ORIGINAL RESEARCH

A cross-sectional baseline survey investigating the relationship between dietary diversity and cardiovascular risk factors in women from the Vaal Region, South Africa

Wilna H Oldewage-Theron, Abdulkadir A. Egal

Centre of Sustainable Livelihoods, Vaal University of Technology, Vanderbijlpark, South Africa

Correspondence: Wilna H Oldewage-Theron. Address: Centre of Sustainable Livelihoods, Vaal University of Technology, Private bag X021, Vanderbijlpark, 1900, South Africa. Email: wilna@vut.ac.za.

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Abstract

Objective: Dyslipidaemia, an abnormality in circulating serum cholesterol, triglycerides, high-density and low-density lipoproteins, is one of the risk factors of cardiovascular disease. The role of nutrients is well known in the development of cardiovascular disease, but little emphasis is placed on total diet quality. Food group diversity and food variety scores are often used to reflect diet quality. The objective of this study was to investigate the relationship between dietary diversity and cardiovascular disease risk factors among low-income women in the Vaal Region.

Methods: A cross-sectional, observational baseline survey was undertaken in 722 randomly selected black women in four purposively selected peri-urban settlements in the Vaal Region. Measurements included socio-demographic data, dietary intake (24-hour recall), dietary diversity (food frequency), anthropometric (weight and height), blood pressure and biochemical indices (lipid profile). Data analyses included descriptive statistics, multivariate analyses of variance, analyses of variance and regression analyses.

Results: The mean individual dietary diversity score±standard deviation (SD) for the total group was 6.4±2.4. Those women in the low dietary diversity category were significantly (p=0.020) younger (45.8±4.4 years) and had a significantly (p=0.002) higher body mass index (30.7±2.8 kg/m^2). The mean±SD of body mass index for the low and medium dietary diversity categories respectively indicated obesity (≥30 kg/m^2) compared to overweight in the high dietary diversity category (29.3±5.4 kg/m^2). The mean±SD systolic blood pressure (134.9±19.5) was significantly (p=0.000) higher in the low dietary diversity category, whereas the medium dietary diversity category showed the highest mean±SD total triglyceride level of 70.3±23.7 mg/dl. The high dietary diversity category was associated with the highest total serum cholesterol (176.4±24.2 mg/dl), low density lipoprotein cholesterol (103.8±28.7 mg/dl) and lowest high density lipoprotein cholesterol (46.1±10.6 mg/dl) levels.

Conclusions: Higher dietary diversity was associated with a healthier diet, not only in terms of nutrient intakes, but also with regard to food group variety across all nine nutritious food groups. Although relationships between dietary diversity and cardiovascular disease risk factors were observed, discrepant findings have been noted.

Key words

Dietary diversity, Food variety score, CVD risk factors

1 Introduction

The literature has indicated that obesity is associated with a risk for hypertension and cardiovascular disease (CVD). South Africa (SA) is following the world trend in terms of an increasing prevalence of obesity and related hypertension and CVD [1]. Dyslipidaemia, an abnormality in circulating total serum cholesterol (TC), triglycerides, high-density and low-density lipoproteins usually also lead to CVD [2, 3] whereby obesity, hypertension and dyslipidaemia are thus some of the risk factors of CVD [4]. Mortality from CVD is increasing and already responsible for 17% of all deaths in SA. It is estimated that 5.5 million South Africans older than 30 years are at risk of developing CVD due to raised TC levels and hypertension which are affecting 22% and 27% of men and women older than 15 years respectively [3]. Environmental factors, especially diet, play a major role in the development of CVD despite its heterogeneous etiology. The role of nutrients is well known in the development of CVD, but little emphasis is placed on total diet quality [5]. Both observational and intervention studies indicated the effect of dietary intake patterns on all-cause mortality and CVD [6].

The South African food-based dietary guidelines (FBDG) were adopted to address the double burden of under- (micronutrient deficiencies) and over- (chronic diseases of lifestyle) nutrition, indicative of nutrition in transition apparent in SA. One of the SA FBDG recommends food variety across and within food groups to ensure micronutrient adequacy [7]. Furthermore, an Austrian cohort study found that food diversity has a significant positive relationship to health [8]. Food group diversity and food variety scores are often used to reflect diet quality [9]. Food frequency questionnaires (FFQ) are mostly used for the characterization of food group intakes as part of total dietary patterns related to CVD risk [10]. Studying the effects of overall diet quality is preferred to studying the effects of single-nutrient indicators on diet–disease relationships in nutritional epidemiology. Furthermore, a positive correlation has been found between total food variety and arterial wall index as well as between hypertension and poor dietary diversity [5].

The objective of this study was to investigate the relationship between dietary diversity and cardiovascular disease risk factors among low-income women in the Vaal Region, a mostly peri-urban area in SA, where 47.6% of the population is unemployed and 46.1% of the households live in poverty. Agriculture as a sector in the Vaal region is largely underdeveloped and subsistence farmers are not present in the area [11]. Furthermore, most of the unemployed are living in informal settlements in non-permanent zinc shacks with no land available for household gardens [12]. As a result, this poor community does not rely on agriculture as a household food security strategy and dietary diversity has been found to be poor in this area [13, 14]. A previous study among the same sample of women indicated a prevalence of 34.3% for dyslipidaemia, 48.6% for hypertension and 45.0% for obesity [15].

2 Methods

This was a cross-sectional, observational baseline survey study. All research procedures were approved by the University of the Witwatersrand's Medical Ethics Committee for Research on Human Beings (M080931, M070126, M080930, M030556). The research was conducted according to the Declaration of Helsinki and the SA Medical Research Council's guidelines for research on human beings [16]. Written informed consent was obtained from the respondents after an explanation of the objectives and study procedures.

The following sample size formula [17] was used to determine a representative sample size, based on the total number of adult women (> 19 years), 2 877 343 in the Vaal region (Statistics SA, 2001):

$$\text{Sample size} = \frac{\text{Z}\,2 \ * \ (\text{p}) \ * \ (1 - \text{p})}{\text{c}\,2}$$

Where:

Z = Z value (1.96 for 95% confidence level)

p = expressed as decimal, 0.5 used for this study

c = confidence interval, 5.0 used for this study

A sample size of 384 respondents was required for a statistically representative sample. Women were randomly enrolled from four purposively selected peri-urban settlements in the Vaal region. The settlements were purposively selected to meet the criteria of peri-urban, low-income ZAR2000 ($235) per household per month) and predominantly Sotho-speaking (one of the 11 indigenous languages spoken in SA) women. A location map was used and the researchers selected every fourth household for inclusion in the sample. Every fourth household was selected until the sample size was obtained. All the women in the household, including grandmothers, mothers, aunts and grown-up daughters, forming part of the extended family, were used for measurements. The final sample thus included 722 women. The Vaal region is an industrial area situated 70 kilometres south of Johannesburg in the Gauteng Province, the largest province with 10.5 million people of which half of the population is female [18]. Peri-urban black women are particularly prone to poverty and low income, accompanied by poor socio-economic circumstances, limited access to services and also food insecurity – all major determinants of the health and nutrition outcomes [19].

Trained fieldworkers assisted in the completion of questionnaires. Anthropometric measurements were taken by a registered dietician and a public health nutritionist. Blood samples were collected and blood pressure taken by a registered haematologist and qualified nursing sisters.

Measurements

The age, education level, employment status and monthly household income of the respondents were recorded. Mean nutrient intake levels among the respondents were estimated using three-day (two weekdays and one weekend day) dietary records (24-hour recalls) as an independent assessment of dietary intake. A food frequency questionnaire (FFQ) [24] was adapted and used to collect data on dietary diversity indices. The FFQ consisted of a list of commonly consumed food items in the research area, all grouped according to the nine nutritious food groups determined by the Food and Agriculture Organization (FAO), namely flesh food group, cereal, legume, dairy, egg, fats and oils, vitamin A-rich vegetables and fruit, other fruit and other vegetable food groups. All the questionnaires were completed by the field-workers in one-on-one interviews with the respondents. Food models were used to quantify the foods consumed as recorded in the 24-hour recall and to identify and clarify the food items listed on the FFQ.

Dietary intake data were analysed by a registered dietician, using the FoodFinder® version 3 software program, developed by the South African Medical Research Council and based on the South African food composition tables [20]. The average intakes for the three days were calculated for all the nutrients and divided by three to determine the mean daily intake.

The different dietary diversity measures were calculated as follows: 1) the overall food variety score (FVS) (simple count of food items), and 2) a variety score within every food group, referred to as dietary diversity score (DDS) or food group diversity score (FGDS) [21]. These scores were calculated for a reference period of seven days [22]. These dietary diversity scores were similar to those scores used in previous studies in other developing countries [8, 14, 23]. The nine nutritious food groups recommended by the FAO were used to classify food intakes categorically. Fewer than 30 foods consumed in the period of seven days indicated low food variety, 30 to 60 foods indicated medium variety, and more than 60 foods, high variety (FVS) [24]. Similarly, one to three food groups consumed in the period of seven days indicated low FGDS, four to five groups indicated medium FGDS and six to nine groups indicated high FGDS [24]. All the dietary diversity scores (FVS and FGDS) were calculated from the seven-day FFQ.

With the subjects minimally clothed and barefoot, anthropometric measurements (body weight and height) were taken according to standard procedures [25] using a calibrated Philips electronic scale, model HF350 (135 kg/100g) (Lifemax, Johannesburg, SA) with a two-point decimal precision and a Scales 2000 (Durban, SA) stadiometer respectively. All

measurements were taken twice and the average of the two measurements recorded. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2).

Fasting venous blood samples were drawn after an overnight fast of 8–10 hours before 10.00 hours with a Vacutainer needle with minimal use of tourniquets. Breakfast was served immediately after blood collection. The blood was placed on ice until separation within two hours of blood collection. Serum and plasma were stored for two weeks at -80°C before analysis to prevent changes in fatty acid composition with prolonged storage times [26]. All blood parameters were analysed according to standard protocol in the biochemical analysis laboratory at the tertiary institution. TC, HDL-Cholesterol (HDL-C) and triglycerides (TG) were analysed by means of the colorimetric method on a KonelabTM analyser with a coefficient of variation (percent CV) between runs of 1.2-2.8% for all serum variables analysed. In this study the CV was lower than those reported elsewhere [26]. The Friedewald formula was used to calculate LDL-Cholesterol (LDL-C) [27].

Blood pressure measurements were taken in a seated position by the registered nursing sisters, using a Tensoval digital blood pressure monitor (Johannesburg, SA). Two measurements were taken and the average of the two measurements was used.

Definition of terms

Obesity was classified as BMI ≥ 30 kg/m^2 according to the World Health Organization (WHO) cut-off points [28].

The Adult Treatment Panel III guidelines of the National Cholesterol Education Programme were used to define the following:

- Hypercholesterolaemia as TC ≥240 mg/dL;
- Hypertriglyceridaemia as TG ≥200 mg/dL;
- Low HDL-C as <40 mg/dL;
- High LDL-C as ≥160 mg/dL [1, 29].

The SA hypertension guidelines [30] were used to define blood pressure cut-off points of ≥140 mmHg for systolic and ≥90 mm Hg for diastolic blood pressure respectively.

Statistical analyses

The Stata, version 12MP, statistical program was used for all statistical analyses. The socio-demographic parameters were captured and analysed for descriptive statistics (frequencies, means and standard deviations [SDs]). The respondents were categorised according to the cut-off points for FGDS: Category 1 as low DDS ≥1≤ 3 (n=117), Category 2 as medium DDS ≥4≤ 5 (n=156), and Category 3 as high DDS ≥6≤ 9 (n=449) [24]. The number of respondents in the categories differed as the FGDS categorical cut-off points, not the distribution of respondents based on tertiles, were used for categorising the respondents. Multivariate analyses of variance (MANOVA) were used to determine the means and SDs for CVD risk factors, daily nutrient intakes and FGDS for the nine nutritional food groups across the DDS category categories. Analyses of covariance (ANOVA) with the correction of the Bartlett's test for equal variances were used to compare these means at a significance level of $p \leq 0.05$. Logistic regression models, controlled for age, income, biochemical parameters, blood pressure, nutrient intakes (independent variables) and FBDG of food groups (dependent variable), were used. In all the multivariate models, the FVS was used as the reference. The Mantel-Haenszel extension test was used to calculate the common odds ratio estimates and to assess the overall trend of increasing categories of FGDS associated with an increasing prevalence of CVD risk factors. The Mantel-Haenszel common odds ratio estimate and natural log of the estimate was asymptomatically normally distributed under the common odds ratio of 1.00 assumptions. Pearson correlations were performed to determine significant ($p \leq 0.05$) relationships between DDS and the blood and dietary intake parameters.

3 Results

The mean±SD age of the respondents (n=722) was 46.0±11.9 years. The mean monthly household income was ZAR 732.12±420.03 (US$86.13±49.42). The majority of the respondents (77.2%) had only primary school education, followed by 20.3% with secondary school education and 1.8% with no education. Only 7.3% of the respondents were employed. The rest were unemployed, however, 14.5% received a monthly pension as they were retired.

Although 97 different food items were mentioned by all the respondents, this was not a mean intake value of all the respondents, but meant that different combinations of the individual food items were consumed by the respondents. The mean FVS±SD was 19.6±15.1, indicating a low food variety (<30 food items) [24]. The cereal group showed the highest mean FVS±SD of 5.5±3.5, followed by the flesh and vegetable groups with 3.3±2.6 and 3.1±2.7 respectively. However, the vegetable food group showed the most variety in terms of individual food items (n=27), followed by the cereal and other fruit groups with 17 individual items each (see Table 1).

Table 1. Summary of variety of food items consumed within the nutritious food groups (n=722)

Food group	Mean	SD	Range of individual food items consumed per group
Cereals, roots and tubers	5.5	3.5	0-17
Other vegetables	3.1	2.7	0-27
Vitamin A-rich fruit and vegetables	1.9	1.9	0-11
Flesh foods (meat, poultry, fish)	3.3	2.6	0-12
Fats and oils	1.5	1.2	0-5
Dairy	1.3	1.5	0-9
Other fruit	1.5	2.6	0-17
Legumes and nuts	0.9	1.0	0-4
Eggs	1.0	0.0	0-1
Total food variety (FVS)	19.6	15.1	0-97

The mean individual FGDS±SD for the total group was 6.4±2.4 and the total range of food groups used during the seven-day data collection period was 0-9. The majority of respondents (n=449, 62.2%) could be classified with a high FGDS (6-9 food groups), followed by 21.6% (n=156) with medium FGDS (4-5 food groups) and 16.2% (n=117) with low (0-3 groups) [24] FGDS.

Mean±SD age, income, anthropometric measures and cardiovascular risk across categories of FGDS are shown in Table 2. Those women in the low FGDS category were significantly (p=0.020) younger (45.8±4.4 years) and had a significantly (p=0.002) higher BMI (30.7±2.8 kg/m^2). The mean±SD of BMI for the low and medium FGDS categories respectively indicated obesity (≥30 kg/m^2) compared to overweight in the high FGDS category (29.3±5.4 kg/m^2). Although statistically significant differences were observed for all CVD risk factors, except diastolic blood pressure, between the FGDS categories, no clear trend was comprehensible. The mean±SD systolic blood pressure (134.9±19.5) was significantly (p=0.000) higher in the low FGDS category, whereas the medium FGDS category showed the highest mean±SD total triglyceride level of 70.3±23.7 mg/dl followed by the low FGDS category (70.0±19.3 mg/dl). The high FGDS category was associated with the highest TC (176.4±24.2 mg/dl), LDL-C (103.8±28.7 mg/dl) and lowest HDL-C (46.1±10.6 mg/dl) levels. However, all of the CVD risk factors showed normal mean±SD levels.

FGDS was positively significantly associated with total serum cholesterol (r=0.298, p=0.000), LDL-cholesterol (r=0.417, p=0.000) and triglyceride (r=0.298, p=0.000) levels. An inverse relationship existed with systolic (r=-0.143, p=0.000) blood pressure and HDL-cholesterol (r=0.213, p=0.000) levels. Significant positive relationships further exist between FGDS and

employment (r=0.158, p=0.000) and education levels (r=0.255, p=0.000) and between FGDS and all the nutritious food group diversity scores (see Table 3).

Table 2. Characteristics of Vaal women (n=722) by FGDS category

	DDS Categories			Significant difference between groups *p*
	Low FGDS (n=117) Mean±SD	**Medium FGDS (n=156) Mean±SD**	**High FGDS (n=449) Mean±SD**	
Age (years)	45.8±4.4	46.0±5.8	46.1±14.6	0.020
Income (ZAR)	721.71±86.54	785.80±617.39	716.19±385.78	0.196
Weight (kg)	63.3±7.4	63.7±8.2	66.7±13.7	0.003
Height (m)	1.44±0.03	1.44±0.04	1.51±0.06	0.000
BMI (kg/m^2)	30.7±2.8	30.6±3.4	29.3±5.4	0.002
Total serum cholesterol (mg/dl)	164.2±7.1	164.7±9.3	176.4±24.2	0.000
Total serum triglycerides (mg/dl)	70.0±19.3	70.3±23.7	57.6±32.8	0.000
HDL-Cholesterol (mg/l)	50.4±5.7	49.8±6.7	46.1±10.6	0.000
LDL-Cholesterol (mg/dl)	81.7±10.2	82.7±12.6	103.8±28.7	0.000
Systolic blood pressure (mmHg)	134.9±19.5	134.3±22.3	127.6±23.9	0.000
Diastolic blood pressure (mmHg)	85.6±9.5	86.7±11.9	84.8±13.9	0.254

Note. p –value in MANOVA indicates significance/insignificance within and between groups in the same row

In Table 4, means for nutrient intake variables and individual food group diversity scores across FGDS categories are presented. In general, a higher FGDS was associated with a healthier diet, not only in terms of nutrient intakes, but also with regard to food group variety across all nine nutritious food groups. The medium and high FGDS showed significantly higher intakes of total energy, protein, carbohydrates, total fat, calcium, iron and vitamin C, and significantly lower total trans fatty acid and cholesterol intakes. Furthermore, in Table 3 the higher FGDS was positively significantly associated with total energy (r=0.243, p=0.000), carbohydrate (r=0.410, p=0.000), dietary fibre (r=0.228, p=0.000), dietary calcium (r=0.075, p=0.045), iron (r=0.1863, p=0.000) and zinc (r=0.173, p=0.000) intakes, as well as with all the nutritious food group diversity scores. A significant inverse relationship was found between FGDS and dietary cholesterol (r=-0.089, p=0.017) intake.

The Mantel-Haenszel Odds Ratio estimate is asymptomatically normally distributed under the common odds ratio of 1.000 assumption.

The odds ratio (OR) and 95% confidence interval (CI) for the incidence of CVD risk factors across FGDS categories are shown in Table 5. It is shown that the probability of having hypertriglyceridaemia (p=0.767), high systolic (p=0.025) and diastolic (p=0.430) blood pressure as well as obesity (p=0.034) increased from the low FGDS to the medium FGDS category, and decreased from the medium FGDS to high FGDS category. No clear trend was observed.

Table 3. Correlations between FGDS and other parameters (n=722)

Parameters	Correlation r	Significance *p*
Income	-0.022	0.553
Employment	0.158	0.000
Education	0.255	0.000
Age	0.033	0.373
BMI	-0.106	0.004
Systolic blood pressure	-0.143	0.000
Diastolic blood pressure	-0.048	0.194
Total serum cholesterol	0.298	0.000
HDL-Cholesterol	-0.213	0.000
LDL-Cholesterol	0.417	0.000
Triglycerides	0.298	0.000
Total energy intake	0.243	0.000
Total dietary fat intake	-0.038	0.303
Dietary cholesterol intake	-0.089	0.017
Total carbohydrate intake	0.410	0.000
Total dietary fibre intake	0.228	0.000
Dietary calcium intake	0.075	0.045
Dietary iron intake	0.186	0.000
Dietary zinc	0.173	0.000
Dietary vitamin A intake	-0.005	0.884
Mean adequacy ratio	0.051	0.175
Food variety score (FVS)	0.806	0.000
Flesh group FGDS	0.539	0.000
Egg group FGDS	-	-
Dairy group FGDS	0.553	0.000
Cereal group FGDS	0.135	0.000
Legumes group FGDS	0.745	0.000
Vitamin A-rich food group FGDS	0.755	0.000
Fruit group FGDS	0.766	0.000
Vegetable group FGDS	0.598	0.000
Fat and oil group FGDS	0.652	0.000

Table 4. Dietary intakes of Vaal women (n=722) by category of dietary diversity score (DDS)

	DDS Categories			Significant difference between groups *p*
	Low DDS (n=117) Mean±SD	Medium DDS (n=156) Mean±SD	High DDS (n=449) Mean±SD	
Nutrients				
Total energy (kJ)	3733±1869	4663±2272	5169±2095	0.000
Total protein (g)	34±25	46±29	40±24	0.000
Total plant protein (g)	15±9	17±9	21±9	0.000
Total animal protein (g)	19±24	29±27	18±21	0.000
Carbohydrates (g)	125±61	138±64	192±73	0.000
Total dietary fibre (g)	9±7	9±6	11±6	0.000
Total fat (g)	24±25	37±33	28±26	0.000
Saturated fatty acids (g)	7.5±9.1	12.2±13.0	8.2±8.7	0.000
Monounsaturated fatty acids (g)	8.4±10.3	14.0±14.1	9.0±9.6	0.000

(Table 4 continued on page 57)

Table 4. (continued)

	DDS Categories			Significant difference between groups *p*
	Low DDS (n=117) Mean±SD	Medium DDS (n=156) Mean±SD	High DDS (n=449) Mean±SD	
Polyunsaturated fatty acids (g)	5.4±5.6	7.3±5.9	7.7±9.7	0.031
Total trans fatty acids (g)	0.6±1.9	0.7±1.7	0.3±0.6	0.000
Total dietary cholesterol (mg)	133.0±220.2	165.0±232.3	109.1±189.5	0.012
Linoleic acid (n-6) C18:2	4.9±5.4	6.7±5.6	7.3±9.5	0.022
Linolenic acid (n-3) C18:3	0.2±0.3	0.3±0.3	0.2±0.2	0.000
Calcium (mg)	172.4±191.1	205.8±201.8	205.1±219.5	0.305
Iron (mg)	4.3±3.8	5.1±3.3	5.9±4.5	0.000
Vitamin C (mg)	17.5±28.8	21.2±36.0	20.5±34.1	0.638
Food groups (FGDS)				
Flesh food group	0.5±0.6	1.3±1.2	4.7±2.3	0.000
Egg group	1.0±0.0	1.0±0.0	1.0±0.0	1.000
Dairy group	0.3±0.5	0.5±0.6	1.9±1.7	0.000
Cereal group	2.0±1.0	2.7±1.2	7.4±3.2	0.000
Legume & nut group	0.1±0.3	0.1±0.3	1.4±1.1	0.000
Vitamin A-rich food group	0.1±0.3	0.5±0.7	2.9±1.7	0.000
Fruit group	0.1±0.2	0.1±0.3	2.5±2.9	0.000
Vegetable group	0.6±0.9	1.7±1.1	4.2±2.8	0.000
Fat & oil group	0.2±0.4	0.8±0.6	2.0±1.0	0.000
Total FGDS	2.4±0.6	4.5±0.5	8.0±1.1	0.000
Total food variety score (FVS)	3.8±1.5	7.8±2.6	27.8±13.5	0.000

Table 5. Odds ratio (95% confidence interval) of having cardiovascular risk factors by FGDS categories

Risk factor (NCEP, 2002)	FGDS Categories			Significance of the trend *p*
	Low FGDS (n=117)	Medium FGDS (n=156)	High FGDS (n=449)	
Hypercholesterolemia (TC≥240 mg/dl)	a	a	8.870 (0.982-80.088)	0.052
Hypertriglyceridemia (TG≥200 mg/dl)	1.086 (0.402-2.934)	2.126 (1.034-4.374)	0.831 (0.522-1.322)	0.767
Low HDL-Cholesterol (< 40mg/dl)	a	a	3.177 (2.772-3.643)	0.000
High systolic blood pressure (≥140 mm Hg)	1.417 (0.633-3.170)	0.641 (0.335-1.225)	2.111 (1.380-3.231)	0.025
High diastolic blood pressure (≥90 mm Hg)	1.624 (0.709-3.719)	0.410 (0.211-0.796)	1.586 (1.050-2.396)	0.430
Obesity (BMI≥30 kg/m2)	0.852 (0.377-1.924)	2.484 (1.296-4.763)	0.949 (0.627-1.435)	0.034

a No statistics could be completed

However, the results in Table 6 indicate the OR for the incidence of CVD risk factors across categories for the fruit group diversity score. It is clear that the probability of being obese, having lower HDL-cholesterol and hypertriglyceridaemia decreased progressively in the higher fruit group FGDS categories. A similar trend was observed in the legume group where the probability of being obese, having lower diastolic blood pressure, lower HDL-cholesterol and hypertriglycerid-aemia decreased progressively in the higher FGDS category, but also the probability of having lower LDL-cholesterol. The flesh group showed a similar trend for diastolic blood pressure, HDL-cholesterol and triglycerides, but the probability of being obese and having hypertriglyceridaemia is increased progressively in the higher FGDS categories.

Table 6. Odds ratio (95% confidence interval) of having cardiovascular risk factors by fruit, legume and flesh group FGDS categories

Food group	FGDS category	Variables						
		BMI	Systolic BP	Diastolic BP	Serum cholesterol	HDL-C	LDL-C	Triglycerides
Fruit	Low	1.1	1.0	1.0	1.9	6.6	1.0	6.4
	Medium	1.0	1.0	1.0	0.0	3.8	2.6	1.7
	High	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Legumes	Low	5.2	0.4	4.9	0.0	3.0	10.4	3.9
	Medium	1.0	1.0	1.0	0.0	2.2	9.4	1.7
	High	1.0	1.0	1.0	0.8	1.3	1.0	1.1
Flesh	Low	0.1	0.8	1.4	0.0	2.5	1.4	13.3
	Medium	1.0	1.0	1.0	0.0	2.5	1.6	10.3
	High	1.0	1.0	1.0	0.7	1.5	1.0	1.2

4 Discussion

Previous studies have found that CVD risk was reduced by 14%–28% with increased diet quality [26]. In the past, most studies focused on single foods such as fish or olive oil, or nutrients such as cholesterol and vitamin E and their effect on CVD risk. Foods and nutrients are not consumed separately, but in combination with various interactions, and it is thus recommended that the overall diet be studied through dietary patterns or dietary scores [5]. Dietary variety is a proven valid and useful indicator as a more varied diet is associated with improved health indicators [21]. This is the only study that the authors are aware of that studied the relationship between dietary diversity and CVD risk factors in SA.

Several limitations should be considered when evaluating the findings of this study. Cross-sectional survey data were used for the association of dietary diversity with CVD risk and thus no causal inferences can be made. The sample did not exclude women with cardiovascular or any other chronic disease of lifestyle and this may have confounded the results due to risk factors being interrelated. The sample is representative of women residing in the Vaal region, but findings should not be generalised to other population sub-groups. Furthermore, the dietary diversity results may have been confounded by memory loss of the elderly women as it was a retrospective questionnaire relying on memory.

Data from this study further showed low dietary variety as the mean food variety score (19.6) was low compared to a high mean individual FGDS±SD for the total group of 6.4±2.4 [24]. This shows contradictory results in that the FGDS indicated high dietary diversity and the FVS indicated low dietary diversity. This indicates that although most food groups were consumed by the women, only a few foods from each group were included. This was confirmed by the low individual FGDSs with the cereal group showing the highest mean FGDS, followed by the flesh and vegetable groups. Consuming one or two foods from each of the nine groups does not, therefore, constitute a varied intake. The food intakes of this group of black women were thus not in line with the FBDG of "eat a variety of foods". These findings were consistent with a national study conducted in South Africa where low dietary diversity (mean FGDS of 4.02) was reported for adult South Africans. Furthermore, the

national study found that the black ethnic group had the lowest mean FGDS of 3.63 and the highest percentage (50%) of people with low dietary diversity [31].

In general, a higher DDS was associated with a healthier diet, not only in terms of nutrient intakes, but also with regard to food group variety across all nine nutritious food groups. The medium and high DDS showed significantly higher intakes of most of the macro- and micronutrients and significantly lower total trans fatty acids and cholesterol intakes. This was reflected in the positive and negative relationships of DDS and the nutrients.

The results showed that poverty, low literacy and unemployment were prevalent in this study of women. In Mexico, it was found that dietary diversity appears to be strongly related to household socio-economic parameters in men from both urban and rural populations [9]. This was also true in these elderly women where a positive relationship was found between FGDS and employment and education. The women in the low FGDS category were significantly younger and had a significantly higher BMI. This was inconsistent with the findings of Dzien and co-authors (2011) who reported a continuous increase in BMI with age in a cohort of men and women aged 20 to 80 years old in Austria. However, in both the low and medium FGDS categories obesity was mainly found compared to overweight in the high FGDS category which was inconsistent with the results of a study in Mexican men where a more diversified diet was associated with a higher rate of obesity and over-weight [9]. Although the high FGDS category reflected lower BMI than the low and medium FGDS categories in these older women, overweight and obesity remain risk factors for CVD [32]. Furthermore, a significant negative association was found between FGDS and BMI. Thus, a more varied diet resulted in lower rates of obesity or overweight.

Previous studies showed a relationship between FGDS and serum lipid levels in elderly people [33]. Although all the mean blood lipid levels of the elderly women in Sharpeville indicated normal levels, statistically significant differences were observed for all CVD risk factors, except diastolic blood pressure, between the FGDS categories, with no clear trend. The medium FGDS category showed the highest mean total triglyceride level, which was consistent with the higher obesity rate, whereas the low FGDS category was associated with the lowest total serum cholesterol, LDL-cholesterol and highest HDL-cholesterol levels. These findings were inconsistent with the results of a Danish study in 61301 adult respondents where an inverse relationship between diet quality and serum cholesterol levels were found [6]. This observation in this study of older women in Sharpeville may have been due to other confounding factors and/or underlying mechanisms influencing the results and not evaluated in this study. More recently an inverse relationship was found between overall dietary score and/or FGDS and blood pressure, high LDL-cholesterol levels [5, 34], hypercholesterolaemia, diabetes [5], and triglycerides [34], all known CVD risk factors in adults. The findings of this study of elderly women was consistent with these study findings in adults where FGDS was positively significantly associated with total serum cholesterol, LDL-cholesterol and triglyceride levels, despite the high FGDS category reflecting the opposite trend for mean levels. The high FGDS category showed the lowest systolic and diastolic blood pressure levels which was reflected in the inverse relationship existed between FGDS and systolic blood pressure and HDL-cholesterol levels.

A higher FGDS has been associated with lower risk of having hypercholesterolaemia, hypertension and diabetes in 581 Iranian men and women [5]. No clear trend for risk could be observed in this study of elderly women, however. It was clear that FGDS may be associated with lower CVD risk, but not for all risk factors. These findings were supported by another study where it was found that the healthy eating index, another diet quality measure, was weakly associated with lowered risk of CVD in French men, but not in women [35]. The fruit group diversity score was associated with a lower risk of being obese, having lower HDL-cholesterol and hypertriglyceridaemia compared to the legume food diversity score being associated with a lower risk for all of these plus having a lower diastolic blood pressure and lower LDL-cholesterol in these elderly women. The variety score of individual food groups are thus related to specific CVD risk factors.

5 Conclusions

In general, a higher DD was associated with a healthier diet, not only in terms of nutrient intakes, but also with regard to food group variety across all nine nutritious food groups. Although relationships between dietary diversity and CVD risk factors

were observed, the discrepant findings have also been observed in other studies [34]. Owing to the paucity of data regarding dietary diversity in South Africa, longitudinal studies are needed to further explore the effect of dietary diversity on risk, not only for CVD, but also other chronic lifestyle diseases (CDL), including all confounding factors that may have an effect. It is recommended that a unified measuring tool and protocol be used to evaluate dietary diversity so that comparisons are made easier.

Competing interests

No competing financial or other conflict of interest exists.

Author's contributions

Both authors were involved in the study execution (study design, data collection, analyses and interpretation) as well as writing the manuscript. WOT was responsible for ethics approval and funding applications.

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