the poorest FGDS of only one and two different food items being consumed in the seven-day period at baseline and follow-up, respectively. The soy included in the gardening programme could have contributed to the increase in FGDS for the legumes and nuts group.

The low FVS and FGDS of most of the food groups is reflected in the low NARs. The prevalence of nutrient adequacy for total dietary protein and carbohydrate intake (macronutrients) significantly improved from marginal to adequate after the intervention, whereas the overall prevalence of micronutrient adequacy was low for the majority of the micronutrients before and after the intervention. Despite a significant improvement in the levels of calcium, magnesium, selenium, iodine, vitamins A, B_2, B_6, B_{12}, C and D, and folate, the prevalence of nutrient adequacy for these nutrients remained low. These results are consistent with a study on women in five resource-poor countries, namely Bangladesh, Mali, Burkina Faso, Mozambique and the Phillipines, where a low nutrient adequacy was prevalent for a range of micronutrients.[6,39] In our study, only three nutrients, namely dietary iron, phosphate and vitamin B_3, reflected a NAR of > 1 at follow-up. A significant correlation was not observed between the FVS, DDS and FGDS of any of the food groups, and the NAR of these micronutrients. The low NAR for the individual nutrients was reflected in the MAR, an indicator of overall nutrient adequacy. Given the ideal cut-off for nutrient adequacy being 1,[29] the nutrient adequacy of the diet was still suboptimal despite a significantly improved MAR after the intervention. None of the respondents consumed an adequate diet. Although other studies have found that DDS and FVS are strongly correlated with MAR,[39] this was not the case in this study.

Interestingly, not many significant differences were observed between the food-secure and -insecure groups of women. A significantly higher FVS, as well as FGDS, for the legumes and nuts, and other fruit group, was observed in the food-secure group at follow-up. Similarly, a higher FVS, DDS, as well as FGDS, for the legumes and nuts, other vegetables, and fats and oils groups, was observed in the food-insecure group at follow-up. Thus, it seems as if the food-insecure group benefited more from the intervention than the food-secure group. A higher median FGDS was reflected for the different food groups in the food-secure group. However, a significant difference between the FGDS for the different food groups was not observed with respect to the the food-secure and -insecure groups at baseline and follow-up. The exception was the higher FGDS recorded for the other fruit, and fats and oils groups, in the food-secure group. This finding is not consistent with a study in the USA which reported that, in comparison with the food-secure group, the food-insecure group consumed less dairy, and fruit and vegetables.[5] Although the FVS and DDS was higher in the food-secure group than that in the food-insecure group at follow-up, this was not significant. However, this finding is consistent with that of the American study.[5] The median FVS of the women in the food-secure group improved from being low to medium at follow-up, whereas the FVS for the food-insecure group remained the same. A significant improvement in the FVS of both groups was observed after the intervention, as well as a significant improvement in the DDS of the food-insecure group.

Significantly higher NARs for calcium, phosphate and selenium, as well as vitamins B_2 and D, were observed between baseline and follow-up in the food-secure group, compared to a higher NAR for vitamin C only in the food-insecure group. Although the overall nutrient adequacy of the diet improved in the food-insecure group, the MAR did not improve significantly in either group. Furthermore, significant differences in NAR for the majority of the nutrients and MAR did not exist between the food-secure and food-insecure groups. By comparison with the food-insecure group, a significantly higher NAR for vitamin A at baseline, and that for selenium and vitamin E at follow-up, were recorded in the food-secure group.

Although MAR did not reach 100% adequacy, the MAR increased significantly with an increasing DDS, proving that a diversified diet is needed to reach micronutrient adequacy. A significant correlation was not observed before or after the intervention between DDS and FVS and any of the NARs or MAR. This is not consistent with other studies, where a significant relationship with a variety of micronutrients[6,29] and MAR[6] was found.

There were some limitations to this study. A relatively homogeneous sample of women was used, with no control group. This may be a limitation when generalising the results, although the sample size was sufficient. Nevertheless, statistical power was reached because the sample size calculation was based on a 20% improvement in DDS, which was achieved in this study. Another limitation was that the results were based on the overall intervention. The effect of the different interventions on the overall outcome was not determined. Furthermore, the relatively low NARs were based on micronutrient intake only. Energy or macronutrients were not considered. The measurements were taken during the same month every year. Thus, seasonality could not have affected the results.

Conclusion and recommendations

Our study has confirmed that women in resource-poor communities lack a variety of food in their diet, and thus have an inadequate micronutrient intake. A combination of nutrition education, soy and vegetable gardening, and food preparation skill training interventions, seemed to positively influence the nutrient adequacy and overall dietary diversity of the women participating in this study, despite nutrient adequacy and dietary variety not reaching optimal levels. This raises the issue of the ability of resource-poor households to consume a varied diet. Food choices are influenced by many different factors. More research is required to understand this complex issue, as well as the factors which contribute to food insecurity and poor dietary intake in this resource-poor community, in order to plan an appropriate and sustainable intervention. Dietary diversification is still one of the primary strategies recommended globally for the improvement of micronutrient intake.[37] Thus, dietary diversification, as well as nutrition education and skill training interventions, may be a worthwhile investment in this poverty-stricken, food-insecure community. Programmes which involve gardening can increase access to food in the household, and can also contribute to psychological and social well-being, financial savings and overall food security.[38] However, income-generation projects should also be implemented in very poor communities to assist resource-poor households with access to a variety of foods.

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Conflict of interest

The authors declare that there was no conflict of interest with respect to this study.

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