UNIVERSITY OF THE WESTERN CAPE

Faculty of Community and Health Sciences

Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods

UNIVERSITY of the
WESTERN CAPE

Samukelisiwe Sthokozisiwe Madlala

Student number: 3967209

A thesis submitted in fulfilment of the requirements for the degree of Doctor Philosophiae (Ph.D.), School of Public Health, University of the Western Cape (South Africa)

Supervisor: Prof. Mieke Faber

Co-Supervisors: Dr Jillian Hill and Prof. Ernesta Kunneke

Date: 20 June 2023

KEYWORDS

Dietary diversity

Nutritional status

Type 2 Diabetes mellitus risk

Cost

Nutrient density

Food choices

Resource-poor communities

Local retail food environment

Food access

Cape Town, South Africa

ABSTRACT

Background: South Africa has a high prevalence of non-communicable diseases (NCDs), with a triple burden of malnutrition, which includes childhood under- and over-nutrition, micronutrient deficiencies, and overweight and obesity among adults. The current nutrition transition, in combination with high unemployment rates, low household incomes and rising food prices, has contributed to unhealthy diets, malnutrition and NCDs in South Africa. Dietary diversity (DD), a measure of nutrient adequacy promoted globally through food-based dietary guidelines (FBDGs), is low in South African adults. Data on the association of DD with an intake of unhealthy foods and cardiometabolic risk factors for NCDs, including type 2 diabetes mellitus (T2DM) in the South African context, is limited. In addition, data are lacking on the barriers and enablers of consuming a diverse diet. South Africans with lower incomes may have difficulty adhering to the FBDGs because of high food costs. Nutrient profiling models, such as the Nutrient Rich Food Index (NRF9.3) in combination with food prices, can assist in identifying nutritious and affordable foods.

Aim: To determine the association of DD with nutritional status and food choices of adults at risk of T2DM and explore the barriers and enablers for consuming a diverse diet in resource-poor communities around Cape Town, and to determine the nutrient density of foods relative to cost with the aim to identify foods with the best nutritional value per cost.

Objectives: The four objectives were to **1)** conduct a scoping review to assess whether adult food choices are associated with the local food retail environment in resource-poor communities; **2)** determine the association of DD with nutritional status (body mass index and waist-to-hip ratio), cardiometabolic risk factors and food choices; **3)** explore the barriers and enablers for consuming a diverse diet; and **4)** determine the nutrient density of foods relative to cost in South Africa to identify foods within food groups with the best nutritional value per cost.

Methods: First, the scoping review was conducted following a methodological framework. Second, a cross-sectional study was conducted using existing data from the South African Diabetes Prevention Programme (SA-DPP) baseline study. Study participants were Black and Mixed-ancestry adults (n=693) aged 25-65 years, at risk of T2DM. The following data were extracted from the SA-DPP data set: socio-demographic information, anthropometric measurements, and biochemical indicators. Food groups consumed the previous day based on an unquantified 24-hour recall were used to calculate the DD score, using the Minimum Dietary Diversity for Women guidelines. Data from a short seven-day food frequency questionnaire

were used to reflect food choices. Data analysis was performed using IBM SPSS for Windows version 27. In the analysis, descriptive statistics were done, Pearson chi-square tests were performed for categorical variables, binary and multinomial logistic regression analyses were done to determine associations between DD and nutritional status and cardiometabolic risk factors and Spearman's correlation was used to determine the relationship between the DD score and unhealthy food and sugary food scores. Third, 14 focus group discussions (FGDs) were conducted with 45 Black and Mixed-ancestry female adults. Purposive sampling was used to select female SA-DPP participants previously enrolled in the SA-DPP baseline study for FGDs based on eligibility criteria. Additionally, a short, structured questionnaire was used to collect data on food purchasing practices among FGD participants. A hybrid deductive and inductive content analysis approach was used to analyse qualitative data using ATLAS.ti 9 software. Fourth, the nutrient density of foods (n=116) was determined using the NRF9.3 index. Nutrient-to-price ratio (NPR) for foods was calculated per 100 kcal and 100 g respectively for each food item. Analysis of variance (ANOVA) and Tukey post-hoc analysis were done to compare energy density, nutrient density, and NPR across food groups.

Results: Results of the scoping review showed inconsistent evidence regarding the relationship between adult food choices and the local retail food environment. Overall, 70.4% of SA-DPP participants had a low DD (< 5 food groups). No association was found between DD, nutritional status and cardiometabolic risk factors except for triglycerides (TG). A low DD was associated with elevated serum TG [AOR: 1.49, 95% CI (1.03, 2.15) p=0.036]. Positive correlations were found between the DD score and unhealthy food score (r=0.189, p=0.050) and the sugary food score (r=0.139, p=0.01). Six themes identified from the FGDs included nutrition knowledge, perceptions of DD and its impact on health, individual factors, and social, physical environment, and societal influences on food choices. Financial constraints, high food prices, and family taste preferences were perceived barriers to consuming a diverse diet. Individual taste preferences, access to food stores, store specials, and community food aid were perceived enablers. Fruit and vegetables, specifically the vitamin A-rich fruit and vegetables food group, had the highest NRF9.3 score and energy cost compared to all food groups. Overall, pulses had the best nutritional value per cost. Foods high in fat and sugar had the lowest nutritional value per cost.

Conclusion: Participants at risk of diabetes consumed a diet low in DD; however, DD was not associated with nutritional status or cardiometabolic risk factors except for TG. The lack of association between DD and nutritional status highlights the limitation of the usefulness of DD

indicators in NCD research. This study provides insight into the barriers and enablers for consuming a diverse diet in women living in resource-poor communities. To ensure resource-poor individuals consume diverse diets, choose healthy foods, and adhere to the FBDGs, public health interventions should not only focus on nutrition education but also address financial barriers to healthy diets. Foods with the best nutritional value per cost were identified using nutritional profiling. Food groups with the best nutritional value per cost were pulses, starchy foods, dairy, vegetables and fruits and fish, chicken, meat, and eggs, respectively. Knowledge of nutrient density and the cost of foods may be suitable for developing public health educational tools to promote adherence to FBDGs and diverse diets in South Africa.

DECLARATION

I declare that the study titled, *Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods*, is my own work and has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full name …Samukelisiwe Sthokozisiwe Madlala.…

Date…20 June 2023……

Signed……

ACKNOWLEDGEMENTS

First and foremost, I would like to thank, my Lord and saviour Jesus Christ for through him all things are possible. Thank you, God, for your grace and mercy each day, and for giving me the strength to complete this journey.

I would like to express my deepest gratitude the following people and institutions:

- My heartfelt thanks and appreciation to my supervisor Prof Mieke Faber for her excellent mentorship and guidance, support, and patience with me throughout this journey. Thank you to my co-supervisors Dr Jillian Hill and Prof Ernesta Kunneke for their valuable input, support, and encouragement.
- Thank you to the South African Medical Research Council (SAMRC), Division of Research Capacity Development for funding provided through the SAMRC Internship Scholarship Programme.
- Thank you to Prof Andre Kengne of the SAMRC, Non-Communicable Diseases Research Unit (NCDRU) for granting me access to the South African Diabetes Prevention Programme (SA-DPP) study data and providing additional financial support.
- Thanks to all the staff and fellow students at the NCDRU for the positive supportive environment to learn, grow and acquire new academic and professional skills.
- Thank you to the SA-DPP study participants, without you there would be no study.
- To my parents, thank you for everything you have done for me, I appreciate your love and support. Thank you to the rest of my family and friends for your support and motivation.
- Thank you to the late Mrs Philisiwe Xulu and family, I will forever be grateful for your support.
- Thank you for the prayers and encouragement from the brethren from my home churches in Pietermaritzburg and Cape Town.
- I am grateful for the academic support I received from UWC School of Public Health administrative staff and PhD Programme team (Prof Helen Schneider, and Dr Wolde Kifle Amde).
- Thank you to my colleagues in the PhD Nutrition and NCDs cluster for the academic and emotional support.
- Many thanks to Ms Jean Fourie for language editing.

ACRONYMS AND ABBREVIATIONS

ADRS	African Diabetes Risk Score
BMI	Body mass index
CVDs	Cardiovascular diseases
COVID-19	Coronavirus disease 2019
DD	Dietary diversity
DDS	Dietary diversity score
FAO	Food and Agricultural Organization
FBDGs	Food-based Dietary Guidelines
FGD	Focus group discussions
FPG	Fasting plasma glucose
FV	Fruits and vegetables
HbA1c	Glycated haemoglobin
HC	Hip circumference
HDL-C	High-density lipoprotein cholesterol
HLPE	High Level Panel of Experts on Food Security and Nutrition
HICs	High income countries
kcal	Kilocalorie
LDL-C	Low-density lipoprotein cholesterol
LMICs	Low- and middle-income countries
MDD-W	Minimum Dietary Diversity for Women
NCDs	Non-communicable diseases
NGO	Non-governmental organisation
NP	Nutrient profiling
NPR	Nutrient-to-price ratio
NRF	Nutrient rich food
OGTT	Oral glucose tolerance test
SA-DPP	South African Diabetes Prevention Programme
SADHS	South African Demographic Health Survey
SA-FBDGs	South African Food-based Dietary Guidelines
SAFOODS	South African Food Data System
SANHANES	South African Health and Nutrition Examination Survey
SAMRC	South African Medical Research Council
SDG	Sustainable Development Goal
SES	Socioeconomic status
SSA	Sub-Saharan Africa
SSB	Sugar-sweetened beverages
T2DM	Type 2 diabetes mellitus
TC	Total cholesterol
TG	Triglycerides
WC	Waist circumference
WHO	World Health Organization
WHR	Waist-to-hip ratio

DEFINITION OF TERMS

Term	Operational Definition
Food environment	"The physical, economic, political and socio-cultural contexts in which people engage with the food system to make their decisions about acquiring, preparing and consuming food" (HLPE, 2017).
Food choices	Food choices are defined as foods selected and consumed based on an individual's decision, which is influenced by a combination of individual, environmental and economic factors (Buttriss et al., 2004).
Food access	The concept of food access has five dimensions, i.e., availability, proximity, affordability, acceptability and accommodation (Caspi et al., 2012).
Community nutrition environment	The community nutrition environment refers to the number, type, location and accessibility of food stores in a community (Glanz et al., 2005).
Consumer nutrition environment	The consumer nutrition environment refers to the availability of healthy food choices, price, promotion, quality, and placement of food items (Glanz et al., 2005).
Local food retail environment	The retail food environment refers to the food stores and markets physically present in communities, including various healthy and affordable foods available in local stores (Glanz et al., 2005).
Cardiometabolic risk factors	In this study, cardiometabolic risk factors include elevated fasting plasma glucose (6.1–7 mmol/L), 2-hour oral glucose tolerance test values (≥ 7.8–11.1 mmol/L), elevated glycated haemoglobin (HbA1c) (≥ 5.7 mmol/L), high triglycerides (> 1.5 mmol/L), high total cholesterol (TC) (≥ 5 mmol/L), low high-density lipoprotein cholesterol (HDL) (< 1.2 mmol/L) and high low-density lipoprotein cholesterol (LDL) (≥ 3 mmol/L).
Dietary diversity	Dietary diversity (DD) is the number of food items or food groups consumed during the reference period (Kennedy et

	al., 2013). In this study, DD is defined as the number of food groups consumed over one day based on an unquantified 24-hour dietary recall.
Dietary diversity scores	The sum of the number of food groups consumed during the last 24 hours (Krebs-Smith et al., 1987). In this study, the DD score is defined as a simple count of food groups that an individual has consumed over a period of 24 hours using a scale of ten food groups based on the minimum DD for women (MDD-W) (FAO & FHI 360, 2016).
Food groups	A group of foods with similar amounts of key nutrients. For this study ten predefined food groups specific to the MDD-W were: (1) grains, roots and tubers; (2) pulses (beans, peas and lentils); (3) nuts and seeds; (4) dairy; (5) meat, poultry and fish; (6) eggs; (7) dark-green leafy vegetables; (8) other vitamin A-rich fruit and vegetables; (9) other vegetables and (10) other fruits (FAO & FHI 360, 2016).
Healthy diet	Consists of adequate amounts of diverse foods that support health, such as fruits and vegetables, legumes and whole grains, and low amounts of sugars, salt and fats, which should be consumed in moderation (FAO, 2016).
Low dietary diversity	For the MDD-W, dietary intake of four or fewer of the ten predefined food groups (FAO & FHI 360, 2016).
Nutrient density	Nutrient density is the nutrient content of foods per 100 kcal (418 kJ) or 100 g (Drewnowski, 2009).
Nutrient profiling	The science of classifying or ranking foods according to their nutritional composition to promote public health dietary goals is nutrient profiling (WHO, 2011).
Nutritional status	In this study, nutritional status is assessed by body mass index [weight(kg)/height(m)^2] and waist-to-hip ratio.
Unhealthy foods	Unhealthy foods are those high in fats, sugars and salt (i.e. energy-dense, nutrient-poor foods) (WHO, 2015).

TABLE OF CONTENTS

LIST OF TABLES

Manuscript Three

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

According to the World Health Organization (WHO), non-communicable diseases (NCDs) are the leading cause of death worldwide, accounting for 74% of deaths annually (WHO, 2022). The top four annual NCD deaths are cardiovascular diseases (CVDs) (17.9 million), cancers (9.3 million), chronic respiratory disease (4.1 million) and diabetes (2.0 million) (WHO, 2022). Of all NCD deaths, 77% occur in low- and middle-income countries (LMICs). In Sub-Saharan Africa (SSA), the prevalence of overweight and obesity is increasing with a subsequent rise of metabolic diseases and CVDs, especially among households of high socio-economic status (SES) (Popkin et al., 2020) and in urban areas (NCD Risk Factor Collaboration, 2019).

Unhealthy diets, physical inactivity, tobacco use, and excessive alcohol consumption are the main risk factors for NCDs (WHO, 2022). Globally, dietary risk is the second and third leading risk factor for mortality among females and males, respectively (Murray et al., 2020). Poor diets are the leading risk factor for NCDs globally (GBD 2019 Risk Factors Collaborators, 2020), contributing to approximately half of the deaths and two-thirds of diet-related disability-adjusted life years (GBD 2017 Diet Collaborators, 2019).

This thesis is embedded within the context of the Sustainable Development Goals (SDG), initiated by the United Nations in 2015 to address poverty, inequality, health burdens and climate change and improve the economy and planet (United Nations Development Programme, 2022). Goal one of the SGDs focuses on ending poverty in all its forms everywhere by 2030. In SDG 3.4, the goal is to reduce deaths from NCDs by one-third through prevention and treatment; specifically, SDG 3.4.1 focuses on reducing mortality from CVDs, cancers, diabetes and chronic respiratory diseases (WHO, 2018a). As dietary intake is vital to meeting an individual's nutritional needs and, consequently, in reducing disease, it is crucial to focus on the diet to improve health status (FAO, 2018).

1.1 Conceptual and theoretical framework

This thesis is informed by the concepts and frameworks of the model to classify risk factors of NCDs (Budreviciute et al., 2020) (Figure 1.1), the ecological framework of the determinants of food choices (Story et al., 2008) (Figure 1.2) and the conceptual model for community nutrition environments (Glanz et al., 2005) (Figure 1.3).

As shown in Figure 1.1, NCDs are caused by, among other things, biological risk factors (factors of medical conditions) that include high blood pressure, abnormal serum lipids, high blood glucose levels and obesity/overweight, which are influenced by behavioural risk factors (factors of self-management) which includes food choices (Budreviciute et al., 2020).

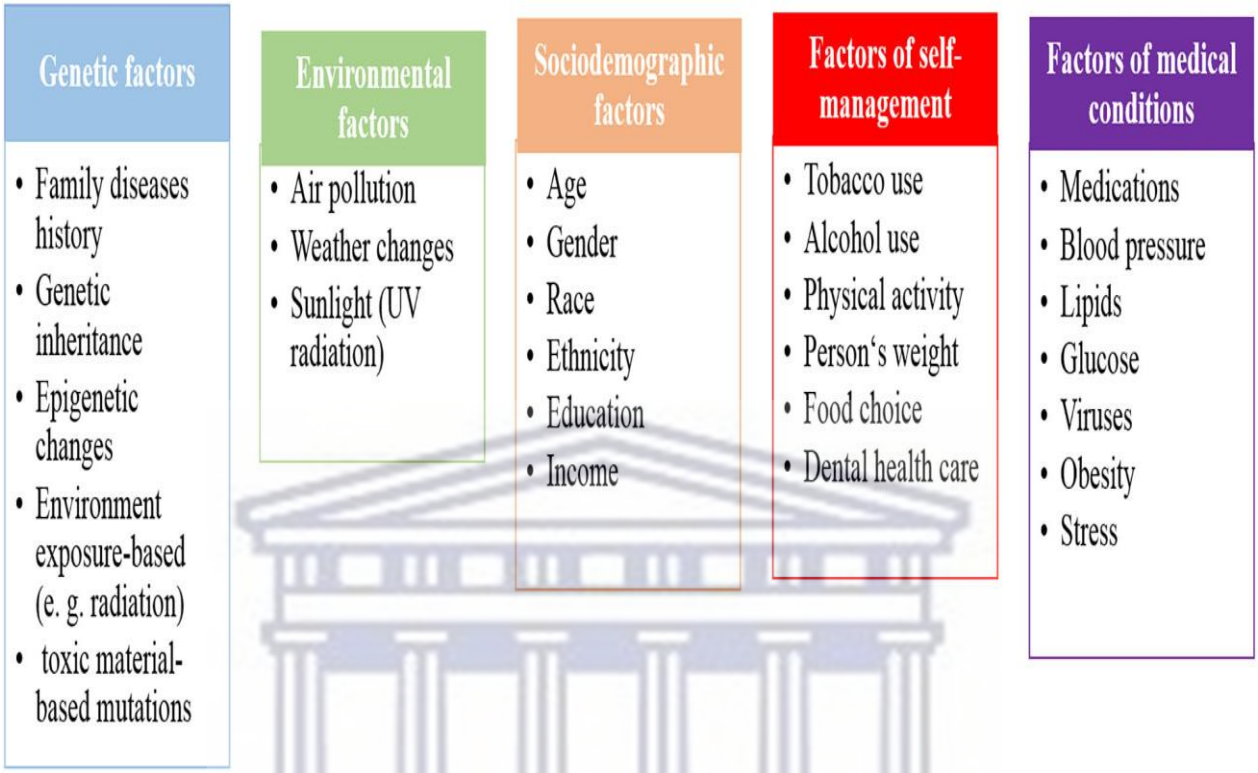


Figure 1.1: Model to classify risk factors of non-communicable diseases.
Source: Budreviciute et al., 2020.

Overall, the eating habits of individuals are dependent on food choices. Food choices are defined as "foods selected and consumed based on an individual's decision which is influenced by a combination of individual, environmental and economic factors" (Buttriss et al., 2004). As reflected in the ecological framework (Figure 1.2), food choices are driven by multiple factors, such as individual, social, physical, and macro-level factors (Story et al., 2008). The food environment is defined as the "physical, economic, political, and socio-cultural contexts in which people engage with the food system to make their decisions about acquiring, preparing, and consuming food" (HLPE, 2017). The physical environment includes various settings where people consume or purchase food, such as homes, schools, workplaces, restaurants, and supermarkets (Story et al., 2008).

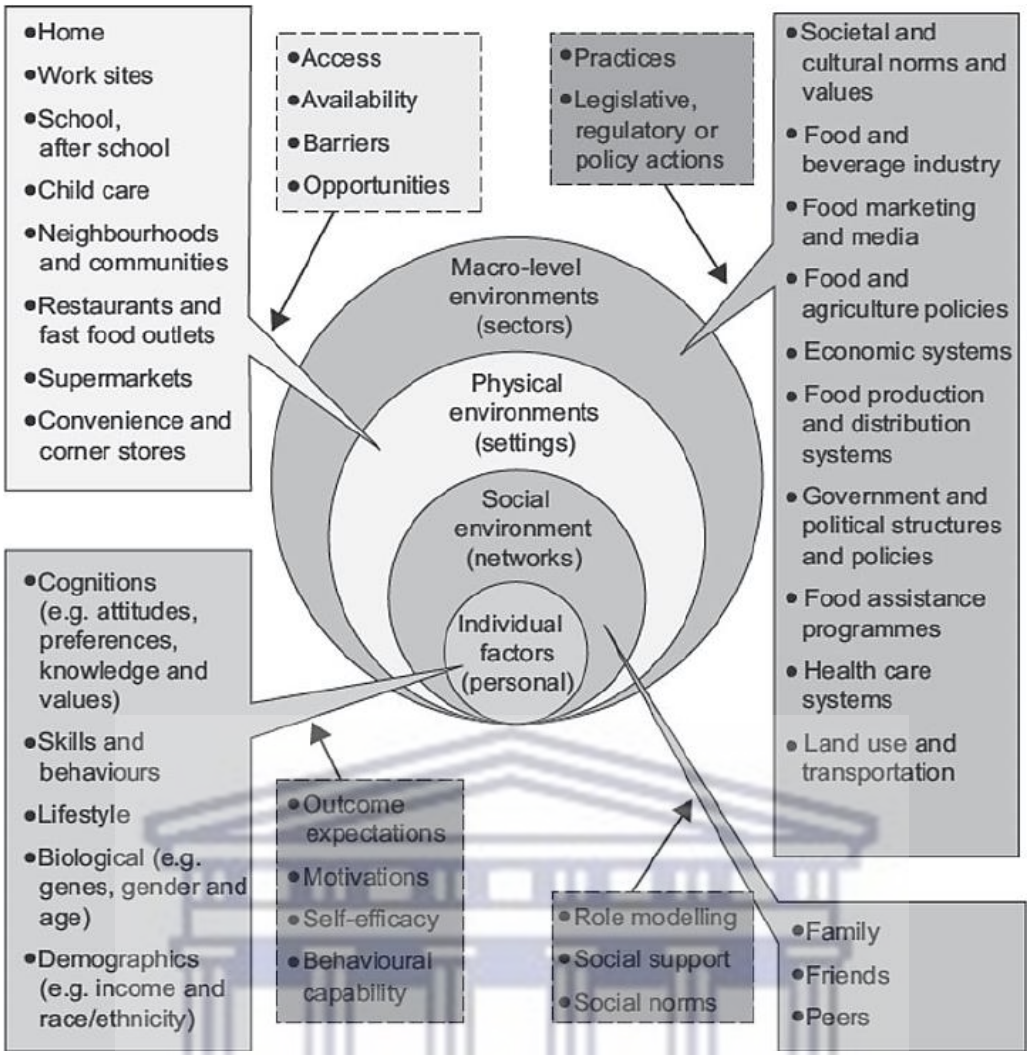


Figure 1.2**:** An ecological framework of the determinants of food choices.

Source: Story et al., 2008.

Glanz and colleagues (2005) created a conceptual model that depicts four types of nutrition (food) environments (Figure 1.3) (Glanz et al., 2005). In this model, the community nutrition environment describes the type of food stores, location, and accessibility of food stores, while the consumer nutrition environment describes the availability of foods, food price, promotion and placement of foods in food stores. Collectively, the community and consumer nutrition environments are referred to as the local retail environment (Glanz et al., 2005).

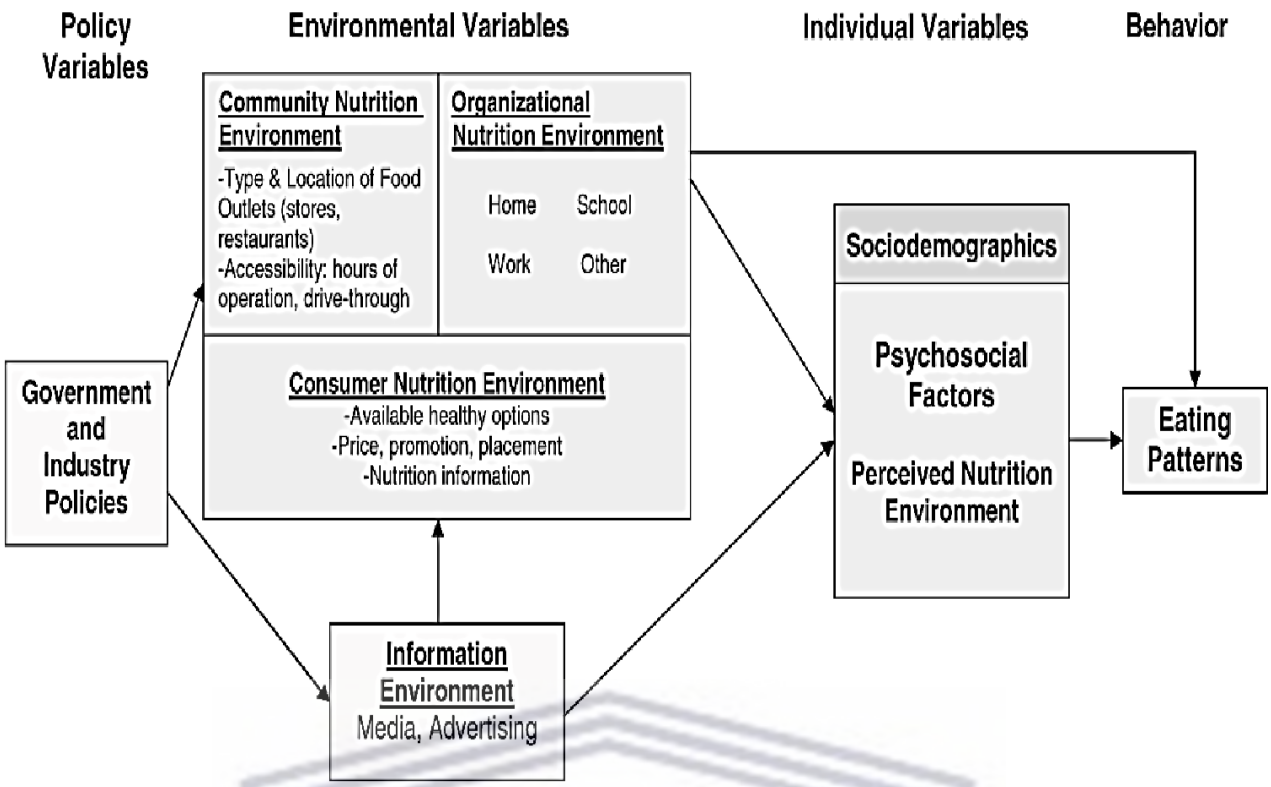


Figure 1.3: Model of community nutrition environments

Source: Glanz et al., 2005.

The framework developed for this study (Figure 1.4) is informed by the three conceptual frameworks mentioned. Local retail food environments and food access influence food choices, food choices determine dietary diversity (DD). Dietary diversity, combined with socio-demographic factors, tobacco use, alcohol use, physical inactivity, and nutritional status, influence the prevalence of health outcomes.

In this PhD research, (i) the relationship between the local retail food environment and food access with food choices, and (ii) that of DD and food choice with health outcomes (nutritional status and cardiometabolic risk factors) were examined, (iii) factors that impact DD and food choices explored, and (iv) the nutrient density and cost of commonly consumed foods determined.

Figure 1.4: Thesis theoretical framework

1.2 Background and rationale

Nutrition Transition in South Africa

South Africa is currently undergoing a nutrition transition from a traditional to a Westernised diet, whereby packaged, convenience, ultra-processed foods, as well as sugar-sweetened beverages (SSBs), are widely consumed (Igumbor et al., 2012). The nutrition transition is usually attributable to societal, economic, and cultural environmental changes such as urbanisation, migration, higher incomes, modernisation, and technological advancement (Nnyepi et al., 2015, Crush et al., 2011). Westernised diets, unhealthy food choices characterised by high consumption of ultra-processed foods and beverages, and physical inactivity are associated with a higher risk of obesity and overweight, which could cause NCDs like hypertension, stroke, type 2 diabetes mellitus (T2DM), CVD and certain cancers (Cerf, 2021, Popkin et al., 2012, Reardon et al., 2021).

Food choices and food environments

First, despite the growing body of research, there is still limited evidence on the influence of the local retail food environment on the food choices of adults living in resource-poor areas. Food environments influence food choices (Bucher et al., 2016) and play a fundamental role in determining diets and empowering individuals to make healthier choices (Caspi et al., 2012).

Food environments are generally controlled by food systems which determine the type and quantities of foods that are supplied to consumers (FAO, 2016). Around the world, these systems and environments may limit consumers from making informed food choices that promote good nutrition and healthy diets (FAO, 2016). Factors such as variety, affordability and acceptability of healthy foods available for purchasing within different food environments may limit the consumption of a healthy diet (Lee et al., 2011). Inadequate access to healthy foods within the local retail food environment may result in unhealthy food choices and dietary patterns, which may lead to the development of NCDs (Black et al., 2014). A cross-sectional study in the United States of America (USA) showed that low-income individuals living in communities with limited healthy foods available are at risk of developing NCDs (Kelli et al., 2017).

Dietary diversity

Second, limited data exist on the association between DD and intake of unhealthy foods and cardiometabolic risk factors for NCDs, including T2DM, in the South African setting. Food choices determine the variety of foods consumed in an individual's diet. Dietary diversity is recommended globally for nutrient adequacy and good health through food-based dietary guidelines (FBDGs) (Herforth et al., 2019). The South African FBDGs (SA-FBDGs) recommend that South Africans should "Enjoy a variety of foods" (Vorster et al., 2013). While DD is suggested and is an essential component of a healthy diet, some studies have shown that higher DD may be associated with a higher intake of unhealthy foods, higher energy intake, and overweight and obesity in adults (de Oliveira Otto et al., 2018, Vadiveloo et al., 2013, Bezerra & Sichieri, 2011).

Third, several studies have shown that South African adults consume a diet low in variety (Chakona & Shackleton, 2017, Drimie et al., 2013, Labadarios et al., 2011, Oldewage-Theron & Kruger, 2011). Therefore, it is necessary to explore the barriers and enablers of consuming a diverse diet, particularly in resource-poor communities. Understanding the factors that influence the consumption of diverse diets is essential in developing and implementing interventions, including their effectiveness in assisting resource-poor communities in making better food choices, improving dietary intake, and promoting diverse diets in low-income settings.

Nutrient density and cost of food

Fourth, it has been argued that following the FBDGs is not within the reach of poor South Africans (Schonfeldt et al., 2013). Consumer food choices are affected by food prices and affordability, which ultimately has an impact on dietary patterns, nutrition, health, and food security (Lee et al., 2013). Studies show that overweight/obesity and NCDs are associated with diet and food costs (Drewnowski, 2018, Drewnowski & Darmon, 2005). Therefore, implementing public health interventions and national guidelines, such as FBDGs, may be hindered by high food prices, population growth, urbanisation and inflation (Schonfeldt et al., 2013). The dietary habits of populations could be improved by improving the affordability of healthy food (Russell et al., 2022). Public health interventions are aimed at making healthy foods affordable (Glanz et al., 2016, Lee et al., 2011).

Nutrient profiling (NP), which is defined as "the science of categorizing foods according to their nutritional composition" (Townsend, 2010), can be used to assist consumers in making healthier food choices, regulate nutrition and health claims on food products, and develop food quality indices (WHO, 2011). Using NP models can strengthen country-specific FBDGs by encouraging the consumption of local, affordable, nutrient-dense foods (WHO, 2011). Nutrient profiling models, such as the Nutrient Rich Food Index (NRF9.3) NP model, are suitable tools for determining the nutrient density of foods but also the relationship between the nutrient density of foods and their cost (Darmon & Drewnowski, 2015). In the South African context examining the nutrient density and affordability of food may be suitable for developing public health educational tools to help South Africans make healthier food choices and promote adherence to FBDGs in resource-poor settings.

1.3 Problem statement

In South Africa, approximately 51% of deaths are attributable to NCDs (WHO, 2018a) with diabetes being the sixth leading cause of death (Pillay-van Wyk et al., 2016) accounting for 7% of NCD-related mortality (WHO, 2018a). According to the International Diabetes Federation (IDF), approximately 4.2 million South Africans between 20 and 79 years have diabetes (NDoH et al., 2019). In the Western Cape, 13.1% Black (Peer et al., 2012) and 26.3% Mixed-ancestry adults (Erasmus et al., 2012) have been reported to have T2DM. The leading causes of T2DM in South Africa are increased urbanisation and unhealthy lifestyle factors (Pheiffer et al., 2018). Type 2 diabetes can be managed and prevented by changing lifestyle and eating habits. Diabetes could lead to other health conditions, such as heart disease, kidney failure, eye

damage, and foot ulcers which could lead to limb amputation (Budreviciute et al., 2020). Overweight and obesity are leading risk factors for T2DM (American Diabetes Association Professional Practice Committee, 2021). The South African Demographic and Health Survey (SADHS) reported that more than 68% of South African women and 39% of men are either overweight or obese (NDoH et al., 2019).

In 2021, 11.6% of South African households were vulnerable to hunger, and 20.9% had limited access to food (Stats SA, 2022a). Currently, 32.9% of South Africans are unemployed (Stats SA, 2023).The most vulnerable to food insecurity in South Africa are the unemployed urban poor, the landless rural poor, and the unemployed youth (OXFAM, 2014). Historically, NCDs have been associated with increased economic growth (Budreviciute et al., 2020). However, lower SES is also associated with NCDs (Williams et al., 2018). Vulnerable and socially disadvantaged groups are susceptible to unhealthy lifestyle behaviours such as tobacco smoking and unhealthy diets and may have limited access to health-care services (WHO, 2022, French et al., 2019).

Most South Africans consume a diet lacking variety and low in vegetables and fruit (Shisana et al., 2013). Cost (affordability) may be a critical barrier to DD and healthy food choices in South Africa. Estimates are that, in South Africa, a healthy diet costs approximately 69% more than a unhealthy diet (Temple & Steyn, 2011). The national Household Affordability Index report showed that between December 2021 and December 2022, the average household food basket purchased by lower-income households increased by 13.5% (Pietermaritzburg Economic Justice & Dignity Group, 2022). Literature shows that an increase in food prices negatively impacts poverty levels and increases food insecurity and undernutrition, especially in lower-income households (McLachlan & Landman, 2013, Dorward, 2012, World Bank, 2011).

The food environment in South Africa is characterised by greater access to low-priced chain food stores such as supermarkets, the presence of street food vendors and informal retailers (Claasen et al., 2016). The food environment in urban areas promotes the consumption of energy-dense processed foods compared to rural areas as a result of greater access to supermarkets, access to television, internet, fuel and electricity, and advertisements encouraging the consumption of processed foods (Blimpo & Cosgrove-Davies, 2019, Claasen et al., 2016). Globally, approximately 97% of low-income urban households depend on

purchased foods, therefore, healthy food environments are crucial for good nutrition (Cohen & Garrett, 2010). Public health nutrition interventions must consider the impact of food systems and food environments on food access as they play a critical role in reducing the risk of NCDs (Budreviciute et al., 2020).

1.4 Aim and objectives

1.4.1 Aim

For this study, the aim was to determine the association of DD with nutritional status and food choices of adults at risk of T2DM and explore the barriers and enablers for consuming a diverse diet in resource-poor communities around Cape Town, and to determine the nutrient density of foods relative to cost and identify foods with the best nutritional value per cost.

1.4.2 Research Objectives

The study had four main objectives:

1. To provide an overview of the evidence on adult food choices in association with the local retail food environment and food access in resource-poor communities using a systematic scoping review.
2. To determine the relationship of DD with nutritional status [body mass index (BMI) and waist-to-hip ratio (WHR)], cardiometabolic risk factors (plasma glucose levels and serum lipids) and food choices of adults at risk of T2DM in resource-poor communities around Cape Town.
3. To explore the barriers and enablers for consuming a diverse diet in resource-poor communities in Cape Town, South Africa.
4. To determine the nutrient density of foods relative to cost in South Africa in identifying foods within food groups with the best nutritional value per cost.

1.5 Setting

South Africa is an upper-middle-income country with an estimated population of 60.6 million people, of which approximately 51.1% are female (Stats SA, 2022b). The study was conducted in the Cape Flats, an area in the metropolitan City of Cape Town, Western Cape, South Africa. The Western Cape province has the third largest population in South Africa, comprising 11.9% of the total population. In 2021, the City of Cape Town had a population of 4,758,433 (50.5% female and 49.5% male) (Western Cape Government, 2021). In 2016, the city population was

42.6% Black African, 39.9% Mixed-ancestry and 16.5% White (Small, 2016). The unemployment rate in 2020 was 22.4%, 31.1% of people lived below the lower poverty line, and the average household size was 3.3 people (COGTA, 2020). The city is historically divided into separate areas based on ethnicity and SES. Black and Mixed-ancestry townships in the Cape Flats are traditionally disadvantaged, and the SES of residents in these areas are generally low (May, 1998). English, Afrikaans, and IsiXhosa are the official languages of the Western Cape Province (Western Cape Language Committee, 2022).

For the second objective, existing baseline data from the South African Diabetes Prevention Programme (SA-DPP) was used. The SA-DPP is a cluster randomised control trial currently ongoing in the Cape Town metropolis, which aims to prevent the progression of diabetes and pre-diabetes in resource-poor communities. Baseline data has been collected for 700 adults (aged 25-65 years) at risk of T2DM, recruited from 16 resource-poor communities in the Cape Flats and part of the Southern Suburbs of Cape Town (Figure 1.5). The African Diabetes Risk Score (ADRS) which is based on age, BMI, hypertension, and WC was used to screen participants for risk of T2DM (Hill et al., 2020). Thereafter, blood glucose tests were done to identify those at risk for T2DM. Fasting plasma glucose 6.1-7 mmol/L and 2-hour glucose load > 7.8-11.1 mmol/L (WHO,1999) was used to define risk for T2DM. For this study, baseline data for 693 SA-DPP participants were used; seven participants were excluded because of missing socio-demographic or dietary data. For the third objective, focus group discussions (FGDs) were done with 45 female SA-DPP participants residing in 12 out of 16 communities. For the fourth objective, food price data were collected from the websites of three large supermarkets (Shoprite, Checkers and Pick n Pay) in the Western Cape.

Figure 1.5: Map of the city of Cape Town illustrating the location of the study area.
Source: VectorStock.com

1.6 Thesis Outline

The thesis consists of eight chapters and is organised as follows:

- **Chapter 1: Introduction**. The conceptual and theoretical framework, background information and rationale, problem statement, aim and objectives, settings and a brief overview of methods and structure of the thesis are provided.
- **Chapter 2: The literature review**. An outline of the literature on NCDs, its risk factors, diets, DD, and food choices globally and in South Africa, determinants of food choice and access, current knowledge on food environments and access to food, the nutrient density of foods and diet cost is given.
- **Chapter 3: Methodology**. The overall methodology employed in the research is outlined. It includes the research design, data collection methods, data analysis and ethical considerations for each of the four study objectives.
- **Chapter 4: Manuscript one**: The summary, contribution to the thesis, and that of the candidate on the first manuscript entitled, "Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review"

are presented. This manuscript has been published in *BMC Public Health* (Madlala et al, 2023).

- **Chapter 5: Manuscript two.** The summary, contribution to the thesis, and that of the candidate's second manuscript entitled, "Dietary diversity and its association with nutritional status, cardiometabolic risk factors and food choices of adults at risk for type 2 diabetes mellitus in Cape Town, South Africa," are presented. This manuscript has been published in the journal, *Nutrients* (Madlala et al., 2022).
- **Chapter 6: Manuscript three**. The summary, contribution to the thesis, and that of the candidate on the third manuscript titled, "Perceived barriers and enablers for consuming a diverse diet in women residing in resource-poor communities in Cape Town, South Africa: A qualitative study," are presented. This manuscript will be submitted for publication to *Public Health Nutrition* according to the journal's guidelines.
- **Chapter 7: Manuscript four**. The summary, contribution to the thesis, and that of the candidate on the fourth manuscript entitled "Nutrient density and cost of commonly consumed foods: A South African perspective," are provided. This manuscript has been published in the *Journal of Nutritional Science* (Madlala et al., 2023).
- **Chapter 8: Discussion, conclusion, and recommendations**: The findings and integrated key concepts explored throughout the thesis are summarised, contributing toward the knowledge of public health nutrition. The strengths and limitations of the study are discussed, and recommendations for policy and future research conclude the chapter.

1.7 References

American Diabetes Association Professional Practice Committee. (2021). 2. Classification and diagnosis of diabetes: Standards of medical care in diabetes-2022. *Diabetes Care,* 45, S17-S38.

Bezerra, I. N. & Sichieri, R. (2011). Household food diversity and nutritional status among adults in Brazil. *Int J Behav Nutr Phys Act,* 8, 22.

Black, C., Moon, G. & Baird, J. (2014). Dietary inequalities: What is the evidence for the effect of the neighbourhood food environment? *Health Place,* 27, 229-242.

Blimpo, M. P. & Cosgrove-Davies, M. (2019). *Electricity access in Sub-Saharan Africa: Uptake, reliability, and complementary factors for economic impact*. Africa Development Forum series. Washington, DC: World Bank. doi:10.1596/978-1-4648-1361-0.

Bucher, T., Collins, C., Rollo, M. E., et al. (2016). Nudging consumers towards healthier choices: A systematic review of positional influences on food choice. *Br J Nutr,* 115, 2252-2263.

Budreviciute, A., Damiati, S., Sabir, D. K., et al. (2020). Management and prevention strategies for non-communicable diseases (NCDs) and their risk factors. *Front Public Health,* 8, 574111.

Buttriss, J., Stanner, S., Mckevith, B., et al. (2004). Successful ways to modify food choice: Lessons from the literature. *Nutr Bull,* 29, 333-343.

Caspi, C. E., Sorensen, G., Subramanian, S. V., et al. (2012). The local food environment and diet: A systematic review. *Health Place,* 18, 1172-1787.

Cerf, M. E. (2021). Healthy lifestyles and Noncommunicable Diseases: Nutrition, the life-course, and health promotion. *Lifestyle Med,* 2, e31.

Chakona, G. & Shackleton, C. (2017). Minimum dietary diversity scores for women indicate micronutrient adequacy and food insecurity status in South African towns. *Nutrients,* 9, 812.

Claasen, N., van der Hoeven, M. & Covic, N. (2016). Food environments, health and nutrition in South Africa. Cape Town: PLAAS, UWC and Centre of Excellence on Food Security [Online]. Available https://repository.uwc.ac.za/xmlui/handle/10566/4520 [23 March 2019].

Cogta. (2020). City of Cape Town: Profile and analysis district development model. [Online]. Available https://www.cogta.gov.za/ddm/wp-content/uploads/2020/11/City-of-CT-September-2020.pdf [11 November 2022].

Cohen, M. J. & Garrett, J. L. (2010). The food price crisis and urban food (in)security. *Environ Urban,* 22, 467-482.

Crush, J., Frayne, B. & Mclachlan, M. (2011). *Rapid urbanization and the nutrition transition in Southern African.,* Kingston and Cape Town, Queen's University and AFSUN. [Online]. Available https://www.fsnnetwork.org/sites/default/files/rapid_urbanization_and_the_nutrition.pdf [8 November 2019].

Darmon, N. & Drewnowski, A. (2015). Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: A systematic review and analysis. *Nutr Rev,* 73, 643-660.

De Oliveira Otto, M. C., Anderson, C. A. M., Dearborn, J. L., et al. (2018). Dietary diversity: Implications for obesity prevention in adult populations: A science advisory from the American Heart Association. *Circulation,* 138, e160-e168.

Dorward, A. (2012). The short- and medium-term impacts of rises in staple food prices. *Food Secur,* 4, 633-645.

Drewnowski, A. (2009). Defining nutrient density: Development and validation of the Nutrient Rich Foods Index. *J Am Coll Nutr,* 28, 421S-426S.

Drewnowski, A. (2018). Nutrient density: Addressing the challenge of obesity. *Br J Nutr,* 120, S8-S14.

Drewnowski, A. & Darmon, N. (2005). The economics of obesity: Dietary energy density and energy cost. *Am J Clin Nutr,* 82, 265S-273S.

Drimie, S., Faber, M., Vearey, J., et al. (2013). Dietary diversity of formal and informal residents in Johannesburg, South Africa. *BMC Public Health,* 13, 911.

Erasmus, R. T., Soita, D. J., Hassan, M. S., et al. (2012). High prevalence of diabetes mellitus and metabolic syndrome in a South African coloured population: Baseline data of a study in Bellville, Cape Town. *S Afr Med J,* 102, 841-844.

FAO. (2016). *Influencing food environments for healthy diets*. Rome: FAO. [Online]. Available https://www.fao.org/3/i6484e/i6484e.pdf [7 July 2019].

FAO. (2018). *Food-based dietary guidelines.* [Online]. [Online]. Available https://www.fao.org/nutrition/education/food-dietary-guidelines/en/ [19 October 2021].

FAO & FHI 360. (2016). *Minimum dietary diversity for women: A guide for measurement*. Rome: FAO. [Online]. Available https://www.fao.org/3/i5486e/i5486e.pdf [20 February 2019].

French, S. A., Tangney, C. C., Crane, M. M., et al. (2019). Nutrition quality of food purchases varies by household income: The SHoPPER study. *BMC Public Health,* 19**,** 231.

GBD 2017 Diet Collaborators. (2019). Health effects of dietary risks in 195 countries, 1990-2017: A systematic analysis for the global burden of disease study 2017. *Lancet,* 393, 1958-1972.

GBD 2019 Risk Factors Collaborators. (2020). Global burden of 87 risk factors in 204 countries and territories, 1990-2019: A systematic analysis for the global burden of disease study 2019. *Lancet,* 396, 1223-1249.

Glanz, K., Johnson, L., Yaroch, A. L., et al. (2016). Measures of retail food store environments and sales: Review and implications for healthy eating initiatives. *J Nutr Educ Behav,* 48, 280-288.

Glanz, K., Sallis, J. F., Saelens, B. E., et al. (2005). Healthy nutrition environments: Concepts and measures. *Am J Health Promot,* 19, 330-333.

Herforth, A., Arimond, M., Álvarez-Sánchez, C., et al. (2019). A global review of food-based dietary guidelines. *Adv Nutr,* 10**,** 590-605.

Hill, J., Peer, N., Jonathan, D., et al. (2020). Findings from community-based screenings for Type 2 Diabetes Mellitus in at risk communities in Cape Town, South Africa: A pilot study. *Int J Environ Res Public Health*, 17, 2876

HLPE. (2017). *Nutrition and food systems. A report by the high level panel of experts on food security and nutrition of the committee on world food security*. Rome: HLPE. [Online]. Available https://www.fao.org/3/i7846e/i7846e.pdf [30 August 2020].

Igumbor, E. U., Sanders, D., Puoane, T. R., et al. (2012). "Big food," the consumer food environment, health, and the policy response in South Africa. *PLoS Med,* 9, e1001253.

Kelli, H. M., Hammadah, M., Ahmed, H., et al. (2017). Association between living in food deserts and cardiovascular risk. *Circ Cardiovasc Qual Outcomes,* 10, e003532.

Kennedy, G., Ballard, T., Dop, M., et al. (2013). *Guideline for measuring household and individual dietary diversity.* Rome: FAO. [Online]. Available https://www.fao.org/3/i1983e/i1983e00.pdf [28 October 2019].

Krebs-Smith, S. M., Smiciklas-Wright, H., Guthrie, H. A., et al. (1987). The effects of variety in food choices on dietary quality. *J Am Diet Assoc,* 87, 897-903.

Labadarios, D., Steyn, N. & Nel, J. (2011). How diverse is the diet of adult South Africans? *Nutr J,* 10, 33.

Lee, J. H., Ralston, R. A. & Truby, H. (2011). Influence of food cost on diet quality and risk factors for chronic disease: A systematic review. *Nutr Diet,* 68, 248-261.

Lee, A., Mhurchu, C. N., Sacks, G., et al. (2013). Monitoring the price and affordability of foods and diets globally. *Obes Rev,* 14, 82-95.

Madlala, S., Hill, J., Kunneke, E., et al. (2022). Dietary diversity and its association with nutritional status, cardiometabolic risk factors and food choices of adults at risk for type 2 diabetes mellitus in Cape Town, South Africa. *Nutrients,* 14, 3191.

Madlala, S., Hill, J., Kunneke, E., et al. (2023). Nutrient density and cost of commonly consumed foods: A South African perspective. *J Nutr Sci,* 12, e10.

Madlala, S. S., Hill, J., Kunneke, E., et al. (2023). Adult food choices in association with the local retail food environment and food access in resource-poor communities: A scoping review. *BMC Public Health,* 23, 1083.

May, J. (1998). Poverty and inequality in South Africa, the centre for social development studies. *Indicator SA,* 15, 53-58.

McLachlan, M. & Landman, A. P. (2013). Nutrition-sensitive agriculture – A South African perspective. *Food Secur,* 5, 857-871.

Murray, C. J. L., Aravkin, A. Y., Zheng, P., et al. (2020). Global burden of 87 risk factors in 204 countries and territories, 1990-2019: A systematic analysis for the global burden of disease study 2019. *Lancet,* 396, 1223-1249.

NCD Risk Factor Collaboration. (2019). Rising rural body-mass index is the main driver of the global obesity epidemic in adults. *Nature,* 569, 260-264.

NDoH, Stats SA, SAMRC, et al. (2019). *South Africa Demographic and Health Survey 2016,* Pretoria: South Africa, and Rockville, Maryland, USA, NDoH, Stats SA, SAMRC, and ICF. [Online]. Available https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf [29 March 2022].

Nnyepi, M., Gwisai, N., Lekgoa, M., et al. (2015). Evidence of nutrition transition in Southern Africa. *Proc Nutr Soc,* 74, 478-486.

Oldewage-Theron, W. & Kruger, R. (2011). Dietary diversity and adequacy of women caregivers in a peri-urban informal settlement in South Africa. *Nutrition,* 27, 420-427.

Oxfam. (2014). *Hidden hunger in South Africa*. Oxford: Oxfam GB. [Online]. Available https://www-cdn.oxfam.org/s3fs-public/file_attachments/hidden_hunger_in_south_africa_0.pdf [17 August 2022].

Peer, N., Steyn, K., Lombard, C., et al. (2012). Rising diabetes prevalence among urban-dwelling black South Africans. *PLoS One,* 7, e43336.

Pheiffer, C., Pillay-van Wyk, V., Joubert, J. D., et al. (2018). The prevalence of type 2 diabetes in South Africa: A systematic review protocol. *BMJ Open,* 8, e021029.

Pietermaritzburg Economic Justice & Dignity Group (PMBEJD). (2022). *Household affordability index. December 2022.* PMBEJD. [Online]. Available https://pmbejd.org.za/wp-content/uploads/2023/01/December-2022-Household-Affordability-Index-PMBEJD_28122022.pdf [Accessed January 25, 2023].

Pillay-van Wyk, V., Msemburi, W., Laubscher, R., et al. (2016). Mortality trends and differentials in South Africa from 1997 to 2012: Second national burden of disease study. *Lancet Glob Health,* 4, e642-653.

Popkin, B. M., Adair, L. S. & Ng, S. W. (2012). Global nutrition transition and the pandemic of obesity in developing countries. *Nutr Rev,* 70, 3-21.

Popkin, B. M., Corvalan, C. & Grummer-Strawn, L. M. (2020). Dynamics of the double burden of malnutrition and the changing nutrition reality. *Lancet,* 395, 65-74.

Reardon, T., Tschirley, D., Liverpool-Tasie, L. S. O., et al. (2021). The processed food revolution in African food systems and the double burden of malnutrition. *Glob Food Secur,* 28, 100466.

Russell, C., Whelan, J. & Love, P. (2022). Assessing the cost of healthy and unhealthy diets: A systematic review of methods. *Curr Nutr Rep*, 11, 280-288.

Schönfeldt, H., Hall, N. & Bester, M. (2013). Relevance of food-based dietary guidelines to food and nutrition security: A South African perspective. *Nutr Bull,* 38, 226-235.

Shisana, O., Labadarios, D., Rehle, T., et al. (2013). *South African National Health and Nutrition Examination Survey (SANHANES-1),* Cape Town, HSRC Press. [Online]. Available https://hsrc.ac.za/uploads/pageNews/72/SANHANES-launch%20edition%20(online%20version).pdf [19 January 2020].

Small, K. (2017). *2016 Community survey Cape Town trends 1996 to 2016.* [Online]. Available https://resource.capetown.gov.za/documentcentre/Documents/Maps%20and%20statistics/2016%20Community%20Survey%20Cape%20Town%20Trends.pdf [6 December 2022].

Stats SA. (2022a). *General Household Survey, 2021*. Pretoria: Stats SA. [Online]. Available https://www.statssa.gov.za/publications/P0318/P03182021.pdf [21 November 2022].

Stats SA. (2022b). *Mid-year population estimates*. Pretoria: Stats SA. [Online]. Available https://www.statssa.gov.za/publications/P0302/P03022022.pdf [11 January 2023].

Stats SA. 2023. *Quarterly Labour Force Survey (QLFS) – Q1:2023*. [Online]. Available https://www.statssa.gov.za/publications/P0211/Media%20release%20QLFS%20Q1%202023.pdf [13 June 2023].

Story, M., Kaphingst, K. M., Robinson-O'Brien, R., et al. (2008). Creating healthy food and eating environments: Policy and environmental approaches. *Annu Rev Public Health,* 29, 253-272.

Temple, N. J. & Steyn, N. P. (2011). The cost of a healthy diet: A South African perspective. *Nutrition,* 27, 505-508.

Townsend, M. (2010). Where is the science? What will it take to show that nutrient profiling systems work? *Am J Clin Nutr,* 91, 1109S-1115S.

United Nations Development Programme. (2022). *Background of the sustainable development goals* [Online]. Available https://www.undp.org/sdg-accelerator/background-goals [14 December 2022].

Vadiveloo, M., Dixon, L. B. & Parekh, N. (2013). Associations between dietary variety and measures of body adiposity: A systematic review of epidemiological studies. *Br J Nutr,* 109, 1557-1572.

Vorster, H. H., Badham, J. & Venter, C. (2013). An introduction to the revised food-based dietary guidelines for South Africa. *S Afr J Clin Nutr,* 6, S5-S12.

Western Cape Government (2021). *Socio-economic profile: City of Cape Town.* [Online] Available https://www.westerncape.gov.za/provincial-treasury/sites/provincial-treasury.westerncape.gov.za/files/atoms/files/SEP-LG%202021%20-%20City%20of%20Cape%20Town.pdf [1 December 2022].

Western Cape Language Committee (2022). *Annual report 2021/2022*. [Online]. Available https://www.wcpp.gov.za/sites/default/files/Western%20Cape%20Language%20Committee%202021-2022.pdf [11 January 2023].

WHO. (1999). *Definition, diagnosis and classification of diabetes mellitus and its complications*. Geneva, Switzerland: WHO. [Online]. Available https://apps.who.int/iris/handle/10665/66040 [27 May 2022].

WHO. (2011). *Nutrient profiling: Report of a WHO/IASO technical meeting*. London, United Kingdom: WHO. [Online]. Available https://apps.who.int/iris/bitstream/handle/10665/336447/9789241502207-eng.pdf?sequence=1&isAllowed=y [6 June 2022].

WHO. (2015). *Healthy diet: Key facts.* [Online]. Available https://www.who.int/news-room/fact-sheets/detail/healthy-diet [9 March 2019].

WHO. 2018a. *Noncommunicable diseases country profiles 2018*. Geneva: World Health Organization. [Online]. Available https://apps.who.int/iris/handle/10665/274512 [28 March 2022].

WHO. 2018b. *SDG target 3.4 Non-communicable diseases and mental health* [Online]. Available https://www.who.int/data/gho/data/themes/topics/sdg-target-3_4-noncommunicable-diseases-and-mental-health [14 December 2022].

WHO. 2022. *Noncommunicable diseases* [Online]. Available https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases#:~:text=Noncommunicable%20diseases%20(NCDs)%20kill%2041,%2D%20and%20middle%2Dincome%20countries. [16 January 2023].

Williams, J., Allen, L., Wickramasinghe, K., et al. (2018). A systematic review of associations between non-communicable diseases and socioeconomic status within low- and lower-middle-income countries. *J Glob Health,* 8, 020409.

World Bank. (2011). *Responding to global food price volatility and its impact on food security.* [Online]. Available https://reliefweb.int/report/world/responding-global-food-price-volatility-and-its-impact-food-security [17 January 2023].

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

An overview of the latest statistics on the global and South African prevalence of NCDs will be given in this chapter. Also discussed will be risk factors for NCDs, with importance given to unhealthy diets and the nutrition transition, which have a significant impact on food choices and other factors such as the food environment. An overview of the dietary intake and DD of South African adults will also be described. Studies on the association between DD, nutritional status and NCDs will be described. To conclude, nutrient density and that concerning food and diet costs will be discussed.

2.2 Prevalence of non-communicable diseases

2.2.1 Global prevalence of non-communicable diseases

In 2022, NCDs accounted for 41 million (74%) deaths worldwide (WHO, 2022a). The leading global NCD deaths include CVDs (17.9 million), cancers (9.3 million), chronic respiratory diseases (4.1 million) and diabetes (2 million) (WHO, 2022a). An estimated 86% of NCD deaths occurred in LMICs (WHO, 2022a). In Africa, NCDs account for 22% of all deaths (WHO, 2018a). The leading NCDs in Africa include CVDs, T2DM, chronic obstructive lung disease and cancer (WHO, 2016).

2.2.2 Prevalence of non-communicable diseases in South Africa

Approximately 51% of deaths in South Africa are attributed to NCDs (WHO, 2022b). The five main NCDs in South Africa include CVDs, cancer, T2DM, respiratory illnesses, and mental health disorders (WHO, 2018a). Statistics show that 19% of CVDs, 11% of other NCDs, 10% of cancers, 7% of diabetes and 4% of respiratory illnesses account for NCD-related mortality in South Africa (WHO, 2018a).

2.3 Risk factors for non-communicable diseases

Multiple factors lead to the development of NCDs (Figure 1.1). These factors can be biological risk factors, unmodifiable risk factors and modifiable risk factors (WHO, 2022a). Unmodifiable and modifiable behavioural risk factors could lead to metabolic and biological changes such as raised blood pressure, blood lipids and blood glucose, overweight and obesity and subsequently, NCDs (WHO, 2022a, Budreviciute et al., 2020).

2.3.1 Biological risk factors

The biological risk factors for NCDs include overweight (BMI 25.0 to < 30 kg/m^2) and obesity (BMI ≥ 30 kg/m^2), high WHR, raised blood pressure, raised blood glucose, abnormal lung function and blood lipids (Budreviciute et al., 2020).

Malnutrition is a key risk factor for NCDs (Global Panel on Agriculture and Food Systems for Nutrition, 2016). Stunting, wasting, underweight and micronutrient deficiencies are types of malnutrition most commonly seen in vulnerable groups such as children, pregnant women and older people (WHO, 2021a). Malnutrition also includes overweight and obesity, a result of excessive and unbalanced food intake (Branca et al., 2019).

Being overweight and obese are critical risk factors for diet-related NCDs (Branca et al., 2019). According to the WHO, 39% of adults were overweight and 13% obese worldwide in 2016 (WHO, 2021b). Obesity prevalence is higher in LMICs than in high-income countries (HICs) (NCD Risk Factor Collaboration (NCD-RisC), 2016). Obesity leads to adverse metabolic effects on blood cholesterol and triglycerides (TG) (Feingold, 2020) and increases the likelihood of diabetes, hypertension, coronary heart disease (CHD), stroke, certain cancers, obstructive sleep apnoea and osteoarthritis (Nnyepi et al., 2015, WHO, 2014). In 2017, globally, high BMI caused 2.4 million mortalities (Dai et al., 2020). Waist circumference, or WHR, is a determinant of risk for T2DM (Jayedi et al., 2022).

Raised blood pressure is one of the leading causes of global deaths and is estimated to cause 7.5 million (12.8%) deaths (WHO, 2023a). Africa has the highest prevalence of raised blood pressure (27%) globally (WHO, 2023b). Uncontrolled raised blood pressure can lead to stroke, myocardial infarction, cardiac failure, dementia, renal failure, and blindness (WHO, 2023b, Weldegiorgis & Woodward, 2020, Wajngarten & Silva, 2019, Sierra, 2020).

Diabetes, a consequence of raised blood glucose, is the cause of premature death and disability, including heart attack, stroke, kidney failure, blindness, nerve damage and lower limb amputation (Budreviciute et al., 2020). In 2017, 1.4 million deaths and 2.5% of total mortality were attributed to diabetes globally (Arokiasamy et al., 2020). The prevalence of dyslipidaemia, defined as abnormal blood concentrations of one or more of the following: total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and TG in Africa was 29.7% (Noubiap et al., 2018). Raised total blood cholesterol

is associated with an increased risk of developing ischaemic heart disease, stroke and vascular diseases (Du & Qin, 2023) and causes an estimated 2.6 million deaths and 4.5% of total deaths (WHO, 2023c).

2.3.2 Unmodifiable risk factors

Unmodifiable risk factors are those factors that cannot be reduced or controlled by intervention. Age, gender, ethnicity or race, genetics (family history and DNA methylation), intra-uterine factors such as maternal obesity, gestational weight gain, gestational diabetes, intrauterine environment, and prenatal exposure to tobacco are all unmodifiable risk factors for NCDs (Budreviciute et al., 2020).

2.3.3 Modifiable risk factors

Modifiable risk factors for NCDs include socio-economic, environmental, and behavioural factors. Some risk factors, such as behavioural risk factors, can be reduced or controlled by intervention, thereby decreasing the likelihood of developing NCDs (Budreviciute et al., 2020).

2.3.3.1 Socio-economic and environmental risk factors

Socio-economic and environmental risk factors for NCDs include early child development, education, work and employment environments, poverty, living and housing conditions, the built environment (Budreviciute et al., 2020, Marmot & Bell, 2019), access to services, geographic location, air pollution, globalisation, and industrialisation (Budreviciute et al., 2020, Tokunaga et al., 2012). The risk of NCDs in HICs and LMICs is greater among people with low SES (Ford et al., 2017).

Behavioural risk factors for NCDs may be influenced by socio-economic and environmental risk factors. For example, the consequences of poverty include food insecurity or poor diet quality (unbalanced starch-based diets). Socio-economic factors may also affect the diagnosis and treatment of NCDs. For instance, limited access to healthcare and healthy eating may be impacted by limited affordability (Marmot & Bell, 2019). Excessive alcohol consumption and low fruit and vegetable (FV) consumption have been associated with lower SES in low-income and LMICs (Allen et al., 2017).

2.3.3.2 Behavioural risk factors for non-communicable diseases

The WHO has identified four modifiable risk factors that are associated with the prevalence of NCDs. These risk factors include physical inactivity, tobacco use, excessive alcohol use and unhealthy diets (WHO, 2022a). Regular physical activity is necessary for psychological well-being, healthy muscles and bones and reduces blood pressure among people with hypertension (WHO, 2022c). At least 150-300 minutes of moderate-intensity physical activity, such as brisk walking, doing household chores and dancing or 60 minutes of vigorous activity, such as running, carrying heavy loads, swimming and cycling are recommended for adults per week (WHO, 2022c). Physical inactivity results in weight gain and obesity, which increase the risk of developing NCDs, such as diabetes, hypertension, CHD, stroke, colon cancer, breast cancer and depression (WHO, 2022c, Lavie et al., 2017). The prevalence of physical inactivity in Africa is 22.1% among adults (WHO, 2020a).

It has been estimated that tobacco use is the cause of more than 8 million deaths annually (WHO, 2022d). In 2019, tobacco use accounted for 7.69 million deaths and 200 million disability-adjusted life-years (DALYs) (Reitsma et al., 2021). Among men, tobacco use was the primary risk factor for death, accounting for 20.2% of male deaths (Reitsma et al., 2021). Smokers have a higher risk of developing lung cancer, heart disease, stroke, chronic obstructive pulmonary disease, diabetes and other diseases (CDC, 2022).

Alcohol use is the cause of approximately 3.3 million deaths annually and is estimated to cause 5.1% of the global disease burden, as estimated by DALYs (WHO, 2022e). Excessive alcohol use is associated with the risk of developing NCDs, including mental and behavioural disorders, such as alcohol dependency, injuries, road traffic accidents and violence (WHO, 2022e).

Diets are key contributors to malnutrition and subsequent health outcomes (HLPE, 2017). Unhealthy diets consisting of high sodium intake, high intake of red meat, processed meat, SSBs and trans fats, besides low intake of whole grains and fruits, are primary risk factors for global mortality and DALYs (Afshin et al., 2019). The obesity pandemic can be attributed to the taste preference and affordability of high-fat, salt and sugar-containing foods (van Liere MJ & Curtis, 2018).

Consumption of FV is one component of a healthy diet. However, billions of people worldwide do not consume the recommended amount of 400 g or five servings of FV per day to prevent

NCDs and micronutrient deficiencies, especially in LMICs (WHO, 2020b). In 2017, a low intake of FV was estimated to cause 3.6 million deaths and 93 million DALYs globally (Afshin et al., 2019).

The global mean intake of salt was estimated at 10.78 g daily, versus the WHO recommended salt intake was 5 g daily (WHO, 2023d). In 2017, a diet high in salt was estimated to contribute to 3 million deaths and 70 million DALYs (Afshin et al., 2019). High salt consumption is associated with high blood pressure, CHD, and stroke (Grillo et al., 2019, Graudal et al., 2014).

2.3.4 Risk factors for non-communicable diseases in South Africa

The main risk factors for NCDs in South Africa include excessive alcohol use, tobacco use, physical inactivity, high salt/sodium intake, high blood pressure, obesity, environmental factors and household pollution (WHO, 2018a). Some of these risk factors are related to nutrition and, therefore, can be addressed by modifying the diet.

Tobacco use and alcohol consumption are more prevalent among South African men than women (NDoH et al., 2019). Approximately 7% of women and 37% of men aged 15 and older reportedly use tobacco products (NDoH et al., 2019). The prevalence of cigarette smoking is higher in urban areas than in peri-urban and rural areas (NDoH et al., 2019). An estimated 61% of men and 26% of women aged 15 years and older reported they drink alcohol (NDoH et al., 2019).

In South Africa, physical inactivity is estimated to range between 43% and 49% in individuals aged 15 years or older (Muthuri et al., 2014, Micklesfield et al., 2014, Mayosi et al., 2009). The SADHS findings show that 46% of women and 44% of men aged 15 and older reported having elevated blood pressure (NDoH et al., 2019).

2.4 Nutritional status

Nutritional status is an indicator of health and is determined by a variety of factors including (i) individual factors such as age, sex, socioeconomic status, ethnicity, knowledge and skills, food preferences, food insecurity and dietary intake; (ii) environmental factors such as sanitation, climatic changes, type of housing and food availability; (iii) physical/biological factors such as taste, smell, digestion and infections; (iv) sociocultural factors which include religion, traditions and body image; and (v) psychological factors such as depression,

loneliness, substance abuse and eating disorders (Kesari & Noel 2023). Anthropometric measurements, dietary assessment, clinical assessment, biochemical measurements and food security are various methods used to measure nutritional status (Bates et al., 2017, FANTA, 2016). Anthropometric measurements generally include weight and height (this is used to calculate the BMI), mid-upper-arm circumference, waist circumference (WC) and hip circumference (HC) (WC and HC are used to calculate the WHR) (Bates et al., 2017).

Methods to assess dietary intake include the 24-hour recall, food frequency questionnaire, food records/diaries, and a food group questionnaire (Bates et al., 2017, FANTA, 2016). Clinical assessments include checking visible signs of nutritional deficiencies, for example, oedema or wasting and asking a patient for symptoms of medical conditions that may affect nutrition intake or absorption of nutrients, such as fever, vomiting and diarrhoea (FANTA, 2016). Biochemical assessment includes the examination of nutrients in the blood, urine or stools (FANTA, 2016).

2.4.1 Nutritional status of South African adults

Findings from the South African National Health and Nutrition Examination Survey (SANHANES-1) indicated a high prevalence of overweight and obesity in women compared to men (24.8% and 39.2% vs 20.1% and 10.6%, respectively) (Shisana et al., 2013). The mean WHR for males and females was 0.87 and 0.85, respectively (Shisana et al., 2013). Overall the prevalence of vitamin A deficiency and anaemia in South African females of reproductive age was 13.3% and 17.5%, respectively (Shisana et al., 2013).

According to the SADHS, 68% of women in South Africa were overweight or obese, 3% were underweight, and 30% had a normal weight (NDoH et al., 2019). The same survey found that 31% of men were overweight or obese, 10% underweight, and 59% were normal weight (NDoH et al., 2019). It has also been reported that 20% (1 in 5 women) were severely obese BMI $\geq$ 35 kg/m^2, and only 3% of men were severely obese. Other South African studies also show that the prevalence of obesity is increasing in urban areas, especially in poor urban areas (Okop et al., 2016, Cois & Day, 2015).

According to Stats SA (Stats SA, 2020), 11% of the South African population (6.5 million) experience hunger or are food insecure. The key drivers for hunger and food insecurity in South

Africa include the coronavirus disease 2019 (COVID-19), unemployment and poor economic growth, food prices and drought (Integrated food security phase classification (IPC), 2021).

2.5 Nutrition transition

2.5.1 Global nutrition transition

It is well-known that an unhealthy diet is one of the main risk factors for NCDs. The global rise in unhealthy food consumption is a consequence of the nutrition transition. Nutrition transitions refer to dietary changes resulting from modernisation, urbanisation, globalisation, trade, economic development, better wealth and mass food marketing (Popkin & Ng, 2022). In Figure 2.1, the five stages of the nutrition transition are presented, 1) collecting food, 2) famine, 3) receding famine, 4) chronic disease (NCDs), and 5) behavioural change (Popkin & Ng, 2022). The current global nutrition transition (stage 4 chronic disease (NCDs)) is characterised by the shift from people consuming traditional diets rich in fibre, lean meats, legumes, vegetables and fruits to more Westernised diets, which include foods that are energy-dense, refined, ultra-processed foods, lacking phytochemicals and fibre and high SSBs consumption (Popkin & Ng, 2022, Popkin, 2015).

Ultra-processed foods are generally high in salt, sugar, and saturated fat, with some including highly refined grains (Reardon et al., 2021, Baker et al., 2020). Low- and middle-income countries may also have poor diet quality because of the consumption of high-fat street food (Reardon et al., 2021). The recent global nutrition transition is accompanied by significantly low physical activity, further increasing the prevalence of diet-related NCDs (Popkin & Ng, 2022). A Western diet is associated with a greater risk for NCDs such as CVD (Oikonomou et al., 2018), metabolic syndrome, and diabetes (Pestoni et al., 2021, Drake et al., 2018, Amini et al., 2010).

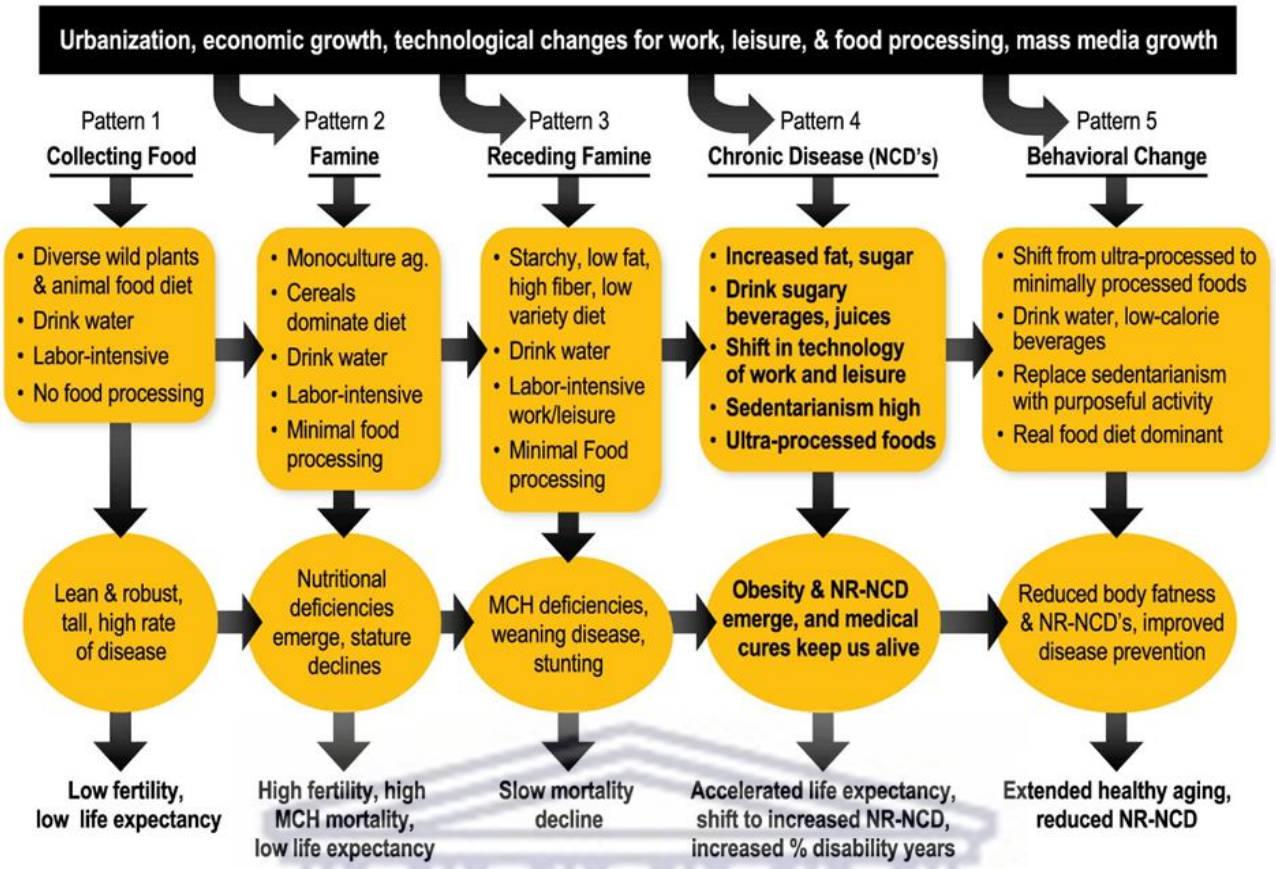


Figure 2.1: Stages of the nutrition transition

Source: Popkin & Ng, 2022.

2.5.2 The nutrition transition in South Africa

According to Vorster and colleagues (2011), the nutrition transition in South Africa may be attributed to economic growth (job creation and better wages/salaries), the move from rural to urban areas and modernisation. This nutrition transition has led to unhealthy dietary patterns and intakes of unhealthy food, undernutrition in young children, and overweight and obesity in younger and older children and adults (McLachlan & Landman, 2013).

Changes noted in the dietary patterns of South Africans include reduced intake of high starch and fibre-rich foods, high intakes of fatty meats which are high in saturated fats, low intakes of legumes and vegetables and a high intake of energy-dense, nutrient-deficient snacks, SSBs and convenience foods which generally have a high salt content (Vorster et al., 2011).

In South Africa, the intake of fast foods, which are defined as convenience foods obtained from take-away vendors and are usually energy-dense, low in micronutrients and fibre, and high in

fat, simple sugars and salt has increased (Steyn & Labadarios, 2011, Feeley et al., 2011). South Africans also consume ultra-processed packaged foods widely (Frank et al., 2021).

2.6 Food choices

Healthy food intake and dietary patterns are dependent on consumer food choices. Factors determining food choices include urbanisation, globalisation, geographic location (urban vs rural), seasonal variation, government and other support services, food prices, marketing, social networks, socio-demographic factors, such as education, disposable income, and individual characteristics, such as religion, culture, ethnicity, time, taste preferences, satiation, nutrition knowledge and health (Laraia et al., 2017, Antin & Hunt, 2012, Wenhold et al., 2012).

2.6.1 Determinants of food choice

2.6.1.1 Socio-economic status

Food choices have been associated with socio-economic factors, such as education level, occupation, income, and resident area (Mayén et al., 2016, Pechey & Monsivais, 2016, Vlismas et al., 2009). Malnutrition prevalence can be decreased by increasing income, according to Smith and Haddad (Smith & Haddad, 2015). Mayén and colleagues (Mayén et al., 2014) argue that greater access to diverse and nutrient-rich foods and less nutrient-poor, energy-dense foods could be attainable through increasing incomes.

Several studies show that low SES is associated with purchasing and consuming unhealthy foods (Best & Papies, 2019, López-Olmedo et al., 2018, Pechey et al., 2013, Darmon & Drewnowski, 2008). Low SES has also been shown to be associated with a lack of nutrition knowledge and not following dietary guidelines (Doglikuu et al., 2021, Lagström et al., 2019, Spronk et al., 2014). Other studies have further shown that lower education and income are associated with unhealthy diets (Rippin et al., 2020) and low intakes of vegetables and fruit (Msambichaka et al., 2018, Prättälä et al., 2009).

2.6.1.2 The economic situation in South Africa

South Africa is classified as an upper-middle-income country (World Bank, 2018). However, according to the Gini index, South Africa has a high economic inequality (Sulla & Zikhali, 2018). The two main sources of household income include wages and salaries (59.4%) and social grants (51.0%) (Stats SA, 2021). The country is characterised by high unemployment,

with the current unemployment rate being 32.7% (Stats SA, 2023) and 55.5% of the population living below the upper-bound poverty line (PMBEJD, 2023).

The educational level is low in South Africa. A total of 13.6% (4 million) of the population had primary schooling as their highest education level in 2021, 39.2% (11.6 million) attended some secondary school, 31.9% (9.5 million) completed secondary school education, and 15.3% (4.5 million) had a certificate, diploma, degree, or other qualification as their highest education level (Khuluvhe & Ganyaupfu, 2022).

In South Africa, price is the determining factor of whether a food item will be purchased (Shisana et al., 2013). Money is necessary to acquire foods that are adequate and diverse to prevent malnutrition and the development of NCDs (Vorster et al., 2007). However, according to the SANHANES-1 study, as much as 39% of South Africans do not have enough money to purchase food (Shisana et al., 2013). Socio-economic inequalities in South Africa are evident in the food choices of the population.

In 2020, the COVID-19 lockdown in South Africa resulted in job losses, contributing to food insecurity (Integrated food security phase classification (IPC), 2021). On average, 40% of households reported having insufficient funds to buy food during the COVID-19 lockdowns (van der Berg et al., 2022). In 2020, Stats SA found that nearly 24% of South Africans experienced moderate to severe food insecurity, of which 15% experienced severe food insecurity (Stats SA, 2020). Households most vulnerable to food insecurity and hunger included those with more than four people and those in rural areas (van der Berg et al., 2022). The government's temporary efforts to support households included the introduction of two grants, the Temporary Employee/Employer Relief Scheme and the Social Relief of Distress grant (van der Berg et al., 2022). Non-governmental organisations (NGOs), religious organisations, communities, and neighbours also assisted those negatively affected by the pandemic and lockdowns by providing emergency food assistance (Wills et al., 2023).

2.6.1.3 Urbanisation

Urbanisation, which is attributable to transitions in social structure, political change, and economic factors, is associated with changes in eating patterns (Ren et al., 2021, Cockx et al., 2019). An estimated 67% of South Africans live in urban areas (UN Habitat, 2021). Urbanisation is one of the key drivers for unhealthy consumption patterns among South Africans. In urban areas, people buy their food rather than grow it, resulting in poorer

households having limited access to nutritious food. Food manufacturing, markets, high prices, and inflation also shape food choices (Claasen et al., 2016, Crush et al., 2011).

Urbanisation has led to greater reliance on transport, increased supermarket growth, higher incomes, and the availability of shopping centres within closer proximity. As a result, people do not have to walk long distances to get food (Pretorius & Sliwa, 2011). Those travelling to places of employment are known to consume convenient foods, ready-made meals and processed snacks high in fat and sugar (Pretorius & Sliwa, 2011). Transportation can be either a barrier or an enabler for healthy food choices. A lack of public transport or no privately owned vehicle can affect food purchasing and, thus, food choices. To acquire affordable fresh produce, some community members may have to drive outside the community to access stores that supply such food (Belon et al., 2016, Fitzpatrick et al., 2016).

2.6.1.4 Food prices

Food prices are a primary determinant of food choices. Affordability and price have been identified as critical barriers to accessing adequate and safe nutritious food to meet dietary requirements and preferences (Herforth et al., 2020, Laraia et al., 2017). Observational studies in the USA have found that low-cost, poor-quality diets are most likely to be consumed by people with lower SES (Rehm et al., 2015, Aggarwal et al., 2012). Low-income households would have to spend a higher percentage of their income to meet recommended FBDGs than higher-income households, as shown by studies (Lewis et al., 2020, Cassady et al., 2007).

A South African study reported that healthier food choices cost more per weight and per 100 kJ than unhealthier food options (Temple & Steyn, 2011). Healthier foods are more readily available in supermarkets than convenience stores and generally cost between 10% and 60% more than less healthy foods (Temple et al., 2011). Low-income South Africans may frequently consume inexpensive ultra-processed foods because of limited resources (Temple & Steyn, 2011). In a study conducted in the Western Cape in 2018, Frank and colleagues (Frank et al., 2021) found that 80% of foods in supermarkets were ultra-processed.

According to the latest Household Affordability Index, the average monthly household food basket costs increased by 13.1% (from R4 355.70 to R4 928.34) between February 2022 to February 2023 (PMBEJD, 2023). Food prices may vary according to the type of food store, which also influences food choices. Food prices were generally lower in supermarkets than

informal retailers because of their different procurement strategies, as found in a South African study (Igumbor et al., 2012).

2.7 Food choices and food environments

The food environment is where consumers make decisions on how to procure, prepare and consume food; it may either support or obstruct healthy food choices. The food environment influences individual food choices, which affect nutritional status and NCDs (HLPE, 2017). People who live in a healthy food environment can access affordable, acceptable, and desirable healthy and nutritious foods (FAO, 2016). Food environments are influenced by food systems shaped by multiple drivers, including biophysical and environmental drivers, innovation, technology and infrastructure drivers, political and economic drivers, socio-cultural factors and demographic drivers (Figure 2.2) (FAO, 2016).

Local food environments are defined as "the physical presence of food that affects a person's diet, a person's proximity to food store locations, the distribution of food stores, food service and any physical entity by which food may be obtained; or a connected system that allows access to food" (CDC, 2014).

According to Glanz and colleagues (Glanz et al., 2005), the local food environments can be classified as the community, consumer organisational and information food environments. Community food environments include the physical availability and accessibility to food stores; the consumer food environment, alternatively, relates to the availability of healthy food in stores, food product price and affordability, placement and promotion, and quality (Glanz et al., 2005).

Collectively, the community and consumer food environment are referred to as the retail food environment (Glanz et al., 2005).

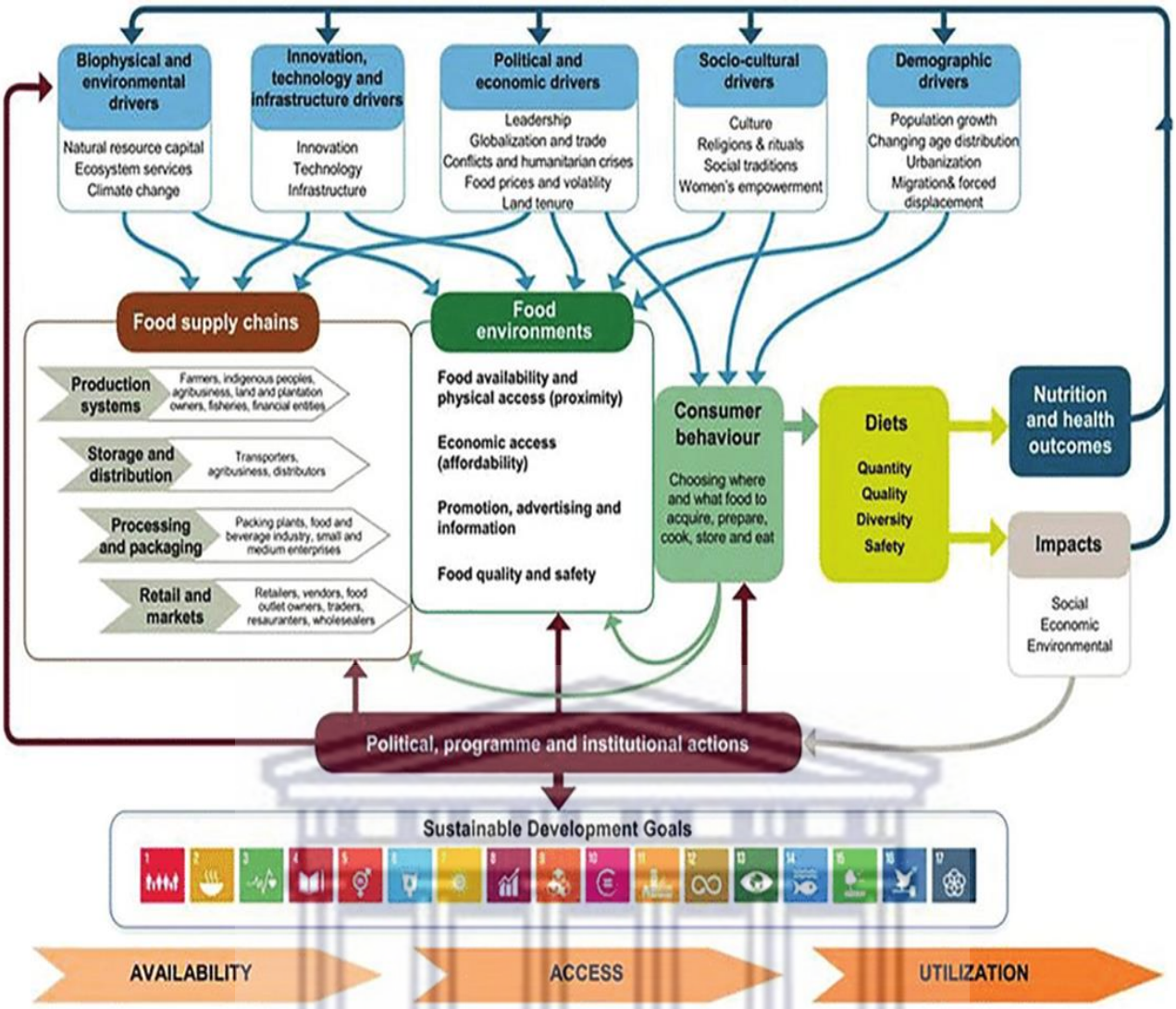


Figure 2.2: Conceptual framework of food systems for diets and nutrition

Source: HLPE, 2017

2.7.1 The South African retail food environment

The South African retail food environment comprises formal and informal retailers (Masojada, 2021, Claasen et al., 2016). Formal food retailers include neighbourhood convenience stores, speciality stores, chain supermarkets, department stores and large wholesale and retail outlets. Informal food retail involves general dealers, small cafes, street vendors, hawkers (mobile vendors), tuck shops, street corner stalls and spaza shops (Claasen et al., 2016). In townships, informal food vending retailers consist of 50% of all informal businesses (Petersen et al., 2017). Formal retailers and fast food outlets are the main sources of food for South African townships, particularly in Cape Town (Battersby, 2011).

2.7.1.1 Formal food retailers

Formal food retail in South Africa is composed of supermarket retailers, online retailers and retail hybrid (Masojada, 2021). Supermarkets form a large part of the South African formal food retail environment and own more than 50% of the retail food market; therefore, most food in South Africa is purchased from supermarkets (Spires et al., 2016). In Cape Town, 90% of people purchase food from supermarkets, as shown in studies (Haysom, 2017, Battersby, 2011). The four leading retail stores in South Africa include Shoprite Checkers, Pick n Pay, Spar and Woolworths (Igumbor et al., 2012). These supermarkets have expanded to rural and lower-income areas (Igumbor et al., 2012).

Supermarket prices are generally lower than community supermarkets or spaza shops (Roos et al., 2013). Supermarket prices are more affordable than informal retailers because they can make profits and can control supply chains (Battersby & Watson, 2018). Although the presence of supermarkets in townships has been linked to greater food access and, therefore, food security, supermarkets are criticised by activists, stating that lower food prices have led to a greater risk of health-related diseases through supplying energy-dense, unhealthy food (Battersby & Watson, 2018).

2.7.1.2 Informal food retailers

Informal trading is central to the livelihoods of many South Africans (Petersen et al., 2017) and is a substantial source of food supply for poorer, food-insecure households (Skinner & Haysom, 2016). A study in resource-poor communities around Cape Town showed that 55% of households purchase food from informal vendors, and 36% purchase from vendors at least once a week (Libman et al., 2015).

Informal food retailers usually sell fresh foods, takeaways, beverages and groceries (Petersen et al., 2017). Convenience stores are more convenient because of their longer trading hours (Vogel, 2018). Street vendors are generally located in areas such as train and bus stations and business and industrial areas where there are factories and warehouses (Steyn et al., 2011).

Spaza shops are smaller convenience stores run by independent property owners from their homes or structures such as shipping containers. Typically, spaza shops are in residential areas and within walking distance from people's homes (Roos et al., 2013). Spaza shops usually stock a few staple items, such as bread, tea, coffee, sugar, condiments, toiletries and cleaning products, and operate seven days a week with longer trading hours (Nielsen, 2016).

2.8 Food environments, diet, and nutritional status

Food environments can promote or hinder healthier food choices and consequently influence health outcomes. Food environments where healthy foods are inaccessible, too expensive and of lower quality may contribute to the prevalence of diet-related NCDs and food insecurity (Swinburn et al., 2013). Examining local environments can help public health professionals to gain an understanding of the characteristics of neighbourhood retail that influence dietary choices and risk for NCDs (Powell et al., 2007a).

Several studies have shown that local food retail environment characteristics, such as food store type, proximity to food stores and food prices, are associated with diet (Engler-Stringer et al., 2014, Caspi et al., 2012) and nutritional status (An et al., 2020, Gustafson et al., 2018, Zenk et al., 2017, Lee et al., 2017). Understanding the relationship between food environments and people's eating behaviour is necessary to ensure food security and healthy diets (Khonje & Qaim, 2019).

2.9 Food security, food access and the food environments

2.9.1 Food insecurity

Food insecurity exists "when people do not have adequate physical, social or economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life" (FAO, 2022) and is a result of low SES (Drewnowski, 2022). Poor diet quality, low DD, low consumption of nutritious food and high intakes of energy-dense nutrient deficient foods are associated with food insecurity (FAO, 2022). Diet restrictions and disordered eating habits, such as overeating and habitual, situational, and emotional eating, are also associated with food insecurity (Seligman & Schillinger, 2010, Seligman et al., 2010).

2.9.2 Food access and the food environment

To be food secure, individuals need access to sufficient, safe, and nutritious food that satisfies their dietary needs and preferences for a healthy, active lifestyle (FAO, 2002). The most important dimension of food security is access. The food environment in which individuals live influences their dietary choices (Robitaille & Paquette, 2020).

Accessibility refers to availability, geographical access, convenience, and economic accessibility, measured by the price and affordability of food choices in stores, including social and cultural acceptance (Turner et al., 2018, Caspi et al., 2012). The quality of food choices is impacted by the availability of healthy foods in communities nearest to the individuals (Darmon & Drewnowski, 2008). Limited access to nutritious foods and healthy store types, such as supermarkets, grocery stores and fruit and vegetable markets in resource-poor communities, is a barrier to quality diets (Gittelsohn et al., 2022, Costa et al., 2019).

In a Western Cape study, high food prices and a lack of variety and quality in the food environment of low-income communities were reported as barriers to food access (Roos et al., 2013). Access to healthy food is dependent on access to transport, distance to shops, availability and the price of nutrient-dense foods such as fresh fruit and vegetables (Caswell et al., 2013, Darmon & Drewnowski, 2008). Lack of availability, accessibility and affordability make it difficult for consumers to have healthier options for food (Osei-Assibey et al., 2012, Bodor et al., 2010).

2.9.3 Neighbourhood/community socio-economic status and the food environment

Neighbourhood poverty or disadvantage is associated with an adverse retail food environment. Low-income communities in urban and rural settings are the most affected by unhealthy food environments (Larson et al., 2009). Food deserts are generally areas with high socio-economic disadvantage levels with low or inadequate access to food stores that stock nutrient-rich foods (HLPE, 2017). Neighbourhoods characterised by access to healthy foods and high access to fast food restaurants and convenience stores are known as food swamps (Sushil et al., 2017, Minaker et al., 2016, Ver Ploeg et al., 2009).

Several studies provide evidence that unhealthy food environments, which tend to occur in low SES neighbourhoods, are associated with obesity because of access to poor quality and energy-dense foods (Colabianchi et al., 2021, Hallum et al., 2020, Laxy et al., 2015, Shih et al., 2013, Kwate et al., 2009, Larson et al., 2009, Powell et al., 2007b, Wang et al., 2016). Improving the

neighbourhood food access environment may encourage consumers to purchase healthier food products and improve their diet quality and overall health.

2.10 Interventions to improve food environments.

Various interventions are already being implemented globally to improve the food environment. Policy interventions include regulation of food marketing, including unhealthy food television advertising, food procurement policies, front-of-pack labelling, taxation of unhealthy foods, subsidies for healthy foods, food assistance programmes and agriculture and trade policies (Løvhaug et al., 2022, Friel et al., 2015). Physical environment interventions include community and school gardens, zoning, and bylaws to decrease the number of fast-food outlets in specific areas, such as around schools (Løvhaug et al., 2022, Downs & Demmler, 2020, Friel et al., 2015).

Retail food environment interventions include building supermarkets in food deserts and increasing the number of food markets and fresh produce street vendors, improving transportation between suppliers and grocery stores to ensure the supply of fresh and healthy foods, displaying healthier options on menus in restaurants, and creating healthier corner stores by improving the availability, promotion and affordability of healthy foods (Løvhaug et al., 2022, Downs & Demmler, 2020, van Liere MJ & Curtis, 2018, Friel et al., 2015).

2.11 Dietary intake and non-communicable diseases

A healthy diet meets the nutritional needs of individuals by providing sufficient, safe, and diversified foods to maintain an active life and reduce disease risks. It contains FV, legumes (lentils and beans), nuts and whole grains (unprocessed maize, millet, oats, wheat and brown rice) and is low in fats (particularly saturated fats), free sugars and salt (WHO, 2018b, de Ridder et al., 2017). Unhealthy diets are high in salt, sugar, trans and saturated fats, processed food, and refined starches and are low in fibre, fresh FV, nuts and whole grains (FAO & WHO, 2019).

The literature shows that dietary patterns and intake of individual foods are associated with NCDs (Liang et al., 2023, Tapsell et al., 2016). Dietary patterns shown to be associated with lower NCD risk include the Mediterranean diet, which is high in fruits, vegetables, nuts, canola oil and olive oil and the Dietary Approaches to Stop Hypertension (DASH) diet (Schulze et al., 2018). Furthermore, higher consumption of nuts, legumes, and vegetable oils was shown to be beneficial in preventing NCDs (Schulze et al., 2018). A consumption high in whole grains and dairy products was associated with a lower risk for cardiometabolic disease (World Cancer Research Fund & American Institute for Cancer Research, 2018, Mozaffarian, 2016). Whole grains were

also associated with a lower risk for cancer (World Cancer Research Fund & American Institute for Cancer Research, 2018). The consumption of SSBs was associated with an increased risk of T2DM, CHD, and stroke. Excessive sugar intake is associated with obesity and may result in a greater risk for diabetes, CVDs, liver and kidney damage, cancer, and cognitive impairment (Rippe & Angelopoulos, 2016).

2.12 Dietary intake in South Africa

The prospective urban and rural epidemiology cohort study in North West Province, South Africa (PURE-NWP-SA) showed that overall energy intake between 2005-2010 increased for urban and rural black adult participants (Wentzel-Viljoen et al., 2018). Energy intake from animal protein, monosaturated fat and added sugar increased in rural and urban participants in the PURE-NWP-SA study. Energy intake from total fat increased only in rural men and women and saturated fat in rural women (Wentzel-Viljoen et al., 2018).

Ronquest-Ross and colleagues (Ronquest-Ross et al., 2015) reported that from 1994 to 2012, South Africans consumed more meat, fats and oils, packaged foods and beverages, such as soft drinks, sauces, dressings, condiments, sweet and savoury snacks and fewer vegetables. The food group consumed mostly by South African adults is the starchy food group (cereals, roots, tubers and grains) (Walsh & Van den Berg, 2022). Staple starchy foods include maize meal and bread, followed by rice (Walsh & Van den Berg, 2022).

According to a recent desktop review, chicken was the most consumed animal protein in South Africa, followed by red meat (beef). The consumption of milk and milk products was significantly low (Walsh & Van den Berg, 2022). According to the review, South Africans consumed FV infrequently. The daily fruit consumption of White and Black South Africans was 71% and 46%, respectively, and the daily vegetable consumption was 84% and 57% (Walsh & Van den Berg, 2022). More women than men consume FV (Walsh & Van den Berg, 2022). Although FV consumption is low, the fruits most often consumed by South Africans include apples, bananas, oranges and vegetables most frequently consumed include onion and tomato (stew, relish or gravy), cabbage, and green leafy vegetables such as imifino or spinach (Walsh & Van den Berg, 2022).

2.12.1 Intake of high sugar, salt, and fat foods

In the SANHANES-1, consuming sweet foods and snacks, such as chocolates and cookies, was the highest for younger people (Shisana et al., 2013). Savoury snacks such as chips and crisps

were consumed by 60% of the participants at least once a week in the SANHANES-1 (Shisana et al., 2013). According to the SADHS 2016, 36% of South Africans consumed SSBs, 10% ate fried foods, 13% ate salty snacks, and 14% ate processed meat daily (NDoH et al., 2019).

The SADHS 2016 further showed that participants who purchased SSBs daily or weekly consumed less than two servings of FV daily. In the SADHS 2016, more Mixed-ancestry and Black participants consumed SSBs (NDoH et al., 2019). Processed and packaged foods high in fat (vegetable oil) and unhealthy foods were most commonly consumed by urban dwellers (NDoH et al., 2019, Walsh & Van den Berg, 2022).

2.12.2 Fast food and street food consumption in South Africa

Fast foods and street foods are frequently consumed by South Africans. A national study by Steyn and Labadarios (2011) reported that South Africans consumed fast food two or three times per month, with 45.3% of Black and 22.4% of Mixed-ancestry people consuming street food (Steyn & Labadarios, 2011). In the SANHANES-1 study, 46% of South Africans consumed fast food from street vendors, and 56% consumed fried street food. (Shisana et al., 2013). The SADHS (2016) reported that 2% of South Africans ate fast food daily (NDoH et al., 2019).

In a study conducted in Cape Town, it was reported that the most frequently purchased foods from street vendors were fruit, cooked food and baked products, SSBs, sweets, peanuts, crisps/chips, fruit juice, chocolates and biscuits (Hill et al., 2016). The same study also noted that street food consumers would be willing to purchase healthier street foods such as fresh fruit juice, yoghurt, milk drinks, salad and whole-wheat sandwiches if these were available at more affordable prices (Hill et al., 2016).

2.13 Dietary diversity

Dietary diversity is a crucial part of a healthy balanced diet, and diverse diets are necessary to meet the macro- and micronutrient requirements for individuals' overall health and well-being (Herforth et al., 2019). Dietary diversity is an essential part of an adequate diet and is recommended globally by dietary guidelines and FBDGs (Cámara et al., 2021, Herforth et al., 2019, FAO/WHO, 1998). The aim of FBDGs is to increase awareness about healthy food choices and encourage people to make them to prevent malnutrition and other NCDs (Vorster, 2013). A diet lacking in variety is said to have adverse effects on individuals' health, development, and mental well-being since their micronutrient needs are not met (Bernstein & Munoz, 2012).

Dietary diversity is measured using dietary diversity scores (DDS), which are measurements for the quality of diets (FAO 2011). Dietary diversity scores can be used as a population-level proxy indicator for micronutrient adequacy in children (Arimond & Ruel, 2004, Steyn et al., 2006) adolescents (Mirmiran et al., 2004), adults (Savy et al., 2006, Azadbakht et al., 2006) and elderly (Tavakoli et al., 2016, Rathnayake et al., 2012, Oldewage-Theron & Kruger, 2008). The DDS is a count of the number of different foods or food groups consumed over a specific reference period (Ruel, 2003). The reference period when measuring DD can be the previous 24 hours, three or seven days (FAO, 2011).

In the literature, multiple methods are used to measure DDS (de Oliveira Otto et al., 2018, FAO, 2011, Ruel, 2003). These methods are chosen by researchers based on the study aim, study population age and setting. Dietary diversity scores can be measured at household and individual levels. Household DD measurement tools, such as the Household Dietary Diversity Score, measure household food access to various foods (FAO, 2011). Individual DDS tools are used to determine nutrient adequacy (FAO, 2011). Individual DD measurement tools include the MDD-W (Martin-Prevel et al., 2015) and Infant and Young Child Dietary Diversity Score (WHO/UNICEF, 2021).

2.13.1 Dietary diversity and global health outcomes

While diverse diets are said to prevent chronic diseases, research on DD scores and health outcomes has yielded confounding results, with some studies showing that DD may protect against NCDs while other studies show that it is associated with a higher prevalence of NCDs (de Oliveira Otto et al., 2018). In a national nutritional survey in Southwest China, higher DD (based on nine food groups) was not necessarily associated with the recommended intake of fruits, vegetables, fish and dairy but with excessive grain, meat and oil (Zhang et al., 2017).

In the Multi-Ethnic Study of Atherosclerosis, high DD was associated with intakes of nutrient-dense foods, such as FV and whole grains, including unhealthy foods, such as processed meats, salty snacks and SSB (de Oliveira Otto et al., 2015). Furthermore, the study showed weak positive associations between DDS and diet quality scores, suggesting that unhealthy foods within a varied diet may reduce the benefits of nutrient-dense foods, resulting in poor diet quality (de Oliveira Otto et al., 2015).

In a systematic review of 16 studies, no association between DD and the prevalence of overweight or obesity was found in seven of the studies (Salehi-Abargouei et al., 2016). In a systematic

review of ten studies looking at the association between DD and adiposity, intake of recommended foods such as FV and grains was negatively associated with body adiposity in six studies, while the remaining studies had mixed findings (Vadiveloo et al., 2013). In pre-diabetic Iranian individuals, higher DD was associated with lower fasting plasma glucose (FPG), HDL-C and TG levels and WC, while lower DD was associated with a higher risk of metabolic syndrome. Therefore, the authors concluded that diets with plenty variety of foods might prevent pre-diabetes (Fanelli Kuczmarski et al., 2019).

De Oliveira Otto et al. (2015) reported that DD was not associated with either T2DM or WC, but that nutritionally adequate diets were associated with a lower risk of T2DM. A study in patients with metabolic syndrome showed that high DD is associated with normal blood glucose levels, while participants with a low DD had higher serum TG concentrations and systolic blood pressure and lower serum adiponectin. Therefore, the authors postulated that consuming a diet high in diversity may prevent metabolic syndrome (Farhangi & Jahangiry, 2018).

In a study conducted in rural Zambia, DD was found to be positively associated with nutritional status; however, no associations were found between DD and health outcomes such as CHD and obesity (Maila et al., 2021). Results from the South Asian Centre for Cardiometabolic Risk Reduction in South Asia study showed that adults with high DD had a lower prevalence of diabetes and hypertension (Kapoor et al., 2018). Some studies also show that DD is negatively correlated with metabolic syndrome (Azadbakht et al., 2005), obesity (Azadbakht & Esmaillzadeh, 2011) and CVDs (Azadbakht et al., 2006).

2.13.2 Dietary diversity in South Africa

The first guideline in the SA-FBDGs is to "Enjoy a variety of foods", encouraging South Africans to consume a diverse diet (Steyn & Ochse, 2013). However, several cross-sectional studies show that South Africans consume a diet low in variety (Saha et al., 2019, de Bruin & Gresse, 2018, Chakona & Shackleton, 2017, Shisana et al., 2013, Drimie et al., 2013, Oldewage-Theron & Kruger, 2011, Labadarios et al., 2011). Compared to other racial groups, the lowest DDS were observed among Black South Africans (Shisana et al., 2013). Barriers to following FBDGs, as reported by South African women in KwaZulu-Natal and the Western Cape, include affordability, availability, household taste preferences, time constraints, traditional/habitual food purchasing or preparation methods and existing attitudes (Love & Sayed, 2001). In their review paper, Schönfeldt and colleagues (2013) reported that limited financial resources are the primary barrier to food choice and adherence to FBDGs among South Africans (Schonfeldt et al., 2013).

2.14 Public health strategies to address non-communicable diseases and risk factors.

Various strategies have been implemented to improve diets, prevent malnutrition and NCDs in populations. These strategies include public nutrition education through FBDGs to promote healthier food choices (Cámara et al., 2021), fortification of staple foods to address micronutrient malnutrition (Hombali et al., 2019, Nuss et al., 2012, Steyn et al., 2008) and the promotion of diverse diets and consumption of nutrient-dense foods (Nair et al., 2016).

The South African government has developed several food, nutrition, and health-related policies, strategies, and programmes to positively influence the food environment and curb the rise of NCDs. These strategies include the national food and nutrition security policy, strategic plan for preventing and controlling non-communicable diseases 2020-2025, national road map for nutrition 2013-2017, strategy to prevent and control obesity 2015-2020, FBDGs, salt regulation and salt watch campaign, levy on salt substitutes and SSBs, national food fortification programme, food pricing strategies such as zero VAT on food and food labelling (NDoH, 2020, Claasen et al., 2016). Healthier food environments are a potential solution for improving food and nutrition security and addressing malnutrition and NCDs in South Africa.

2.15 Nutrient density

Diet quality and nutrient adequacy are enhanced through diets consisting of various foods and food groups and nutrient-rich foods (Drewnowski, 2010). The nutrient density of individual foods, food groups and diets can be measured using NP models (Drewnowski et al., 2021). Nutrient profiling is used to classify or rank foods according to their nutritional value and identify healthier foods (WHO, 2011). Foods are defined as healthy based on their content of several nutrients or food groups (Drewnowski & Fulgoni, 2014, WHO, 2011). Several types of NP models are used to present nutrition information, labelling and regulation of food and beverage marketing and advertising (WHO, 2011). The use of NP models together with food prices can be applied to calculate the nutrient-to-price ratio (NPR) and help identify foods that are nutritious and affordable (Starck et al., 2021, Fulgoni et al., 2009, Drewnowski, 2009).

2.16 Nutrient-dense foods and diets in relation to cost

The cost of nutrient-dense foods (Bai et al., 2021, Drewnowski & Rehm, 2013, Aggarwal et al., 2012) and diets (Darmon & Drewnowski, 2015, Maillot et al., 2007, Monsivais & Drewnowski, 2007, Darmon et al., 2005) has been reported to be expensive in many countries. In South Africa,

Temple and Steyn (Temple & Steyn, 2011) found that healthier nutrient-dense foods were more costly than unhealthy high-energy-dense nutrient-poor foods.

The literature shows that energy-dense diets consisting of staple foods, energy-dense foods and processed foods are less costly and more affordable (Siqueira et al., 2021, Gupta et al., 2019, Drewnowski, 2018, Igumbor et al., 2012). Findings of a recent FAO study point to the challenge of making healthy nutrient-dense foods and diets more affordable, as the study reported that an estimated 3 billion people worldwide lack the income necessary to purchase the cheapest healthy diet recommended by national dietary guidelines (Herforth et al., 2020). The same study also found that healthy diets by any definition were more expensive than the entire international poverty line of $1.90 a day in purchasing power parity terms (Herforth et al., 2020).

2.17 Conclusion

In this chapter, the global and South African prevalence of NCDs were presented. Evidently, South Africa has high mortality rates attributable to NCDs. Being overweight and obese contribute to the high prevalence of diet-related NCDs, including diabetes and hypertension, among South African adults creating a critical public health issue. Unhealthy diets are the main contributor to malnutrition and disease. Diet and food choice are determined by many factors such as SES, nutrition knowledge, food preferences and food environments. Data on South African adults show that most do not consume a diverse diet. The lack of variety in South African diets may be attributable to low SES and unhealthy food environments.

Healthier food environments are a potential solution to improving food and nutrition security and addressing malnutrition and NCDs in South Africa. Although DD is used as an indicator of diet quality, there is a dearth of data on the association between DD and nutritional status. There is also a lack of knowledge on the barriers to consuming diverse diets and healthy food choices.

Although there have been some studies with evidence that healthier diets are more expensive than unhealthier diets, further investigation is needed to examine the nutrient density of food in relation to cost to identify foods with the best nutritional value per cost. The next chapter addresses the research methodology followed in the study.

2.18 References

Afshin, A., Sur, P. J., Fay, K. A., et al. (2019). Health effects of dietary risks in 195 countries, 1990-2017: A systematic analysis for the global burden of disease study 2017. *Lancet,* 393, 1958-1972.

Aggarwal, A., Monsivais, P. & Drewnowski, A. (2012). Nutrient intakes linked to better health outcomes are associated with higher diet costs in the US. *PLoS One,* 7, e37533.

Allen, L., Williams, J., Townsend, N., et al. (2017). Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: A systematic review. *Lancet Glob Health,* 5, e277-e289.

Amini, M., Esmaillzadeh, A., Shafaeizadeh, S., et al. (2010). Relationship between major dietary patterns and metabolic syndrome among individuals with impaired glucose tolerance. *Nutrition,* 26, 986-992.

An, R., He, L. & Shen, M. S. J. (2020). Impact of neighbourhood food environment on diet and obesity in China: A systematic review. *Public Health Nutr,* 23, 457-473.

Antin, T. M. & Hunt, G. (2012). Food choice as a multidimensional experience. A qualitative study with young African American women. *Appetite,* 58, 856-863.

Arimond, M. & Ruel, M. T. (2004). Dietary diversity is associated with child nutritional status: Evidence from 11 Demographic and Health Surveys. *J Nutr,* 134, 2579-2585.

Arokiasamy, P., Salvi, S. & Selvamani, Y. (2020). Global burden of diabetes mellitus. Haring, R., Kickbusch, I., Ganten, D., et al. (eds.), *Handbook of Global Health.* Cham: Springer International Publishing, 1-44.

Azadbakht, L. & Esmaillzadeh, A. (2011). Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. *Public Health Nutr,* 14, 62-69.

Azadbakht, L., Mirmiran, P. & Azizi, F. (2005). Dietary diversity score is favorably associated with the metabolic syndrome in Tehranian adults. *Int J Obes,* 29, 1361-1367.

Azadbakht, L., Mirmiran, P., Esmaillzadeh, A., et al. (2006). Dietary diversity score and cardiovascular risk factors in Tehranian adults. *Public Health Nutr,* 9, 728-736.

Bai, Y., Alemu, R., Block, S. A., et al. (2021). Cost and affordability of nutritious diets at retail prices: Evidence from 177 countries. *Food Policy,* 99, 101983.

Baker, P., Machado, P., Santos, T., et al. (2020). Ultra-processed foods and the nutrition transition: Global, regional and national trends, food systems transformations and political economy drivers. *Obes Rev,* 21, e13126.

Bates, C., Bogin, B. & Holmes, B. (2017). Nutritional assessment methods. Geissler, C. & Hilary, P. (eds.), *Human nutrition.* 13th Ed. Oxford, UK: Oxford University Press, 613-646.

Battersby, J. (2011). Urban food insecurity in Cape Town, South Africa: An alternative approach to food access. *Dev South Afr,* 28, 545-561.

Battersby, J. & Watson, V. (2018). Improving urban food security in African cities: Critically assessing the role of informal traders. Cabannes, Y. & Marocchino, C. (eds.), *Integrating food into urban planning*. London, UCL Press; Rome, FAO, 186-208.

Belon, A. P., Nieuwendyk, L. M., Vallianatos, H., et al. (2016). Perceived community environmental influences on eating behaviors: A photovoice analysis. *Soc Sci Med,* 171, 18-29.

Bernstein, M. & Munoz, N. (2012). Position of the Academy of Nutrition and Dietetics: food and nutrition for older adults: promoting health and wellness. *J Acad Nutr Diet*, 112, 1255-1277.

Best, M. & Papies, E. K. (2019). Lower socioeconomic status is associated with higher intended consumption from oversized portions of unhealthy food. *Appetite,* 140, 255-268.

Bodor, J. N., Rice, J. C., Farley, T. A., et al. (2010). The association between obesity and urban food environments. *J Urban Health,* 87, 771-781.

Branca, F., Lartey, A., Oenema, S., et al. (2019). Transforming the food system to fight non-communicable diseases. *BMJ,* 364, l296.

Budreviciute, A., Damiati, S., Sabir, D. K., et al. (2020). Management and prevention strategies for non-communicable diseases (NCDs) and their risk factors. *Front Public Health,* 8, 574111.

Cámara, M., Giner, R. M., González-Fandos, E., et al. (2021). Food-based dietary guidelines around the world: A comparative analysis to update AESAN scientific committee dietary recommendations. *Nutrients,* 13, 3131.

Caspi, C. E., Sorensen, G., Subramanian, S. V., et al. (2012). The local food environment and diet: A systematic review. *Health Place,* 18, 1172-1187.

Cassady, D., Jetter, K. M. & Culp, J. (2007). Is price a barrier to eating more fruits and vegetables for low-income families? *J Am Diet Assoc,* 107, 1909-1915.

Caswell, J. A., Yaktine, A. L., Board, F., et al. (2013). *Supplemental nutrition assistance program: Examining the evidence to define benefit adequacy*. Washington (DC): National Academies Press (US).

CDC. (2014). *General food environment resources* [Online]. Available http://www.cdc.gov/healthyplaces/healthtopics/healthyfood/general.htm [3 August 2019].

CDC. (2022). *Diseases and death* [Online]. Available https://www.cdc.gov/tobacco/data_statistics/fact_sheets/fast_facts/diseases-and-death.html [8 December 2022].

Chakona, G. & Shackleton, C. (2017). Minimum dietary diversity scores for women indicate micronutrient adequacy and food insecurity status in South African towns. *Nutrients,* 9, 812.

Claasen, N., van der Hoeven, M. & Covic, N. (2016). *Food environments, health and nutrition in South Africa*. Cape Town: PLAAS, UWC and Centre of Excellence on Food Security.

[Online]. Available http://repository.uwc.ac.za/xmlui/handle/10566/4520 [23 March 2019].

Cockx, L., Colen, L., de Weerdt, J., et al. (2019). *Urbanization as a driver of changing food demand in Africa: Evidence from rural-urban migration in Tanzania*. Luxembourg: Publications Office of the European Union [Online]. Available https://publications.jrc.ec.europa.eu/repository/handle/JRC107918 [8 March 2020].

Cois, A. & Day, C. (2015). Obesity trends and risk factors in the South African adult population. *BMC Obes,* 2, 42.

Colabianchi, N., Antonakos, C. L., Coulton, C. J., et al. (2021). The role of the built environment, food prices and neighborhood poverty in fruit and vegetable consumption: An instrumental variable analysis of the moving to opportunity experiment. *Health Place,* 67, 102491.

Costa, B. V. L., Menezes, M. C., Oliveira, C. D. L., et al. (2019). Does access to healthy food vary according to socioeconomic status and to food store type? An ecologic study. *BMC Public Health,* 19, 775.

Crush, J., Frayne, B. & McLachlan, M. (2011). *Rapid urbanization and the nutrition transition in Southern African.,* Kingston and Cape Town: Queen's University and AFSUN. [Online]. Available https://www.fsnnetwork.org/sites/default/files/rapid_urbanization_and_the_nutrition.pdf [8 November 2019].

Dai, H., Alsalhe, T. A., Chalghaf, N., et al. (2020). The global burden of disease attributable to high body mass index in 195 countries and territories, 1990-2017: An analysis of the global burden of disease study. *PLoS Med,* 17, e1003198.

Darmon, N., Darmon, M., Maillot, M., et al. (2005). A nutrient density standard for vegetables and fruits: Nutrients per calorie and nutrients per unit cost. *J Am Diet Assoc,* 105, 1881-7.

Darmon, N. & Drewnowski, A. (2008). Does social class predict diet quality? *Am J Clin Nutr,* 87, 1107-1117.

Darmon, N. & Drewnowski, A. (2015). Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: A systematic review and analysis. *Nutr Rev,* 73, 643-660.

De Bruin, E. & Gresse, A. (2018). Dietary diversity amongst adults who buy at shopping malls in the Nelson Mandela Bay area. *J Consum Sci, Special Edition Food and nutrition challenges in Southern Africa,* 3, 11-21.

De Oliveira Otto, M. C., Anderson, C. A. M., Dearborn, J. L., et al. (2018). Dietary diversity: Implications for obesity prevention in adult populations: A science advisory from the American Heart Association. *Circulation,* 138, e160-e168.

De Oliveira Otto, M. C., Padhye, N. S., Bertoni, A. G., et al. (2015). Everything in moderation - dietary diversity and quality, central obesity, and risk of diabetes. *PLoS One,* 10, e0141341.

De Ridder, D., Kroese, F., Evers, C., et al. (2017). Healthy diet: Health impact, prevalence, correlates, and interventions. *Psychol Health,* 32, 907-941.

Doglikuu, B.-I. D., Abubakari, A., Yaseri, M., et al. (2021). Association of household socioeconomic status, neighborhood support system and adherence to dietary recommendation among persons with T2DM, a facility-based cross-sectional study in Ghana. *BMC Public Health,* 21, 911.

Downs, S. & Demmler, K. M. (2020). Food environment interventions targeting children and adolescents: A scoping review. *Glob Food Secur,* 27, 100403.

Drake, I., Sonestedt, E., Ericson, U., et al. (2018). A Western dietary pattern is prospectively associated with cardio-metabolic traits and incidence of the metabolic syndrome. *Br J Nutr,* 119, 1168-1176.

Drewnowski, A. (2009). Defining nutrient density: Development and validation of the Nutrient Rich Foods index. *J Am Coll Nutr,* 28, 421S-426S.

Drewnowski, A. (2010). The Nutrient Rich Foods index helps to identify healthy, affordable foods. *Am J Clin Nutr,* 91, 1095s-1101s.

Drewnowski, A. (2018). Nutrient density: Addressing the challenge of obesity. *Br J Nutr,* 120, S8-S14.

Drewnowski, A. (2022). Food insecurity has economic root causes. *Nat Food,* 3, 555-556.

Drewnowski, A., Amanquah, D. & Gavin-Smith, B. (2021). Perspective: How to develop nutrient profiling models intended for global use: A manual. *Adv Nutr,* 12, 609-620.

Drewnowski, A. & Fulgoni, V. L., 3rd (2014). Nutrient density: Principles and evaluation tools. *Am J Clin Nutr,* 99, 1223s-1228s.

Drewnowski, A. & Rehm, C. D. (2013). Vegetable cost metrics show that potatoes and beans provide most nutrients per penny. *PLoS One,* 8, e63277.

Drimie, S., Faber, M., Vearey, J., et al. (2013). Dietary diversity of formal and informal residents in Johannesburg, South Africa. *BMC Public Health,* 13, 911.

Du, Z. & Qin, Y. (2023). Dyslipidemia and cardiovascular disease: Current knowledge, existing challenges, and new opportunities for management strategies. *J Clin Med,* 12, 363.

Engler-Stringer, R., Le, H., Gerrard, A., et al. (2014). The community and consumer food environment and children's diet: A systematic review. *BMC Public Health,* 14, 522.

Fanelli Kuczmarski, M., Brewer, B. C., Rawal, R., et al. (2019). Aspects of dietary diversity differ in their association with atherosclerotic cardiovascular risk in a racially diverse US adult population. *Nutrients,* 11, 1034.

FANTA. (2016). *Nutrition assessment, counseling, and support (NACS): A user's guide-module 2: Nutrition assessment and classification, version 2.* Washington, DC: FHI 360/FANTA. [Online]. Available https://www.fantaproject.org/sites/default/files/resources/NACS-Users-Guide-Module2-May2016.pdf [15 February 2023].

FAO. (2002). The state of food insecurity in the world 2001. Rome: FAO. [Online]. Available https://www.fao.org/documents/card/en/c/62e4c9ae-f1e7-508e-8207-ff283a65d9ec [9 February 2019].

FAO. (2011). *Guidelines for measuring household and individual dietary diversity.* Rome: FAO. [Online]. Available https://www.fao.org/3/i1983e/i1983e00.pdf [28 February 2019].

FAO. (2016). *Influencing food environments for healthy diets.* Rome: FAO. [Online]. Available https://www.fao.org/3/i6484e/i6484e.pdf [20 February 2019].

FAO. (2022). *Hunger and food insecurity* [Online]. Available https://www.fao.org/hunger/en/ [1 December 2022].

FAO & WHO. (2019). *Sustainable healthy diets – guiding principle*s. Rome: FAO and WHO. [Online]. Available https://www.fao.org/3/ca6640en/ca6640en.pdf [13 April 2022].

FAO/WHO (1998). *Preparation and use of food-based dietary guidelines.* Geneva: FAO/WHO. [Online]. Available https://apps.who.int/iris/handle/10665/42051 [22 June 2022].

Farhangi, M. A. & Jahangiry, L. (2018). Dietary diversity score is associated with cardiovascular risk factors and serum adiponectin concentrations in patients with metabolic syndrome. *BMC Cardiovasc Disord,* 18, 68.

Feeley, A., Kahn, K., Twine, R., et al. (2011). Exploratory survey of informal vendor-sold fast food in rural South Africa. *S Afr J Clin Nutr,* 24, 199-201.

Feingold, K. R. (2020). Obesity and dyslipidemia. *In:* Feingold, K., Anawalt B, Blackman MR, et al., (ed.) *Endotext [Internet].* South Dartmouth (MA): MDText.com. [Online]. Available https://www.ncbi.nlm.nih.gov/books/NBK305895/ [14 February 2023].

Fitzpatrick, K., Greenhalgh-Stanley, N. & Ver Ploeg, M. (2016). The impact of food deserts on food insufficiency and snap participation among the elderly. *Am J Agric Econ,* 98, 19-40.

Ford, N. D., Patel, S. A. & Narayan, K. V. (2017). Obesity in low- and middle-income countries: Burden, drivers, and emerging challenges. *Annu Rev Public Health,* 38, 145-164.

Frank, T., Thow, A.-M., Ng, S. W., et al. (2021). A fit-for-purpose nutrient profiling model to underpin food and nutrition policies in South Africa. *Nutrients,* 13, 2584.

Friel, S., Hattersley, L., Ford, L., et al. (2015). Addressing inequities in healthy eating. *Health Promot Int,* 30, ii77-88.

Fulgoni, V. L., 3rd, Keast, D. R. & Drewnowski, A. (2009). Development and validation of the nutrient-rich foods index: A tool to measure nutritional quality of foods. *J Nutr,* 139, 1549-1554.

Gittelsohn, J., Kasprzak, C. M., Hill, A. B., et al. (2022). Increasing healthy food access for low-income communities: Protocol of the healthy community stores case study project. *Int J Environ Res Public Health,* 19, 690.

Glanz, K., Sallis, J. F., Saelens, B. E., et al. (2005). Healthy nutrition environments: Concepts and measures. *Am J Health Promot,* 19, 330-333.

Global Panel on Agriculture and Food Systems for Nutrition. (2016). *Food systems and diets: Facing the challenges of the 21st century*. London: Global Panel on Agriculture and Food Systems for Nutrition. [Online]. Available: http://glopan.org/sites/default/files/ForesightReport.pdf [13 April 2022].

Graudal, N., Jürgens, G., Baslund, B., et al. (2014). Compared with usual sodium intake, low- and excessive-sodium diets are associated with increased mortality: A meta-analysis. *Am J Hypertens,* 27, 1129-1137.

Grillo, A., Salvi, L., Coruzzi, P., et al. (2019). Sodium intake and hypertension. *Nutrients,* 11, 1970.

Gupta, S., Hawk, T., Aggarwal, A., et al. (2019). Characterizing Ultra-Processed Foods by Energy Density, Nutrient Density, and Cost. *Front Nutr,* 6, 70.

Gustafson, C. R., Kent, R. & Prate, M. R., Jr. (2018). Retail-based healthy food point-of-decision prompts (PDPs) increase healthy food choices in a rural, low-income, minority community. *PLoS One,* 13, e0207792.

Hallum, S. H., Hughey, S. M., Wende, M. E., et al. (2020). Healthy and unhealthy food environments are linked with neighbourhood socio-economic disadvantage: An innovative geospatial approach to understanding food access inequities. *Public Health Nutr,* 23, 3190-3196.

Haysom, G., Crush, J., & Caesar, M. (2017). No. 3: The urban food system of Cape Town, South Africa. Waterloo, ON, Canada: Hungry Cities Partnership. [Online]. Available https://scholars.wlu.ca/cgi/viewcontent.cgi?article=1016&context=hcp [8 October 2019]

Herforth, A., Arimond, M., Álvarez-Sánchez, C., et al. (2019). A global review of food-based dietary guidelines. *Adv Nutr,* 10, 590-605.

Herforth, A., Bai, Y., Venkat, A., et al. (2020). *Cost and affordability of healthy diets across and within countries.* Background paper for The State of Food Security and Nutrition in the World 2020. FAO Agricultural Development Economics Technical Study No. 9. Rome: FAO. [Online]. Available https://www.fao.org/3/cb2431en/cb2431en.pdf [29 September 2021].

Hill, J., Mchiza, Z., Fourie, J., et al. (2016). Consumption patterns of street food consumers in Cape Town. *J Fam Eco Consum Sci*, 1, 25-35.

HLPE. (2017). *Nutrition and food systems.* A report by the high level panel of experts on food security and nutrition of the committee on world food security. Rome: HLPE. [Online]. Available https://www.fao.org/3/i7846e/i7846e.pdf [30 August 2020].

Hombali, A. S., Solon, J. A., Venkatesh, B. T., et al. (2019). Fortification of staple foods with vitamin A for vitamin A deficiency. *Cochrane Database Syst Rev,* 5, Cd010068.

Igumbor, E. U., Sanders, D., Puoane, T. R., et al. (2012). "Big food," the consumer food environment, health, and the policy response in South Africa. *PLoS Med,* 9, e1001253.

Integrated Food Security Phase Classification (IPC). (2021). IPC South Africa acute food insecurity analysis September 2020 - March 2021. [Online]. Available https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_South_Africa_AcuteFoodInsec_2020Nov2021Mar_Report.pdf [4 July 2022].

Jayedi, A., Soltani, S., Motlagh, S. Z.-T., et al. (2022). Anthropometric and adiposity indicators and risk of type 2 diabetes: Systematic review and dose-response meta-analysis of cohort studies. *BMJ,* 376, e067516.

Kapoor, D., Iqbal, R., Singh, K., et al. (2018). Association of dietary patterns and dietary diversity with cardiometabolic disease risk factors among adults in South Asia: The CARRS study. *Asia Pac J Clin Nutr,* 27, 1332-1343.

Kesari A. & Noel J.Y. (2023). Nutritional Assessment. [Updated 2023 Apr 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing. [Online]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK580496 [14 August 2023].

Khonje, M. G. & Qaim, M. (2019). Modernization of African food retailing and (un)healthy food consumption. *Sustainability,* 11, 4306.

Khuluvhe, M. & Ganyaupfu, E. M. (2022). *Highest level of educational attainment in South Africa.* Pretoria: Department of Higher Education and Training. [Online]. Available https://www.dhet.gov.za/Planning%20Monitoring%20and%20Evaluation%20Coordination/Fact%20Sheet_Highest%20Level%20of%20Educational%20Attainment%20in%20South%20Africa%20-%20June%202022.pdf [1 March 2023].

Kwate, N. O., Yau, C. Y., Loh, J. M., et al. (2009). Inequality in obesigenic environments: Fast food density in New York city. *Health Place,* 15, 364-373.

Labadarios, D., Steyn, N. & Nel, J. (2011). How diverse is the diet of adult South Africans? *Nutr J,* 10, 33.

Lagström, H., Halonen, J. I., Kawachi, I., et al. (2019). Neighborhood socioeconomic status and adherence to dietary recommendations among Finnish adults: A retrospective follow-up study. *Health Place,* 55, 43-50.

Laraia, B. A., Leak, T. M., Tester, J. M., et al. (2017). Biobehavioral factors that shape nutrition in low-income populations: A narrative review. *Am J Prev Med,* 52, S118-s126.

Larson, N., Story, M. T. & Nelson, M. C. (2009). Neighborhood environments: Disparities in access to healthy foods in the U.S. *Am J Prev Med,* 36, 74-81.

Lavie, C. J., Pandey, A., Lau, D. H., et al. (2017). Obesity and atrial fibrillation prevalence, pathogenesis, and prognosis: Effects of weight loss and exercise. *J Am Coll Cardiol,* 70, 2022-2035.

Laxy, M., Malecki, K. C., Givens, M. L., et al. (2015). The association between neighborhood economic hardship, the retail food environment, fast food intake, and obesity: Findings from the survey of the health of Wisconsin. *BMC Public Health,* 15, 237.

Lee, J. J., Hwang, S.-J., Mutalik, K., et al. (2017). Association of built environment characteristics with adiposity and glycaemic measures. *Obes Sci Pract,* 3, 333-341.

Lewis, M., Mcnaughton, S. A., Rychetnik, L., et al. (2020). A systematic scoping review of the habitual dietary costs in low socioeconomic groups compared to high socioeconomic groups in Australia. *Nutr J,* 19, 139.

Liang, S., Mijatovic, J., Li, A., et al. (2023). Dietary patterns and non-communicable disease biomarkers: A network meta-analysis and nutritional geometry approach. *Nutrients,* 15, 76.

Libman, K., Freudenberg, N., Sanders, D., et al. (2015). The role of urban food policy in preventing diet-related non-communicable diseases in Cape Town and New York. *Public Health,* 129, 327-335.

López-Olmedo, N., Popkin, B. M. & Taillie, L. S. (2018). The socioeconomic disparities in intakes and purchases of less-healthy foods and beverages have changed over time in urban Mexico. *J Nutr,* 148, 109-116.

Love, P. & Sayed, N. (2001). Eat plenty of vegetables and fruits everyday – technical support paper for South African food-based dietary guidelines. *S Afr J Clin Nutr,* 14, S24-S32.

Løvhaug, A. L., Granheim, S. I., Djojosoeparto, S. K., et al. (2022). The potential of food environment policies to reduce socioeconomic inequalities in diets and to improve healthy diets among lower socioeconomic groups: An umbrella review. *BMC Public Health,* 22, 433.

Maila, G., Audain, K. & Marinda, P. A. (2021). Association between dietary diversity, health and nutritional status of older persons in rural Zambia. *S Afr J Clin Nutr,* 34, 34-39.

Maillot, M., Darmon, N., Darmon, M., et al. (2007). Nutrient-dense food groups have high energy costs: An econometric approach to nutrient profiling. *J Nutr,* 137, 1815-1820.

Marmot, M. & Bell, R. (2019). Social determinants and non-communicable diseases: Time for integrated action. *BMJ,* 364, l251.

Martin-Prevel, Y., Allemand, P., Wiesmann, D., et al. (2015). *Moving forward on choosing a standard operational indicator of women's dietary diversity*. Rome: FAO. [Online]. Available http://www.fao.org/3/a-i4942e.pdf [26 October 2019].

Masojada, M. (2021). *The South African retail landscape* [Online]. Available https://openbooks.uct.ac.za/uct/catalog/download/29/43/1402?inline=1 [15 February 2023].

Mayén, A.-L., Marques-Vidal, P., Paccaud, F., et al. (2014). Socioeconomic determinants of dietary patterns in low- and middle-income countries: A systematic review. *Am J Clin Nutr,* 100, 1520-1531.

Mayén, A. L., Stringhini, S., Ford, N. D., et al. (2016). Socioeconomic predictors of dietary patterns among Guatemalan adults. *Int J Public Health,* 61, 1069-1077.

Mayosi, B. M., Flisher, A. J., Lalloo, U. G., et al. (2009). The burden of non-communicable diseases in South Africa. *Lancet,* 374, 934-947.

McLachlan, M. & Landman, A. P. (2013). *Nutrition-sensitive agriculture – A South African perspective. Food Secur*, 5, 857-871.

Micklesfield, L. K., Pedro, T. M., Kahn, K., et al. (2014). Physical activity and sedentary behavior among adolescents in rural South Africa: Levels, patterns and correlates. *BMC Public Health,* 14, 40.

Minaker, L. M., Shuh, A., Olstad, D. L., et al. (2016). Retail food environments research in Canada: A scoping review. *Can J Public Health,* 107, 5344.

Mirmiran, P., Azadbakht, L., Esmaillzadeh, A., et al. (2004). Dietary diversity score in adolescents - a good indicator of the nutritional adequacy of diets: Tehran lipid and glucose study. *Asia Pac J Clin Nutr,* 13, 56-60.

Monsivais, P. & Drewnowski, A. (2007). The rising cost of low-energy-density foods. *J Am Diet Assoc,* 107, 2071-2076.

Mozaffarian, D. (2016). Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: A comprehensive review. *Circulation,* 133, 187-225.

Msambichaka, B., Eze, I. C., Abdul, R., et al. (2018). Insufficient fruit and vegetable intake in a low- and middle-income setting: A population-based survey in semi-urban Tanzania. *Nutrients,* 10, 222.

Muthuri, S. K., Wachira, L. J., Leblanc, A. G., et al. (2014). Temporal trends and correlates of physical activity, sedentary behaviour, and physical fitness among school-aged children in Sub-Saharan Africa: A systematic review. *Int J Environ Res Public Health,* 11, 3327-3359.

Nair, M. K., Augustine, L. F. & Konapur, A. (2016). Food-based interventions to modify diet quality and diversity to address multiple micronutrient deficiency. *Front Public Health,* 3, 277.

NCD Risk Factor Collaboration (NCD-RisC). (2016). Trends in adult body-mass index in 200 countries from 1975 to 2014: A pooled analysis of 1698 population-based measurement studies with 19·2 million participants. *Lancet,* 387, 1377-1396.

NDoH. (2020). *National strategic plan for the prevention and control of non-communicable diseases 2020-2025*. [Online]. Available https://www.sancda.org.za/wp-content/uploads/2020/05/17-May-2020-South-Africa-NCD-STRATEGIC-PLAN_For-Circulation.pdf [8 March 2022].

NDoH, Stats SA, SAMRC, et al. (2019). *South Africa Demographic and Health Survey 2016.* Pretoria, South Africa, and Rockville, Maryland, USA: NDoH, Stats SA, SAMRC, and ICF. [Online]. Available https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf [29 March 2022].

Nielsen. (2016). *South Africa's not so traditional, traditional trade.* [Online]. Available http://www.nielsen.com/za/en/insights/reports/2016/south-africas-not-so-traditional-traditional-trade.html [12 June 2019].

Nnyepi, M. S., Gwisai, N., Lekgoa, M., et al. (2015). Evidence of nutrition transition in Southern Africa. *Proc Nutr Soc,* 74, 478-486.

Noubiap, J. J., Bigna, J. J., Nansseu, J. R., et al. (2018). Prevalence of dyslipidaemia among adults in Africa: A systematic review and meta-analysis. *Lancet Glob Health,* 6, e998-e1007.

Nuss, E. T., Arscott, S. A., Bresnahan, K., et al. (2012). Comparative intake of white-versus orange-colored maize by Zambian children in the context of promotion of biofortified maize. *Food Nutr Bull,* 33, 63-71.

Oikonomou, E., Psaltopoulou, T., Georgiopoulos, G., et al. (2018). Western dietary pattern is associated with severe coronary artery disease. *Angiology,* 69, 339-346.

Okop, K. J., Mukumbang, F. C., Mathole, T., et al. (2016). Perceptions of body size, obesity threat and the willingness to lose weight among Black South African adults: A qualitative study. *BMC Public Health,* 16, 365.

Oldewage-Theron, W. H. & Kruger, R. (2008). Food variety and dietary diversity as indicators of the dietary adequacy and health status of an elderly population in Sharpeville, South Africa. *J Nutr Elder,* 27, 101-133.

Oldewage-Theron, W. & Kruger, R. (2011). Dietary diversity and adequacy of women caregivers in a peri-urban informal settlement in South Africa. *Nutrition,* 27, 420-427.

Osei-Assibey, G., Dick, S., Macdiarmid, J., et al. (2012). The influence of the food environment on overweight and obesity in young children: A systematic review. *BMJ Open,* 2, e001538.

Pechey, R., Jebb, S. A., Kelly, M. P., et al. (2013). Socioeconomic differences in purchases of more vs. less healthy foods and beverages: Analysis of over 25,000 British households in 2010. *Soc Sci Med,* 92, 22-26.

Pechey, R. & Monsivais, P. (2016). Socioeconomic inequalities in the healthiness of food choices: Exploring the contributions of food expenditures. *Prev Med,* 88, 203-209.

Pestoni, G., Riedl, A., Breuninger, T. A., et al. (2021). Association between dietary patterns and prediabetes, undetected diabetes or clinically diagnosed diabetes: Results from the KORA FF4 study. *Eur J Nutr,* 60, 2331-2341.

Petersen, L. M., Charman, A. & Kroll, F. (2017). Trade dynamics in Cape Town township informal foodservice – a qualitative and supply chain study. *Dev South Afr,* 35, 70-89.

Pietermaritzburg Economic Justice & Dignity Group (PMBEJD). (2023). *Household affordability index February 2023*. [Online]. Available https://pmbejd.org.za/wp-content/uploads/2023/02/February-2023-Household-Affordability-Index-PMBEJD_28022023.pdf [10 March 2023].

Popkin, B. M. (2015). Nutrition transition and the global diabetes epidemic. *Curr Diab Rep,* 15, 64.

Popkin, B. M. & Ng, S. W. (2022). The nutrition transition to a stage of high obesity and noncommunicable disease prevalence dominated by ultra-processed foods is not inevitable. *Obes Rev,* 23, e13366.

Powell, L. M., Chaloupka, F. J. & Bao, Y. (2007a). The availability of fast-food and full-service restaurants in the United States: Associations with neighborhood characteristics. *Am J Prev Med,* 33, S240-245.

Powell, L. M., Slater, S., Mirtcheva, D., et al. (2007b). Food store availability and neighborhood characteristics in the United States. *Prev Med,* 44, 189-195.

Prättälä, R., Hakala, S., Roskam, A.-J. R., et al. (2009). Association between educational level and vegetable use in nine European countries. *Public Health Nutr,* 12, 2174-2182.

Pretorius, S. & Sliwa, K. (2011). Perspectives and perceptions on the consumption of a healthy diet in Soweto, an urban African community in South Africa a healthy diet in Soweto. *SA Heart,* 8, 178-183.

Rathnayake, K. M., Madushani, P. & Silva, K. (2012). Use of dietary diversity score as a proxy indicator of nutrient adequacy of rural elderly people in Sri Lanka. *BMC Res Notes,* 5, 469.

Reardon, T., Tschirley, D., Liverpool-Tasie, L. S. O., et al. (2021). The processed food revolution in African food systems and the double burden of malnutrition. *Glob Food Secur,* 28, 100466.

Rehm, C. D., Monsivais, P. & Drewnowski, A. (2015). Relation between diet cost and healthy eating index 2010 scores among adults in the United States 2007-2010. *Prev Med,* 73, 70-75.

Reitsma, M. B., Kendrick, P. J., Ababneh, E., et al. (2021). Spatial, temporal, and demographic patterns in prevalence of smoking tobacco use and attributable disease burden in 204 countries and territories, 1990-2019: A systematic analysis from the global burden of disease study 2019. *Lancet,* 397, 2337-2360.

Ren, Y., Castro Campos, B., Peng, Y., et al. (2021). Nutrition transition with accelerating urbanization? Empirical evidence from rural China. *Nutrients,* 13, 921.

Rippe, J. M. & Angelopoulos, T. J. (2016). Relationship between added sugars consumption and chronic disease risk factors: Current understanding. *Nutrients,* 8, 697.

Rippin, H. L., Hutchinson, J., Greenwood, D. C., et al. (2020). Inequalities in education and national income are associated with poorer diet: Pooled analysis of individual participant data across 12 European countries. *PLoS One,* 15, e0232447.

Robitaille, É. & Paquette, M. C. (2020). Development of a method to locate deserts and food swamps following the experience of a region in Quebec, Canada. *Int J Environ Res Public Health,* 17, 3359.

Ronquest-Ross, L.-C., Vink, N. & Sigge, G. (2015). Food consumption changes in South Africa since 1994. *S Afr J Sci,* 111, 1-12.

Roos, J. A., Ruthven, G. A., Lombard, M. J., et al. (2013). Food availability and accessibility in the local food distribution system of a low-income, urban community in Worcester, in the Western Cape Province. *S Afr J Clin Nutr,* 26, 194-200.

Ruel, M. T. (2003). Operationalizing dietary diversity: A review of measurement issues and research priorities. *J Nutr,* 133, 3911S-3926S.

Saha, S., Abu, B., Oldewage-Theron, W., et al. (2019). Available food options at local shops in relation to food insecurity among older adults in Sharpeville, South Africa. *Afr J Food Agric Nutr Dev,* 19, 14500-14516.

Salehi-Abargouei, A., Akbari, F., Bellissimo, N., et al. (2016). Dietary diversity score and obesity: A systematic review and meta-analysis of observational studies. *Eur J Clin Nutr,* 70**,** 1-9.

Savy, M., Martin-Prével, Y., Traissac, P., et al. (2006). Dietary diversity scores and nutritional status of women change during the seasonal food shortage in rural Burkina Faso. *J Nutr,* 136, 2625-2632.

Schönfeldt, H., Hall, N. & Bester, M. (2013). Relevance of food-based dietary guidelines to food and nutrition security: A South African perspective. *Nutr Bull,* 38, 226-235.

Schulze, M. B., Martínez-González, M. A., Fung, T. T., et al. (2018). Food based dietary patterns and chronic disease prevention. *BMJ,* 361, k2396.

Seligman, H. K., Davis, T. C., Schillinger, D., et al. (2010). Food insecurity is associated with hypoglycemia and poor diabetes self-management in a low-income sample with diabetes. *J Health Care Poor Underserved,* 21, 1227-1233.

Seligman, H. K. & Schillinger, D. (2010). Hunger and socioeconomic disparities in chronic disease. *N Engl J Med,* 363, 6-9.

Shih, M., Dumke, K. A., Goran, M. I., et al. (2013). The association between community-level economic hardship and childhood obesity prevalence in Los Angeles. *Pediatr Obes,* 8, 411-417.

Shisana, O., Labadarios, D., Rehle, T., et al. (2013). South African National Health and Nutrition Examination Survey (SANHANES-1). Cape Town: HSRC Press. [Online]. Available http://www.hsrc.ac.za/uploads/pageNews/72/SANHANES-launch%20edition%20(online%20version).pdf [19 January 2020].

Sierra, C. (2020). Hypertension and the risk of dementia. *Front Cardiovasc Med,* 7, 5.

Siqueira, K. B., Borges, C. A., Binoti, M. L., et al. (2021). Nutrient density and affordability of foods in Brazil by food group and degree of processing. *Public Health Nutr,* 24, 4564-4571.

Skinner, C. & Haysom, G. (2016). *The informal sector's role in food security: A missing link in policy debates? Working paper 44.* Cape Town: PLAAS, UWC and Centre of Excellence on Food Security. [Online]. Available https://repository.uwc.ac.za/handle/10566/4527 [13 August 2019].

Smith, L. C. & Haddad, L. (2015). Reducing child undernutrition: Past drivers and priorities for the post-MDG era. *World Dev,* 68, 180-204.

Spires, M., Delobelle, P., Sanders, D., et al. (2016). Diet-related non-communicable diseases in South Africa: Determinants and policy responses. *S Afr Health Rev,* 2016, 35-42.

Spronk, I., Kullen, C., Burdon, C., et al. (2014). Relationship between nutrition knowledge and dietary intake. *Br J Nutr,* 111, 1713-1726.

Starck, C. S., Blumfield, M., Keighley, T., et al. (2021). Nutrient dense, low-cost foods can improve the affordability and quality of the New Zealand diet–A substitution modeling study. *Int J Environ Res Public Health,* 18, 7950.

Stats SA. (2020). *Measuring food security in South Africa: Applying the food insecurity experience scale*. [Online]. Available http://www.statssa.gov.za/publications/Report-03-00-19/Report-03-00-192020.pdf.[28 February 2023].

Stats SA. (2021). *General household survey 2021*. Pretoria: Stats SA. [Online]. Available https://www.statssa.gov.za/publications/P0318/P03182021.pdf [21 November 2022]

Stats SA. (2023). *Incidence of long-term unemployment among women is higher than the national average.* [Online]. Available https://www.statssa.gov.za/?p=16113 [27 March 2023].

Steyn, N. & Labadarios, D. (2011). Street foods and fast foods: How much do South Africans of different ethnic groups consume? *Ethn Dis,* 21, 462-466.

Steyn, N., Labadarios, D. & Nel, J. (2011). Factors which influence the consumption of street foods and fast foods in South Africa - A national survey. *Nutr J,* 10, 104.

Steyn, N. P. & Ochse, R. (2013). "Enjoy a variety of foods": As a food-based dietary guideline for South Africa. *S Afr J Clin Nutr,* 26, S13-S17.

Steyn, N. P., Nel, J. H., Nantel, G., et al. (2006). Food variety and dietary diversity scores in children: Are they good indicators of dietary adequacy? *Public Health Nutr,* 9, 644-650.

Steyn, N. P., Wolmarans, P., Nel, J. H., et al. (2008). National fortification of staple foods can make a significant contribution to micronutrient intake of South African adults. *Public Health Nutr,* 11, 307-313.

Sulla, V. & Zikhali, P. (2018). *Overcoming poverty and inequality in South Africa: An assessment of drivers, constraints and opportunities*. Washington: International Bank for Reconstruction and Development/The World Bank. [Online]. Available https://documents1.worldbank.org/curated/en/530481521735906534/pdf/Overcoming-Poverty-and-Inequality-in-South-Africa-An-Assessment-of-Drivers-Constraints-and-Opportunities.pdf [3 February 2023].

Sushil, Z., Vandevijvere, S., Exeter, D. J., et al. (2017). Food swamps by area socioeconomic deprivation in New Zealand: A national study. *Int J Public Health,* 62, 869-877.

Swinburn, B., Sacks, G., Vandevijvere, S., et al. (2013). INFORMAS (International Network For Food And Obesity/non-communicable diseases Research, Monitoring and Action Support): Overview and key principles. *Obes Rev,* 14, 1-12.

Tapsell, L. C., Neale, E. P., Satija, A., et al. (2016). Foods, nutrients, and dietary patterns: Interconnections and implications for dietary guidelines. *Adv Nutr,* 7, 445-454.

Tavakoli, S., Dorosty-Motlagh, A. R., Hoshiar-Rad, A., et al. (2016). Is dietary diversity a proxy measurement of nutrient adequacy in Iranian elderly women? *Appetite,* 105, 468-476.

Temple, N. J. & Steyn, N. P. (2011). The cost of a healthy diet: A South African perspective. *Nutrition,* 27, 505-508.

Temple, N. J., Steyn, N. P., Fourie, J., et al. (2011). Price and availability of healthy food: A study in rural South Africa. *Nutrition,* 27, 55-58.

Tokunaga, M., Takahashi, T., Singh, R., et al. (2012). Diet, nutrients and noncommunicable diseases. *Open Nutraceuticals J,* 5, 146-159.

Turner, C., Aggarwal, A., Walls, H., et al. (2018). Concepts and critical perspectives for food environment research: A global framework with implications for action in low- and middle-income countries. *Glob Food Secur,* 18, 93-101.

UN-Habitat. (2021). *South Africa* [Online]. Available https://unhabitat.org/south-africa#:~:text=The%20Republic%20of%20South%20Africa,to%20around%2080%25%20by%202050. [22 February 2023].

Vadiveloo, M., Dixon, L. B. & Parekh, N. (2013). Associations between dietary variety and measures of body adiposity: A systematic review of epidemiological studies. *Br J Nutr,* 109, 1557-1572.

Van der Berg, S., Patel, L. & Bridgman, G. (2022). Food insecurity in South Africa: Evidence from NIDS-CRAM wave 5. *Dev South Afr,* 39, 722-737.

Van Liere M. J. & Curtis, V. (2018). How to get consumers to choose fruits, not fries. *Sight & Life,* 32, 113-118.

Ver Ploeg, M., Breneman, V., Farrigan, T., et al. (2009). *Access to affordable and nutritious food: Measuring and understanding food deserts and their consequences: Report to congress*. Administrative Publications 292130, United States Department of Agriculture, Economic Research Service. [Online]. Available https://www.ers.usda.gov/webdocs/publications/42711/12716_ap036_1_.pdf [18 October 2019]

Vlismas, K., Stavrinos, V. & Panagiotakos, D. B. (2009). Socio-economic status, dietary habits and health-related outcomes in various parts of the world: A review. *Cent Eur J Public Health,* 17, 55-63.

Vogel, C. (2018). *The contribution of the local food environment to the food choices of black urban adults in Mamelodi, Pretoria.* Unpublished Master's thesis in Consumer Science (Food Management). Pretoria: University of Pretoria.

Vorster, H., Badham, J. & Venter, C. (2013). 1. An introduction to the revised food-based dietary guidelines for South Africa. *S Afr J Clin Nutr,* 26(S), S5-S12.

Vorster, H. H., Kruger, A. & Margetts, B. M. (2011). The nutrition transition in Africa: Can it be steered into a more positive direction? *Nutrients,* 3, 429-441.

Vorster, H. H., Kruger, A., Venter, C. S., et al. (2007). Cardiovascular disease risk factors and socio-economic position of Africans in transition: The THUSA study. *Cardiovasc J Afr,* 18, 282-289.

Wajngarten, M. & Silva, G. S. (2019). Hypertension and stroke: Update on treatment. *Eur Cardiol,* 14, 111-115.

Walsh, C. & van den Berg, L. (2022). The nutritional status of South African adults: A review of the literature published from 1997–2019 (narrative review based on reference tables). NDoH & DSI-NRF Center of Excellence in Food Security (2022) (eds.). *Foods procured, Nutritional status and Dietary Intake of People Living in South Africa: Desktop review.* Pretoria: National Department of Health, South Africa, 216-229.

Wang, J., Engler-Stringer, R., Muhajarine, N., et al. (2016). Assessing the consumer food environment in restaurants by neighbourhood distress level across Saskatoon, Saskatchewan. *Can J Diet Pract Res,* 77, 9-16.

Weldegiorgis, M. & Woodward, M. (2020). The impact of hypertension on chronic kidney disease and end-stage renal disease is greater in men than women: A systematic review and meta-analysis. *BMC Nephrol,* 21, 506.

Wenhold, F., Annandale, J., Faber, M., et al. (2012). Water use and nutrient content of crop and animal food products for improved household security: A scoping study. *WRC Report No. 2012TT 537/12.* Pretoria: Water Research Commission.

Wentzel-Viljoen, E., Lee, S., Laubscher, R., et al. (2018). Accelerated nutrition transition in the North West Province of South Africa: Results from the prospective urban and rural epidemiology (PURE-NWP-SA) cohort study, 2005 to 2010. *Public Health Nutr,* 21, 2630-2641.

WHO. (2011). *Nutrient profiling: Report of a WHO/IASO technical meeting*. London, United Kingdom: WHO. [Online]. Available https://apps.who.int/nutrition/publications/profiling/WHO_IASO_report2010.pdf?ua=1 [3 September 2021].

WHO. (2014). *Global status report on Noncommunicable Diseases 2014.* Geneva: WHO. [Online]. Available https://apps.who.int/iris/handle/10665/148114 [21 July 2019].

WHO. (2016). *Report on the status of major health risk factors for noncommunicable diseases: WHO African Region, 2015.* WHO Regional Office for Africa. [Online]. Available https://www.afro.who.int/sites/default/files/2017-06/15264_who_afr-situation-ncds-15-12-2016-for-web_0.pdf [6 February 2023].

WHO. (2018a). *Non-communicable diseases (NCD) country profiles* [Online]. Available: https://www.who.int/nmh/publications/ncd-profiles-2018/en/ [28 March 2022].

WHO. (2018b). Fact sheet: Healthy diet. [Online]. Available www.who.int/news-room/fact-sheets/detail/healthy-diet [9 March 2019].

WHO. (2020a). *Framework for the implementation of the global action plan on physical activity 2018-2030 in the who African region* [Online]. Available https://www.afro.who.int/sites/default/files/2020-10/AFR-RC70-

10%20Framework%20for%20the%20implementation%20of%20the%20GAPPA.pdf [6 February 2023].

WHO. (2020b). *Healthy diet* [Online]. Available https://www.who.int/news-room/fact-sheets/detail/healthy-diet [8 December 2022].

WHO. (2021a). *Malnutrition* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/malnutrition#:~:text=There%20are%204%20broad%20sub,deficiencies%20in%20vitamins%20and%20minerals. [8 December 2022].

WHO. (2021b). *Obesity and overweight* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight [6 June 2022].

WHO. (2022a). *Noncommunicable diseases* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases [20 January 2023].

WHO. (2022b). *Noncommunicable diseases progress monitor 2022*. Geneva: WHO. Available https://www.who.int/publications/i/item/9789240047761 [17 January 2023]

WHO. (2022c). *Physical activity* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/physical-activity [6 February 2023].

WHO. (2022d). *Tobacco* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/tobacco [6 February 2023].

WHO. (2022e). *Alcohol* [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/alcohol#:~:text=Overall%2C%205.1%25%20of%20the%20global,adjusted%20life%20years%20(DALYs). [8 December 2022].

WHO. (2023a). *Blood pressure/hypertension* [Online]. Available https://www.who.int/data/gho/indicator-metadata-registry/imr-details/3155#:~:text=Worldwide%2C%20raised%20blood%20pressure%20is,or%203.7%25%20of%20total%20DALYS. [7 February 2023].

WHO. (2023b). *Hypertension* [Online]. Available https://www.who.int/news-room/fact-sheets/detail/hypertension [7 February 2023]

WHO. (2023c). *Raised cholesterol* [Online]. Available https://www.who.int/data/gho/indicator-metadata-registry/imr-details/3236#:~:text=Globally%2C%20a%20third%20of%20ischaemic,or%202%25%20of%20total%20DALYS. [8 February 2023].

WHO. (2023d). *WHO global report on sodium intake reduction*. Geneva: WHO. Available https://www.who.int/publications/i/item/9789240069985 [18 June 2023].

WHO/UNICEF. (2021). *Indicators for assessing infant and young child feeding practices: definitions and measurement methods*. Geneva: WHO and UNICEF. Available https://www.who.int/publications/i/item/9789240018389 [18 June 2023].

Wills, G., Patel, L., van der Berg, S. et al. (2023). *Household resource flows and food poverty during South Africa's lockdown: Short-term policy implications for three channels of social protection.* [Online]. Available https://ssrn.com/abstract=4331504 [14 February 2023].

World Bank. (2018). *World development indicators database: Country profile - South Africa.* [Online]. Available http://databank.worldbank.org/data/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=ZAF [8 August 2019].

World Cancer Research Fund & American Institute for Cancer Research. 2018. *Diet, nutrition, physical activity and cancer: A global perspective. Continuous update project expert report 2018* [Online]. Available: https://www.wcrf.org/diet-activity-and-cancer/ [5 September 2022].

Zenk, S. N., Mentz, G., Schulz, A. J., et al. (2017). Longitudinal associations between observed and perceived neighborhood food availability and body mass index in a multiethnic urban sample. *Health Educ Behav,* 44, 41-51.

Zhang, Q., Chen, X., Liu, Z., et al. (2017). Diet diversity and nutritional status among adults in southwest China. *PLoS One,* 12, e0172406.

CHAPTER 3: METHODS

In this chapter, the study design and population used to answer the research questions about the four study objectives are presented. The study data analysis, reliability and validity, data management and ethical considerations are also described.

3.1 Study design, setting, and population.

The study design for the four objectives is displayed in Figure 3.1.

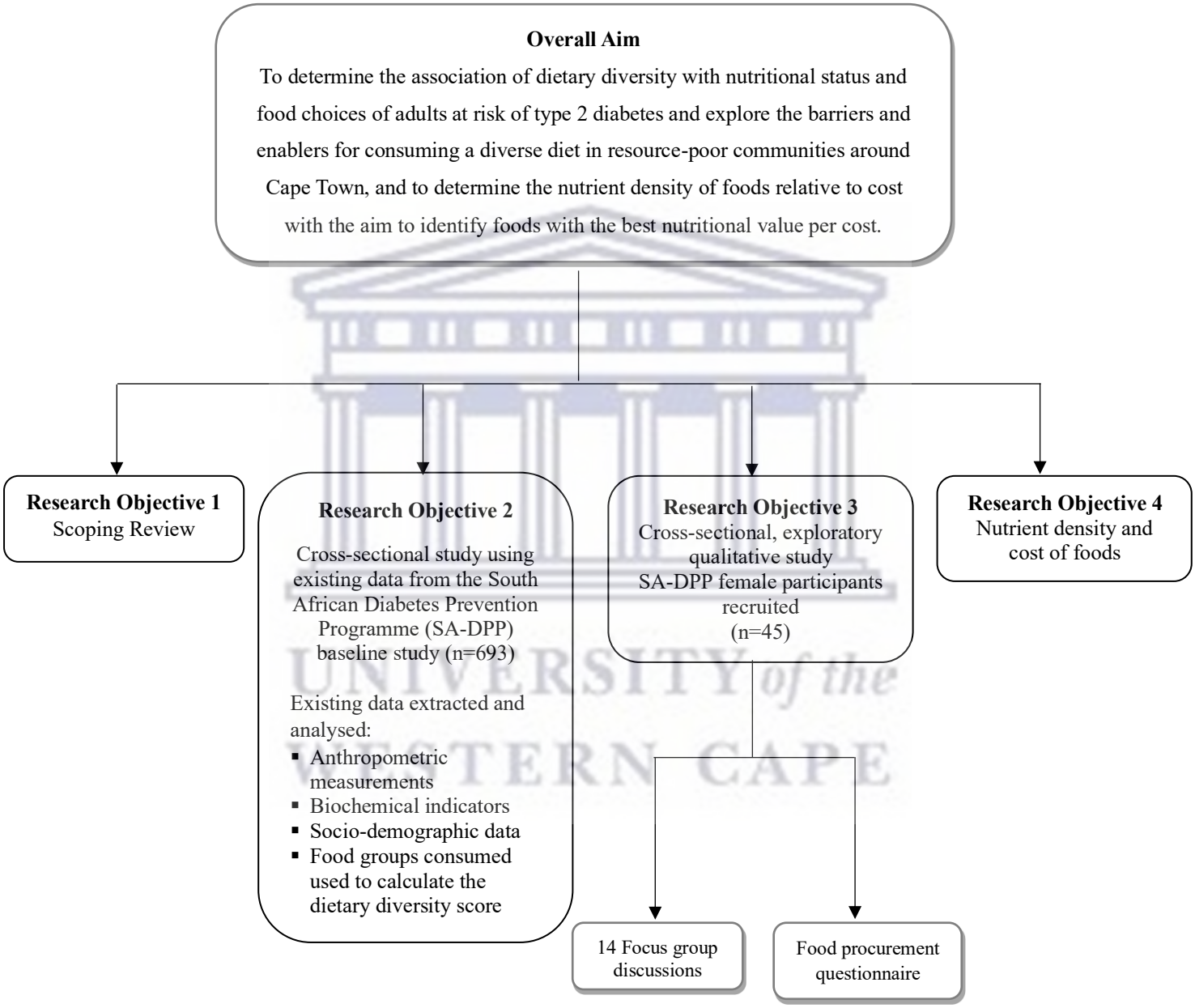


Figure 3.1 PhD Study design

3.1.1 First objective

Since there is limited evidence and knowledge on the association between adult food choices and the local retail food environment and the barriers and facilitators for healthy food access in the local retail food environment in resource-poor communities and neighbourhoods globally, a scoping review was conducted to provide an overview of the evidence. Included in the review was a total of 47 studies.

3.1.2 Second objective

A cross-sectional study using existing data from the SA-DPP baseline study was conducted for the second objective of this PhD. These data were collected from participants residing in 16 resource-poor communities in Cape Town, Western Cape Province, South Africa. Participants eligible for inclusion in the SA-DPP study were 700 adults aged 25-65 years old who were fluent in English or Afrikaans/IsiXhosa, able to give informed consent and willing to participate in the trial. Individuals with diabetes, bedridden, pregnant/breastfeeding, and those receiving either cancer or TB treatment (current or during the past three months) were excluded. The risk of T2DM during community-based risk screening was determined using the ADRS based on age, BMI, hypertension, and WC. Black participants with a ADRS >1.46 and Mixed ancestry participants with ADRS >1.15 were identified as high-risk for developing T2DM (Hill et al., 2020). Blood glucose tests were done during clinic-based screening for risk of T2DM. Fasting plasma glucose 6.1-7 mmol/L and 2-hour glucose load > 7.8-11.1 mmol/L (WHO,1999) were used to define risk for T2DM. Data of 693 participants was analysed, seven participants were excluded because of missing data.

The following data were extracted from the SA-DPP data set: Anthropometric measurements included weight (kg), height (cm), WC (cm) and HC (cm). BMI was calculated [weight (kg)/height $(m)^2$], and participants were categorised as either underweight (BMI < 18.5 kg/m^2), normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2) or obese (BMI ≥ 30 kg/m^2). The participant's WHR was calculated by dividing the WC by the HC. Biochemical indicators included FPG (mmol/l), 2-hour oral glucose tolerance test (OGTT) (mmol/L), HbA1c (%), serum total cholesterol (mmol/L), TG levels (mmol/L), HDL-C (mmol/L) and LDL-C (mmol/L).

Socio-demographic information extracted included age, sex, race, household income, household assets, occupation, education level, alcohol consumption, use of tobacco products and physical

activity level. The food groups consumed the previous day based on an unquantified 24-hour recall were used to calculate a DDS following the guidelines for the MDD-W score (FAO & FHI 360, 2016).

3.1.3 Third objective

The third objective was a cross-sectional exploratory study using a qualitative method. SA-DPP study female participants were purposively sampled from twelve community sites in Cape Town to participate in FGD to explore barriers and enablers for consuming a diverse diet. The twelve communities were Athlone, Bongweni, Bonteheuwel, Crossroads, Gugulethu, Harare, Heideveld, Lavender Hill, Lotus River, Mfuleni, Retreat and Samora. Eligible participants included SA-DPP female participants between 25-60 years and fluent in English/Afrikaans/IsiXhosa. A total of 45 participants (21 Mixed-ancestry and 24 Black females) between the ages of 31-62 years participated in the FGD. A short, structured food procurement questionnaire was also administered to the FGD participants to gather information on food purchasing practices. Food purchasing data was collected to support the FGD data and give more context on the participants' experiences.

3.1.4 Fourth objective

The fourth objective was a desktop study conducted to determine the cost, nutrient density, and nutrient density in relation to the cost of 116 food items. A food checklist based on the SA-FBDGs was created, and prices for the food items were collected from the websites of three national supermarkets. These food prices were limited to the Western Cape Province.

For a summary of study designs used across the four objectives, refer to Table 3.1

Table 3.1: Summary of study designs, sampling, data collection and analysis used across the four objectives.

	Objective 1	Objective 2	Objective 3	Objective 4
Title	Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review	Dietary diversity and its association with nutritional status, cardiometabolic risk factors and food choices of adults at risk for Type 2 diabetes mellitus in Cape Town, South Africa.	Perceived barriers and enablers for consuming a diverse diet in women residing in resource-poor communities in Cape Town, South Africa: a qualitative study.	Nutrient density and cost of commonly consumed foods: A South African perspective.
Objectives	To conduct a systematic scoping review to provide an overview of the evidence on adult food choices in association with the local retail food environment and food access in resource-poor communities.	To determine the relationship of DD with nutritional status (anthropometric status), cardiometabolic risk factors (plasma glucose levels and serum lipids) and food choices of adults at risk of type 2 diabetes (T2DM) in resource-poor communities around Cape Town.	To explore the barriers and enablers for consuming a diverse diet in resource-poor communities in Cape Town, South Africa.	To determine the nutrient density of foods relative to cost in South Africa, with the aim to identify foods within food groups with the best nutritional value per cost.
Study design	Scoping review	Cross-sectional	Exploratory qualitative study	Descriptive
Population / sample	Forty-seven studies published in English peer-reviewed journals, published from July 2005 to March 2022 examining local retail food environments and food access were included.	Data of 693 adults, 25–65 years old were analysed.	Twenty-one Mixed-ancestry and 24 Black female participants (n=45)	Checklist of 116 food items. Dietary data from the validation of the SA-DPP quantified food frequency questionnaire (unpublished data) was used to finalise checklist.

	Objective 1	Objective 2	Objective 3	Objective 4
Data collection	Conducted the review in accordance with the framework outlined by Arksey and O'Malley. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for scoping reviews as a guide.	The following data was extracted from the South African Diabetes Prevention Programme (SA-DPP) baseline dataset: anthropometric measurements, cardiometabolic biomarkers, socio-demographic information, 22 food groups based on an unquantified 24-hour recall, frequency of consumption over the past week for selected healthy and unhealthy foods.	Focus group discussions (FGD) were conducted using a semi-structured FGD guide. A short, structured questionnaire to gather information on food purchasing practices was administered to participants.	Retail food prices for the food items were obtained online from the websites of three national supermarkets. The South African Food Composition Tables were used to obtain energy and nutrient content values per 100 g edible portion.
Analysis	Study characteristics and findings were summarized for all studies and relevant themes summarised for qualitative and mixed method studies.	Descriptive data analysis was done describe socio-demographic characteristics of participants. Chi-square tests were performed to test for associations between categorical variables. Binary and multinomial logistic regression analyses were used to calculate odds ratios (OR) and 95% confidence intervals (95% CI) for the associations between DD independent variable, and dependent variables (anthropometric & cardiometabolic biomarkers). Potential confounders (age, gender, income, education level, alcohol consumption, use of tobacco products and activity level) were included in the analysis.	Audio recordings of the FGD were transcribed into English. The FGD transcripts were imported into Atlas.ti 9 software for data coding and analysis. Content analysis was used to analyse the FGD. A hybrid approach by combining the deductive and inductive approach to coding was performed. Food procurement questionnaire data were analysed using SPSS Windows version 27. Categorical variables are presented as counts and percentages.	The nutrient density for each of the food items was calculated using the Nutrient Rich Foods Index NRF9.3 model. The NRF9.3 index score was calculated per 100 kcal and per 100 g for each food item. The nutrient-to-price ratio (NPR) was calculated by dividing the NRF9.3 score to cost (ZAR) per 100 g and cost (ZAR) per 100 kcal. Descriptive analysis was done using IBM SPSS version 27. Continuous data were expressed as median and interquartile range. Analysis of variance (ANOVA) test was used to compare energy density, nutrient density, and NPR across food groups. The Tukey post hoc test was used to locate differences between food groups. Spearman correlation analysis was performed to assess the relationship

	Objective 1	Objective 2	Objective 3	Objective 4
				between the NRF9.3 score and the cost per 100 kcal of foods.

3.2 Reliability and validity

Objective one: To conduct a systematic scoping review to provide an overview of the evidence on adult food choices in association with the local retail food environment and food access in resource-poor communities.

A review protocol was developed using the Arksey and O'Malley framework (Arksey and O'Malley, 2005) and Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) extension for scoping review guidelines (Tricco et al., 2018). The PRISMA guidelines are a scientific evidence-based methodological system which is internationally recognised. The guidelines are beneficial in avoiding biases and ensuring quality reporting of research (Tricco et al., 2018).

The biases identified were selection bias, publishing bias and language bias. To address selection bias, exposures and outcomes were clearly defined; two reviewers independently screened titles, abstracts and full-text articles and extracted data. The Rayyan software was used in the screening process. This software allows for blind screening, thus reducing selection bias. Although only English articles were included, the literature shows that excluding non-English studies does not influence the findings of the reviews (Nussbaumer-Streit et al., 2020). Publication bias was addressed by reporting all relevant research findings, whether positive or negative. Continuous discussions were held between the candidate and the supervisors to review adherence to the study protocol. Pilot testing of the data extraction form was conducted on sub-samples of articles to ensure that relevant data were captured and ensuring consistency across reviewers.

Objective two: To determine the relationship of DD with nutritional status (anthropometric status), cardiometabolic risk factors (plasma glucose levels and serum lipids) and food choices of adults at risk of T2DM in resource-poor communities around Cape Town.

Content validity of the SA-DPP baseline data was ensured by using existing questionnaires from studies. For example, the socio-demographic questionnaire is based on the SANHANES-1 (Shisana et al., 2013). Face validity was tested to check for clarity of questions and the design of the questionnaire by consulting experts. Cultural validation was performed by testing translated questionnaires' appropriateness for the SA-DPP population through piloting. The dietary data for the SA-DPP were collected following the FAO guidelines for measuring DD (FAO & FHI 360, 2016). The DDS was based on the MDD-W, a validated proxy indicator for

micronutrient adequacy for women in resource-poor settings (FAO & FHI 360, 2016). Fieldworkers were trained to perform anthropometric measurements according to standard procedures (CDC, 2011).

Objective three: To explore the barriers and enablers for consuming a diverse diet in resource-poor communities in Cape Town, South Africa.

Face validity was tested to check for clarity of questions and design of the questionnaire and FGD guide by consulting experts. Cultural validation was performed by testing translated questionnaires' appropriateness for the study population through piloting. Reliability in qualitative research refers to trustworthiness established in these five concepts: credibility, transferability, confirmability, dependability and reflexivity (Leung, 2015). The reliability of the study was also increased by piloting the FGD guide on two focus groups. Credibility was ensured by having a facilitator of the FGD encourage participants to talk, ask follow-up questions and ask participants to support their statements by giving examples of experiences. Concerning the data analyses, credibility was increased by the researcher constantly reading and re-reading transcribed data and analysing and revising developed codes and concepts. Transferability was ensured by providing a detailed description of the participants and the research process.

Rigour is demonstrated by providing a detailed methodology and developing a codebook when performing the content analysis (Roberts et al., 2019). Peer-checking of inter-coder reliability was done during the piloting of the codebook to improve rigour. The candidate and supervisors continuously discussed the transcript coding, interpretations of the findings, and report writing. Error minimisation and bias control were achieved through this process. Confirmability was ensured by addressing potential biases; the researcher reduced these by keeping an audit trail of steps followed during the data collection and analysis, and a rationale was given for the decisions made. The dependability of the study was ensured by having the research procedure reviewed by the ethical committee and keeping an audit trail of all the research steps performed. Reflexivity was guaranteed by the researcher keeping a diary on data collection such as assumptions, preconceptions, and values and how these affect research decisions in phases of research (Korstjens and Moser, 2018). Regarding the short questionnaire, data quality assurance was ensured by reviewing questionnaires in real time to confirm any missing responses with the participant.

Objective four: To determine the nutrient density of foods relative to cost in South Africa by identifying foods within food groups with the best nutritional value per cost.

The food checklist was finalised using dietary data from a validation study of the SA-DPP. The NRF9.3 model has been validated against the United States Healthy Eating Index score (HEI 2005) (Fulgoni et al., 2009). The NRF models have also been tested in several other countries (Francou et al., 2015, O'Sullivan et al., 2015, Zhou et al., 2014).

3.3 Data management

The candidate entered food checklists and food procurement questionnaires into Microsoft Excel spreadsheets that were then converted to SPSS files for analysis. Data files were stored on password-protected computers. All questionnaire data were paper-based and stored in a locked file cabinet with access limited to the relevant research staff.

3.4 Ethical considerations

The baseline survey of the SA-DPP was approved by the ethics committee of the South African Medical Research Council (approval no. EC018-7/2015) (Appendix 1a). The SA-DPP study was carried out according to the ethical guidelines and principles of the International Declaration of Helsinki, 2013 (World Medical Association, 2013). The SA-DPP participants were informed of the study and what was expected of them by receiving an information sheet with a detailed explanation. For individuals who agreed to participate in the study, consent was obtained. Permission to use the SA-DPP baseline data was obtained from the principal investigator of the SA-DPP study (Appendix 1b).

The PhD research proposal was approved by the University of Western Cape Biomedical Research Ethics Committee (approval no. BM20/1/1). Ethical approval was granted on 14 February 2020 for three years (Appendix 1c). Because of possible delays in fieldwork caused by the COVID-19 pandemic, the third objective of the PhD study was amended. An amendment for the PhD proposal was sent to the Biomedical Science Research Ethics Committee of the University of the Western Cape (July 2020) and approved on 18 September 2020 for three years (Appendix 1d).

Participation in the qualitative study was voluntary. An information sheet was given to participants with a detailed explanation of what information the researcher would be collecting. The information sheet (Appendix 2) and consent form (Appendix 3) were translated into the

languages, Afrikaans and IsiXhosa, spoken by the participants. Participants were informed about the aim of the study, what their participation would entail, that participation was voluntary, and the potential risk and benefits of participation. Furthermore, they were assured that responses and questionnaires would be kept confidential and anonymous. Confidentiality and anonymity were ensured by allocating each participant with a unique code on their questionnaire and the FGD transcripts. Permission was requested from participants to audio record FGD sessions. The FGD audio recordings/responses were only used for analysis, and only anonymised extracts from the FGD were quoted in the thesis and any subsequent publications. The details of supermarkets will not appear in the study publication.

3.5 References

Arksey, H. & O'malley, L. (2005). Scoping studies: towards a methodological framework. *Int J Soc Res Methodol,* 8, 19-32.

CDC. (2011). *National Health and Nutrition Examination Survey: Anthropometry Procedures Manual*. [Online]. Available https://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/Anthropometry_Procedures_Manual.pdf [25 May 2019].

FAO & FHI 360. (2016). *Minimum Dietary Diversity for Women: A Guide for Measurement.* Rome: FAO. [Online]. Available http://www.fao.org/3/a-i5486e.pdf [20 February 2019].

Francou, A., Hebel, P., Braesco, V., et al. (2015). Consumption patterns of fruit and vegetable juices and dietary nutrient density among French children and adults. *Nutrients,* 7, 6073-6087.

Fulgoni, V. L., 3rd, Keast, D. R. & Drewnowski, A. (2009). Development and validation of the nutrient-rich foods index: a tool to measure nutritional quality of foods. *J Nutr,* 139, 1549-1554.

Hill, J., Peer, N., Jonathan, D., et al. (2020). Findings from community-based screenings for Type 2 Diabetes Mellitus in at risk communities in Cape Town, South Africa: A pilot study. *Int J Environ Res Public Health*, 17, 2876.

Korstjens, I. & Moser, A. (2018). Series: Practical guidance to qualitative research. Part 4: Trustworthiness and publishing. *Eur J Gen Pract,* 24, 120-124.

Leung, L. (2015). Validity, reliability, and generalizability in qualitative research. *J Family Med Prim Care,* 4, 324-327.

Nussbaumer-Streit, B., Klerings, I., Dobrescu, A. I., et al. (2020). Excluding non-English publications from evidence-syntheses did not change conclusions: A meta-epidemiological study. *J Clin Epidemiol,* 118, 42-54.

O'Sullivan, T. A., Bremner, A. P., Bremer, H. K., et al. (2015). Dairy product consumption, dietary nutrient and energy density and associations with obesity in Australian adolescents. *J Hum Nutr Diet,* 28, 452-464.

Roberts, K., Dowell, A. & Nie, J. B. (2019). Attempting rigour and replicability in thematic analysis of qualitative research data; a case study of codebook development. *BMC Med Res Methodol,* 19, 66.

Shisana, O., Labadarios, D., Rehle, T., et al. (2013). *South African National Health and Nutrition Examination Survey (SANHANES-1),* Cape Town: HSRC Press. [Online]. Available http://www.hsrc.ac.za/uploads/pageNews/72/SANHANES-launch%20edition%20(online%20version).pdf [19 January 2020].

Tricco, A. C., Lillie, E., Zarin, W., et al. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med,* 169, 467-473.

World Medical Association. (2013). World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA,* 310, 2191-2194.

Zhou, Z., Hu, W., Li, M., et al. (2014). Development and validation of a new model of desirable dietary pattern (N-DDP) score for Chinese diets. *Public Health Nutr,* 17, 519-528.

CHAPTER 4: MANUSCRIPT ONE

Chapter 4 was published as a peer-reviewed research article: Madlala, SS, Hill, J, Kunneke, E, Faber, M. Adult food choices in association with the local retail food environment and food access in resource-poor communities: A scoping review. *BMC Public Health,* 2023; 23**:**1083. https://doi.org/10.1186/s12889-023-15996-y

4.1 Summary

A scoping review of the research conducted on local retail food environments, food access and food choices of adults in resource-poor communities, published from July 2005 to March 2022, is presented in this paper. Since there is a lack of research on the relationship between adult food choices and local retail food environments and healthy food access in resource-poor communities, an overview of the evidence in this field among these communities is provided.

4.2 Contribution to the thesis

This paper contributes to the first objective of the thesis: To conduct a systematic scoping review to provide an overview of the evidence on adult food choices in association with the local retail food environment and food access in resource-poor communities. The results from this scoping review provide knowledge on barriers and facilitators for healthy food access in the local retail food environment of resource-poor communities, identify research gaps and can assist in making recommendations to improve food choices in lower-income groups.

4.3 Contribution of the candidate

The candidate, together with the supervisors, conceptualised the study. The candidate was responsible for drafting the scoping review protocol and submitting this for publication in the BMJ Open Journal. The published protocol is available in Appendix 4. The candidate was responsible for searching for literature in the databases and for screening selection, and data extraction of the studies with the second reviewer. The candidate was responsible for drafting the manuscript. All authors edited and gave input on the draft and approved the final version of the manuscript. The candidate led the submission process to the journal. The supplementary material (PRISMA-ScR Checklist) is provided in Appendix 5. The reviewer comments and author responses are available in Appendix 6. The protocol and preliminary results of this paper were presented by the candidate at the SAMRC's 14th Early Career Scientist Convention on 26–27 October 2020.

Madlala *et al. BMC Public Health* (2023) 23:1083
https://doi.org/10.1186/s12889-023-15996-y

BMC Public Health

RESEARCH Open Access

Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review

Samukelisiwe S. Madlala[1,2*], Jillian Hill[1], Ernesta Kunneke[3], Tatum Lopes[1,4] and Mieke Faber[1,3,5]

Abstract

Background There is a growing body of research on local retail food environments globally in both urban and rural settings. Despite this, little research has been conducted on adult food choices, local retail environments, and healthy food access in resource-poor communities. The purpose of this study is therefore to provide an overview of the evidence on adult food choices (measured as dietary intake) in association with the local retail food environment and food access in resource-poor communities (defined as low-income communities and/or households).

Methods We searched nine databases for studies published from July 2005 to March 2022 and identified 2426 records in the primary and updated search. Observational studies, empirical and theoretical studies, focused on adults ≤ 65 years, published in English peer-reviewed journals, examining local retail food environments and food access, were included. Two independent reviewers screened identified articles using the selection criteria and data extraction form. Study characteristics and findings were summarized for all studies and relevant themes summarized for qualitative and mixed methods studies.

Results A total of 47 studies were included in this review. Most studies were cross sectional (93.6%) and conducted in the United States of America (70%). Nineteen (40.4%) studies assessed the association between food choice outcomes and local retail food environment exposures, and evidence on these associations are inconclusive. Associations of certain food choice outcomes with healthy food retail environments were positive for healthy foods (in 11 studies) and unhealthy foods (in 3 studies). Associations of certain food choice outcomes with unhealthy retail food environment exposures were positive for unhealthy foods in 1 study and negative for healthy foods in 3 studies. In 9 studies, some of the food choice outcomes were not associated with retail food environment exposures. A healthy food store type and lower food prices were found to be major facilitators for healthy food access in resource-poor communities, while cost and transportation were the main barriers.

Conclusions More research is needed on the local retail food environment in communities in low- and middle-income countries to develop better interventions to improve food choices and access to healthy foods in resource-poor communities.

Keywords Food environment, Adults, Food choice, Food access, Resource-poor

*Correspondence:
Samukelisiwe S. Madlala
Samukelisiwe.Madlala@mrc.ac.za
Full list of author information is available at the end of the article

Background

Globally, poor diet is a primary risk factor for death and disability [1] and is responsible for various types of malnutrition [2]. In 2016, > 1.9 billion adults (39%) worldwide were overweight and of these 650 million (13%) were obese [3]. On the other side of the spectrum, an estimated 768 million people (10%) worldwide were undernourished and 928 million people (12%) were severely food insecure in 2020 [4]. Poor food systems and unhealthy food environments contribute to the high global prevalence of poor nutritional status [2].

Food choices are influenced by the various physical, economic, political and socio-cultural environments in which people live [5, 6]. The collective of these environments are referred to as the food environment, which reflects the context in which people acquire, prepare and consume foods [5, 7]. According to Glanz and colleagues, local food environments can be categorized into the community nutrition environment, consumer nutrition environment, and organizational nutrition environment [8]. The community nutrition environment refers to number, type, location and accessibility to food stores in a community. The consumer nutrition environment refers to the availability of healthy food choices, price, promotion, quality and placement of food items [8]. The community and consumer nutrition environments combined are referred to as the retail food environment [9]. The retail food environment can therefore be described as accessibility to local food stores and markets, and the availability and affordability of healthy foods in these stores and markets [8].

The five dimensions of the food environment, also known as the dimensions of food access include availability, accessibility, affordability, acceptability and accommodation [10]. In the context of the food environment, availability refers to the density (presence) of different types of food stores within a specific area such as census tracts or buffer zones [10, 11]. Accessibility refers to (i) geographic location of the food stores, defined as proximity which can be measured as travel time and distance to stores [10, 11], and (ii) diversity or variety of different types of food stores, such as supermarkets and fast food (FF) restaurants [12]. Affordability refers to purchasing power and food prices, measured by store audits or price indices [10]. Acceptability refers to people's attitudes on the characteristics of their local food environment, it can be measured as people's perception on quality of foods sold or as store audit food quality score [10]. Accommodation refers to how well the local retail food environment caters to residents' needs such as store operating hours and types of payment options offered to customers [10]. Perceptions on availability, accessibility affordability, acceptability and accommodation in the local retail food environment can also be measured [13].

Food choice is defined as the processes by which people consider, acquire, prepare, store, distribute, and consume foods and beverages [14]. Food choice is determined by individual and social factors, as well as physical and macro-level environments such as the food system [15]. Changes in the food environment due to changes in food supply and demand affect individuals' food choices [16]. Food environments therefore affect diet quality and dietary habits, and ultimately impact diet-related health outcomes [17–19]. In their review paper, Story and colleagues' reported that healthy retail food environments have been shown to be characterized by access to food stores such as supermarkets, grocery stores and farmers markets, and limited presence of FF restaurants in a community, and the availability of healthy affordable food products within stores [20]. A healthy food environment can lead to improved access to fruits and vegetables (FV), greater dietary diversity [21], and provision of healthier options of pre-packaged foods, prepared and readymade meals in different types of retail food stores [22].

The FAO defines food deserts as geographic areas where grocery stores, farmers markets and other healthy food providers are not located within a reasonable travelling distance of residents, restricting their access to healthy food [5]. Canadian studies described food swamps as geographic areas with access to retailers with healthy food options but also a large number of convenience stores, FF outlets and other outlets that sell predominantly unhealthy foods and beverages [23]. Access to healthy food is therefore restricted in food deserts, while unhealthy food is more readily available in food swamps. Food deserts or food swamps are most likely to occur in resource-poor areas [12, 23, 24]. In the United States of America (USA), a study on FF restaurants and convenience stores within close proximity to schools showed that that convenience stores and FF restaurants are most likely to be located in lower-income neighborhoods, and that convenience stores generally stock limited variety of foods, have high prices and stock foods of a lower quality [25]. Studies have shown that living in close proximity to FF restaurants [24] and greater access to convenience stores in comparison to supermarkets may reflect an unhealthy food environment [26].

Residing in a food desert has been associated with inadequate diets [27] and increased risk of obesity [28]. Resource-poor communities often lack access to healthy food such as fresh FV [29–31], and are more susceptible to poor nutrition and diet-related diseases because of their lack of access to healthy and affordable foods [32]. It has been reported that neighborhood deprivation is associated with inadequate dietary patterns [33], and that

people with low socioeconomic status (SES) have low quality diets as they consume more energy-dense and nutrient-poor foods [32]. For the purposes of this scoping review the terms community and neighborhoods are used interchangeably.

Research on the food environment is rapidly growing and several systematic reviews on different aspects of the food environment have been published. To date, systematic reviews focused mostly on the relationship of the local food environment with dietary outcomes and nutritional status [10, 34–38], childhood overweight and obesity [26, 39–43], FF access in food environments [44, 45], food purchasing and food environment [46], community and consumer food environment and children's diet [47–49], and the food environment in low- and middle-income countries [35, 50]. Despite the growing body of research, there is limited synthesis on the characteristics of the food environment that relate to food choices per se, particularly for adults residing in resource-poor communities [51, 52].

There is a greater need to understand the relationship between food environments and diets as government and policy makers are seeking interventions to combat the rise of obesity globally [6, 52]. Therefore, the aim of the scoping review is to provide an overview of the evidence on adult food choices in association with the local retail food environment and food access in resource-poor communities. The objectives of the scoping review are to 1) assess whether adult food choices are associated with the local retail food environment in resource-poor communities; and 2) determine the barriers and facilitators for healthy food access within the local retail food environment in resource-poor communities. Food choice in the context of this scoping review refers to dietary and food intake and pertains to diet scores, diet quality, FV intake, food group intake, salty, fatty, and sugary foods and SSB intake. We defined resource-poor communities as low-income communities/neighborhoods, disadvantaged communities/neighborhoods, and/or low-income/low socioeconomic position (SEP) households/individuals.

Methods

Study design

A scoping review of the literature on adult food choices in association with the local retail food environment and food access in resource-poor communities was conducted, following the scoping review framework outlined by Arksey and O'Malley [53]. A scoping review was conducted to scope the body of literature and to identify knowledge gaps on the topic. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for scoping reviews (PRISMA-ScR) [54] was used to guide the review process (see Additional file 1).

Registration and protocol

The protocol for this scoping review was registered on the Open Science Framework on 9 September 2020 (https://osf.io/shf93), and is available online [55].

Search strategy

The population, concept and context (PCC) framework was applied to inform the search strategy [56]. A systematic literature search of eight multidisciplinary databases and a research platform namely, PubMed/MEDLINE, CINAHL, Green FILE, PsycARTICLES, Social Science Research Network, Scopus, Science Direct, Web of Science and EBSCOhost was performed. Search keywords or medical subject headings (MeSH) were used. Details on the keywords and Mesh terms are described in the protocol [55]. The Boolean (AND, OR) method was used to combine search terms. The original search strategy was developed in PubMed/Medline and was adapted to the other databases (detailed search strategies are listed in Additional file 2). The main concepts searched were based on diet/food choice AND adult AND local retail food environment OR community OR consumer food environments AND resource poor AND food access AND store type. Date restrictions in the original search were set between 2005 and January 2021. The search was updated to include studies published between February 2021 and March 2022.

Inclusion criteria

This review included observational studies (cohort, cross-sectional, case–control and ecological studies) examining the association between adult food choices (outcome) and the local retail food environment and food access (exposures) in resource-poor communities, empirical and theoretical studies, studies including adults 18 – 65 years old, studies on the retail food environment, which includes the community and the consumer food environment, studies on food access, food choices and diets of adults in resource-poor communities and English peer-reviewed journal articles from July 2005 to March 2022 [55].

Exclusion criteria

Excluded studies were experimental studies (randomized control trials), systematic reviews, and meta-analysis, research not reported in peer-reviewed journals, studies examining the organizational food environment (home, school, and work) and information environment (television advertising), studies on children, pregnant women, and the elderly, studies that only focus on the food

environment and nutritional status, studies focusing on indirect measures of diet, such as food purchasing or the number of food store visits, research papers not written in English, and papers published before July 2005 [55]. After conducting the pilot study 'Other' and 'National study' were added as the eighth and nineth exclusion reason. 'Other' refers to papers that were irrelevant to the study but could not be classified under any of the listed exclusion criteria. 'National study' refers to studies for which results were reported at national level, with no distinction between groups or settings of different socio-economic status. After conducting the first round of full text article screening two more exclusion reasons were added: not reporting association between adult food choices and local retail food environment, and not reporting barriers and facilitators for healthy food access in resource-poor communities.

Screening

The primary database search was done for studies published between July 2005 and January 2021, which was updated through a second search to include studies published from February 2021 to March 2022 (see Fig. 1). Studies identified were exported to EndNoteX9 library, and duplicates were identified and removed. The primary database search identified 2132 studies, and after duplicates were removed 1583 records remained. Two reviewers (SSM and TL) independently screened the title and abstracts (TIABS). Of the 1583 TIABS screened, 165 were identified as eligible for full-text screening. The two reviewers independently read the full-text articles to determine whether they meet the eligibility criteria. Full-text screening for the primary database search was done in two rounds. In the first round of full-text screening, 165 articles were screened and 121 articles were deemed eligible. In the second round of screening, 121 articles were screened and 42 articles primary database search articles were eligible for inclusion in the scoping review. In the updated database search, 294 records were identified. After removing duplicates, 237 TIABS were screened. After screening TIABS, 10 articles were eligible for full-text screening. After full-text screening of the updated search results, five studies were deemed eligible for inclusion. Therefore, a total of 47 studies (42 articles from the primary search and five from the updated search) were included. Both TIABs and full-text article screening were performed on the Rayyan Qatar Computing Research Institute (QCRI) systematic reviews web application [57].

Data extraction

A data collection form based on the framework of Arksey and O'Malley [53] was used to obtain the following information from each study: name of authors, title, year of publication, aim/objective of the study, study area, study setting, study participants, sampling method, study design, data collection, measurement tools, data analysis, reported outcomes, most relevant findings, facilitators and barriers (see Additional file 3). The data extraction form was piloted on a sub-sample of 17 articles to ensure the form captures relevant data and ensures consistency between reviewers. The data extraction form was revised to improve capturing of study methods employed in the research. Interrater agreement was high (78%). The percent agreement for two raters was calculated as the number of agreements (full text articles included and excluded by both raters) divided by the sum of the number of agreements and the number of disagreements (conflicts) multiplied by 100 [58]. The calculation was as follows: $137 / (137+38) \times 100 = 78$. Disagreements were resolved through discussion between the two reviewers.

Study characteristics and findings were summarized for all studies, and relevant themes summarized for qualitative and mixed methods studies [53, 59]. We synthesized identified studies by dividing them into two groups 1) studies on the association between food choice and the local retail environment; and 2) studies reporting barrier and facilitators to healthy food access. Barriers and facilitators were further categorized by study design into quantitative, mixed method, and qualitative studies. Qualitative studies and mixed methods reporting relevant qualitative data were grouped together in tables. Quantitative data from mixed method studies were grouped in tables with quantitative data from non-mixed method studies.

Results

Overview of studies included

Forty-seven articles, published between 2006 and 2021, were eligible for inclusion in this review (see Table 1). Most (93.6%) of the studies were cross-sectional in design, except for two cohort studies and one ecological study. To examine the associations between local retail food environment and food choice and to describe barriers and facilitators to healthy food access in the local retail food environment, 23 studies used quantitative methods, nine used qualitative methods, and 15 used mixed methods. Approximately 70% ($n=33$) of studies were conducted in the USA, five in Australia, three in Brazil, three in Spain, one in Mexico, one in Netherlands and one in Canada (see Fig. 2). In total, 76.6% ($n=36$) of the studies were conducted in urban settings and 14.9% ($n=7$) in rural settings. The age of the participants in the studies ranged from 18 to 84 years. Studies were included if the mean age of participants was within the study inclusion criteria. Terms used to describe resource-poor

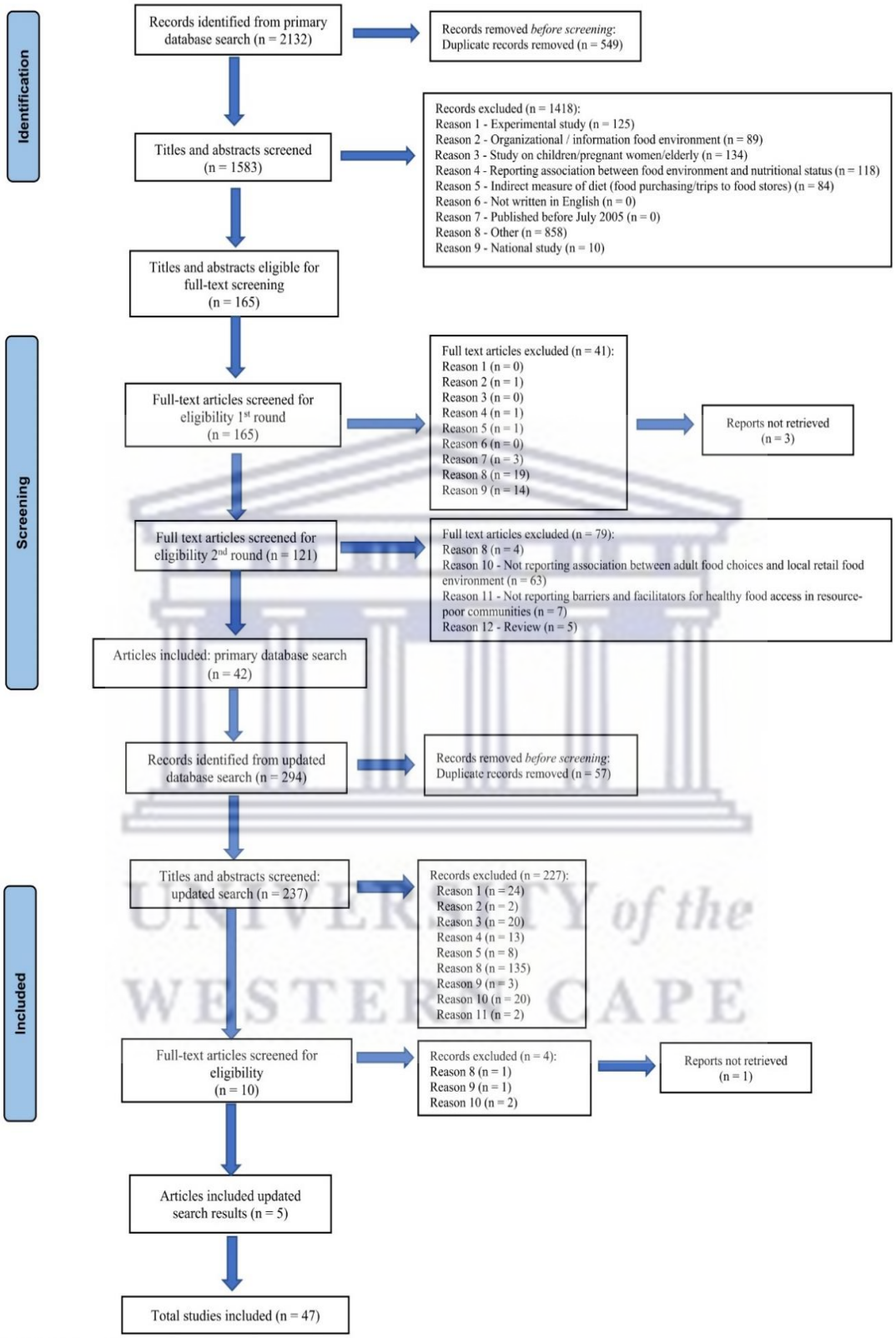


Fig. 1 PRISMA flow diagram of scoping review

Table 1 Characteristics of included studies ($n=47$)

Author (Year)	Location/ Country	Setting	Sample (n)	Study design	Methods				Food Environment Dimensions				
					GIS	Store audit/ Survey	Dietary questionnaire	Qualitative	Availability	Price	Accessibility	Affordability	Quality
Alkon et al. [60]	Oakland & Chicago, USA	Urban	$N=27$ adults (24 women & 3 men)	Cross-sectional: qualitative (interviews & focus groups)	-	-	-	X	-	-	X	X	-
Andress & Fitch [61]	Six West Virginia counties, USA	Rural	$N=30$ women, aged 21 years or older	Cross-sectional: qualitative (focus groups)	-	-	-	X	X	-	X	-	-
Bardenhagen et al. [62]	Michigan, USA	Rural	$N=20$ food stores (7 small grocers/ convenience stores without gas, 6 small or mid-sized grocers with gas, 5 mid-sized independent grocers, & 2 limited assortment/ food mart/gas stations) $N=10$ store owners, food bank representatives & local stakeholder	Cross-sectional: mixed methods	X	X	-	X	X	-	X	-	-
Breyer & Voss-Andrea [63]	Portland Oregon, USA	Urban	$N=204$ stores (79 grocery stores, 51 chain stores & 74 other stores)	Cross-sectional	X	X	-	-	X	X	-	X	-
Bridle-Fitzpatrick [64]	Mazatlán, Sinaloa, Mexico	Urban	$N=20$ mothers $N=593$ food stores	Cross-sectional: mixed methods	X	X	-	X	X	X	-	-	-
Burns & Inglis [65]	Melbourne, Australia	Urban & Semi-rural	$N=15$ supermarkets $N=33$ FF restaurants	Cross-sectional	X	-	-	-	-	-	X	-	-

Table 1 (continued)

Author (Year)	Location/ Country	Setting	Sample (n)	Study design	Methods				Food Environment Dimensions				
					GIS	Store audit/ Survey	Dietary questionnaire	Qualitative	Availability	Price	Accessibility	Affordability	Quality
Cassady et al. [66]	Sacramento & Los Angles, USA	Urban	*N* = 25 supermarkets	Cross-sectional	-	-	-	-	-	X	-	-	-
Chen et al. [67]	Franklin county, Ohio, USA	Urban	*N* = 284 green retailers	Cross-sectional	X	-	-	-	-	-	X	-	-
Childs & Lewis [68]	Cherry Hill, Baltimore, USA	Urban	*N* = 15 supermarkets *N* = 33 FF chain outlets *N* = 30 community members	Cross-sectional: mixed methods	-	X	-	X	-	-	X	-	-
de Menezes et al. [69]	Belo Horizonte, Brazil	Urban	*N* = 336 food stores *N* = 2944 adults, aged 20 years & older, mean age 56.8 years, 88.4% female	Cross-sectional: mixed methods	-	X	X	X	X	-	X	-	-
Diehl et al.[70]	Denver, Colorado, USA	Urban	*N* = 5 neighborhoods *N* = 69 food stores (10 grocery stores, 27 convenience stores, 11 deep-discount stores, 5 neighborhood markets & 16 neighborhood markets catering to specific ethnic groups) *N* = 926 participants	Cross-sectional: mixed methods	X	X	-	X	X	-	-	X	-

Table 1 (continued)

Author (Year)	Location/ Country	Setting	Sample (n)	Study design	Methods				Food Environment Dimensions				
					GIS	Store audit/ Survey	Dietary questionnaire	Qualitative	Availability	Price	Accessibility	Affordability	Quality
Diez et al. [71]	Los Rosales, Madrid, Spain	Urban	*N* = 114 food stores & one street market *N* = 12 adults (6 men & 6 women), mean age 58.7 years)	Cross-sectional: mixed methods	X	X	-	X	X	-	X	X	-
Diez et al. [72]	Villaverde, Madrid, Spain	Urban	*N* = 24 residents, mean age 51.4 years	Cross-sectional: qualitative (participatory)	-	-	-	X	-	-	X	-	-
Duran et al. [73]	Sao Paulo, Brazil	Urban	*N* = 1842 adults aged 20—59 years, mean age 36.5 years, 53% female	Cross-sectional	X	X	X	-	X	X	X	-	X
Flint et al. [74]	Philadelphia, USA	Urban	*N* = 1263 adults, mean age 48 years *N* = 2 neighborhoods	Cross-sectional	-	X	X	-	X	-	-	X	X
Gao et al.[75]	New York, Baltimore city and county, Forsyth County, St Paul, Illinois and Los Angeles County, USA	Urban	*N* = 3634 adults, aged 45–84 years, mean age of 60.3 (SD 9.5), 51.3% female	Cohort	X	-	X	-	-	-	-	-	-
Glickman et al. [76]	Cleveland and Columbus USA	Urban	*N* = 449 adults (239 in Cleveland & 210 in Columbus) *N* = 2 neighborhoods considered food deserts	Cross-sectional	-	X	X	-	-	-	X	-	-

Table 1 (continued)

Author (Year)	Location/ Country	Setting	Sample (n)	Study design	Methods				Food Environment Dimensions				
					GIS	Store audit/ Survey	Dietary questionnaire	Qualitative	Availability	Price	Accessibility	Affordability	Quality
Gravina et al. [77]	Bilbao, Spain	Urban	*N* = 23 participants *N* = 3 neighborhoods	Cross-sectional: qualitative (participatory)	-	-	-	X	X	-	-	-	-
Harbers et al. [78]	Utrecht, Netherlands	Urban	*N* = 15 participants (5 males & 10 females) aged 33 – 79 years	Cross-sectional: qualitative (interviews)	-	-	-	X	-	-	-	-	-
Haynes-Maslow et al. [79]	North Carolina, USA	Urban	*N* = 68 low-income adults, 67.7% Black, 69.1% female	Cross-sectional: qualitative (focus groups)	-	-	-	X	-	-	X	-	-
Haynes-Maslow et al. [80]	12 community sites North Carolina counties, USA	Urban	*N* = 201 adults	Cross-sectional	X	-	-	-	-	-	X	-	X
Hendrickson et al. [81]	Minnesota, USA	Urban & Rural	*N* = 23 food stores *N* = 41 community residents, nutrition professionals & community leaders	Cross-sectional: mixed methods	X	X	-	X	-	-	X	-	-
Holston et al. [82]	Louisiana, USA	Rural	*N* = 44 adults (36 women & 8 men)	Cross-sectional: qualitative (focus groups)	-	-	-	X	-	-	X	-	-
Jiang et al.[83]	Massachusetts, Illinois, Iowa, USA	Urban	*N* = 142 adults (26 males & 116 females)], mean age 73.9 (SD 9.6) years	Cross-sectional: mixed methods	-	-	-	X	-	-	-	-	-
Jillcott et al.[84]	Pitt & Greene County, North Carolina, USA	Urban & Rural	*N* = 23 rural & urban women, aged 23—70 years	Cross-sectional: qualitative (interviews)	-	-	-	X	-	-	X	-	-

Table 1 (continued)

Author (Year)	Location/ Country	Setting	Sample (n)	Study design	Methods				Food Environment Dimensions				
					GIS	Store audit/ Survey	Dietary questionnaire	Qualitative	Availability	Price	Accessibility	Affordability	Quality
Karpyn et al. [85]	Philadelphia & Trenton, USA	Urban	*N* = 29 supermarkets *N* = 31 corner stores *N* = 796 adults (primary household food shoppers)	Cross-sectional	X	X	X	-	X	X	-	X	-
Ko et al. [86]	Washington State, USA	Rural	*N* = 57 food stores *N* = 69 restaurants *N* = 32 community residents, mean age 35.6 (SD 6.2) years	Cross-sectional: mixed methods	-	X	-	-	X	-	X	-	-
LeDoux & Vojnovic [87]	Detroit, Michigan, USA	Urban	*N* = 258 households	Cross-sectional	X	-	X	-	-	-	X	-	-
Leonard et al. [88]	Dallas Texas, USA	Urban	*N* = 298 neighborhood residents	Cross-sectional	-	-	X	-	-	-	X	-	-
Libman [89]	Brownsville & Upper East side, New York, USA	Urban	*N* = 22 residents & store workers (12 Brownsville & 10 Upper East side)	Cross-sectional: mixed methods	X	-	X	X	-	-	X	-	-
MacNell et al. [90]	North Carolina counties, USA	Urban & rural	*N* = 3 counties *N* = 42 women *N* = 28 food stores	Cross-sectional: mixed methods	-	X	-	X	X	X	-	-	-
Pessoa et al. [91]	Belo Horizonte, Brazil	Urban	*N* = 5611 adults, aged 18 years and older, mean age 39.7 years, 54.8% female	Cross-sectional	X	-	X	-	X	-	X	-	-
Rodriguez & Grahame [92]	Pennsylvania, USA	Urban	*N* = 11 adults (6 women & 5 men)	Ecological study: mixed methods	-	-	X	X	-	-	-	-	-

Table 1 (continued)

Author (Year)	Location/ Country	Setting	Sample (n)	Study design	Methods				Food Environment Dimensions				
					GIS	Store audit/ Survey	Dietary questionnaire	Qualitative	Availability	Price	Accessibility	Affordability	Quality
Rummo et al. [93]	Four US cities	Urban	*N* = 3299 adults	Cohort	X	-	X	-	X	-	-	-	-
Sharkey et al. [94]	Texas Brazos Valley, USA	Rural	*N* = 1409 adults	Cross-sectional	X	-	X	-	-	-	X	-	-
Tach & Amorim [95]	Philadelphia, USA	Urban	*N* = 66 adults *N* = 3 neighborhoods	Cross-sectional	-	-	-	X	-	-	X	-	-
Thornton et al. [51]	Melbourne, Australia	Urban	*N* = 1399 women *N* = 45 neighborhoods *N* = 134 food stores	Cross-sectional	-	X	X	-	X	X	-	-	-
Thornton et al. [96]	Melbourne, Australia	Urban	*N* = 932 women, mean age 33.3 (SD 7.6) years	Cross-sectional	X	-	X	-	-	-	X	-	-
Thornton et al. [97]	Victoria, Australia	Urban	*N* = 4335 women, mean age 34 years	Cross-sectional	X	-	X	-	-	-	X	-	-
Valdez et al. [98]	Merced County, South Merced and Winton, USA	Rural	*N* = 79 adults, mean age 41.6 years; 72% female; 79% Latino 53% Spanish-speaking	Cross-sectional: mixed methods	-	X	-	X	X	-	X	-	-
Vallianatos et al. [99]	3 Los Angeles Communities, USA	Urban	*N* = 1023 food outlets *N* = 10 community members	Cross-sectional: mixed methods	-	X	-	X	X	-	X	X	-
Walker et al. [100]	Pittsburgh, USA	Urban	*N* = 25 (men & women)	Cross-sectional: mixed methods	-	-	-	-	X	-	-	-	-

Table 1 (continued)

Author (Year)	Location/ Country	Setting	Sample (n)	Study design	Methods				Food Environment Dimensions				
					GIS	Store audit/ Survey	Dietary questionnaire	Qualitative	Availability	Price	Accessibility	Affordability	Quality
Wang & Qiu [101]	Edmonton, Canada	Urban	*N* = 96 supermarkets *N* = 47 local grocery stores *N* = 61 community gardens *N* = 17 farmers' market *N* = 247 residential neighborhoods	Cross-sectional	X	-	-	-	-	-	X	-	-
Waters et al. [102]	Virginia & North Carolina, USA	Rural	*N* = 813 residents *N* = 483 food outlets (295 restaurants & 188 stores)	Cross-sectional	X	X	X	-	X	-	-	-	-
Williams et al. [103]	Australian community, Australia	Urban	*N* = 355 women, mean age 49.5 (SD 10.89) years	Cross-sectional	-	X	X	-	X	-	X	-	-
Zenk et al. [104]	Chicago IL, USA	Urban	*N* = 30 women, aged 21-45 years	Cross- sectional: qualitative (interviews)	-	-	-	X	X	-	X	-	-
Zhao et al.[105]	Chicago IL, USA	Urban	*N* = 228 women, aged 18—44 years	Cross-sectional	-	X	-	-	-	X	X	-	-

FF Fast food

GIS Geographic information system

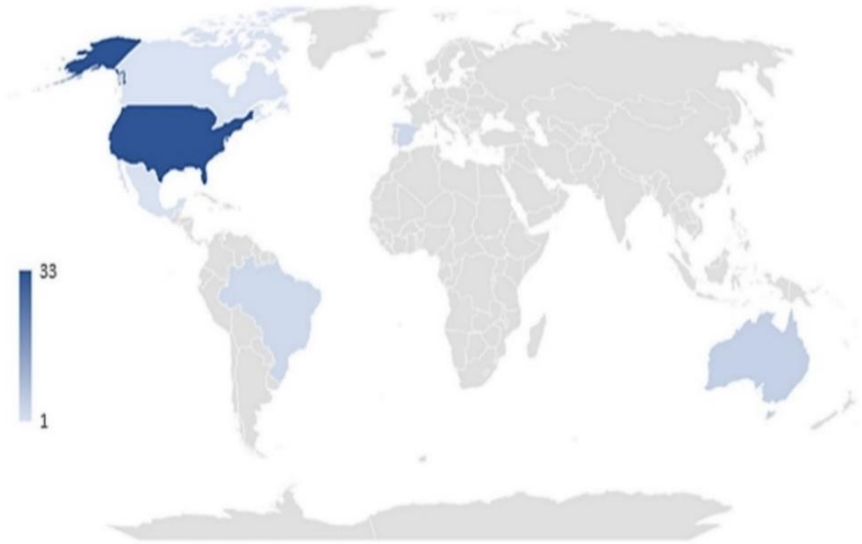


Fig. 2 Map showing countries of studies included in the scoping review

communities included low income, disadvantaged neighborhoods, and low SEP.

Assessing associations between retail food environment exposures and food choices

Table 2 shows the studies that assessed the association between the local retail food environment and food choice using Geographic Information Systems (GIS)-based measures and store audits/surveys. Of the 19 studies that were included, six examined both the community and consumer food environment [51, 70, 73, 76, 85, 102], ten assessed only the community food environment [75, 80, 87, 88, 91, 93, 94, 96, 97, 103] and three assessed only the consumer food environment [69, 74, 105]. Local retail food environment exposures included availability ($n=8$), accessibility ($n=13$), perceived access ($n=2$), healthy food availability ($n=8$), perceived healthy food availability ($n=2$), perceived consumer food environment ($n=1$), perceived quality (n = 1), price ($n=6$), quality ($n=6$), variety ($n=2$), in-store marketing ($n=6$) and product placement ($n=6$). Thirteen studies used GIS-based measures to describe the local retail food environment and geocode study participants' homes and/or store types /outlets. The most used GIS-based measure was accessibility, which was measured as road network distances, Euclidean distances, straight line distance, travel times or spatial interaction models. The second most used GIS-based measure was availability which was measured as presence, ratio, variety, counts (within buffers) or relative density or probability density or kernel density of food stores. Some studies used GIS-based measures along with retrieving registered food store information using business directories and government databases. The use of GIS-based methods to analyze the availability and accessibility of food stores has been discussed in previous reviews [10, 11]. Only one study used global positioning system (GPS) to assess the community food environment [64].

A variety of stores were included in most of the studies. The most common store types were grocery stores, supermarkets, convenience stores, FF restaurants, green grocers, and farmers markets. Tools to measure the consumer food environment were the Nutrition Environment Measure Survey (NEMS) ($n=4$), Obesogenic Environment Study food store observation tool (ESAO-S) ($n=2$), Bridging the Gap Community Obesity Measures project ($n=2$), healthy food basket ($n=1$) and store audit ($n=1$). Only one study used the NEMS-R to collect information on restaurants, and one used the NEMS-P to assess perceptions of the consumer food environment. Food choices/dietary outcomes examined included FV intake ($n=15$), FF consumption ($n=4$), SSB intake ($n=4$), snacks ($n=2$), food groups ($n=2$) and dietary quality indices such as Healthy Eating Index (HEI) ($n=2$), Alternative Healthy Eating Index score (AHEI) ($n=1$) and A Priori diet quality score ($n=1$). Most studies ($n=17$) used questionnaires (set questions or food frequency questionnaires) to assess food choices and two studies assessed dietary intake using 24-h recalls ($n=2$).

Community food environment and consumption of healthy and unhealthy foods

Four studies found no association between proximity to grocery stores or supermarkets and FV intake [69, 70, 76,

Table 2 Studies assessing the association between the local retail food environment and food choice in studies using GIS-based measures and store audits/surveys

Author (Year)	Sample size (n)	Food Environment exposure (GIS Based and/or store audits)	Food choice outcome (Dietary intake)	Results
Diehl et al. [70] Mixed methods	*N* = 5 neighborhoods *N* = 69 food stores *N* = 926 participants classified into three social groups: advantaged, middle, and disadvantaged (low income Black and Hispanic females)	- Food stores were geocoded using ArcMap. Community variables assessed included distance and density - Consumer environment assessed using Healthy Food Basket (15 food items), measured affordability and availability	- Self-reported frequency consumption of FV, SSB, meats, FF & snacks	- Proximity to a grocery store was associated with lower consumption of FV, higher consumption of SSB, and lower consumption of healthy proteins (beans, chicken, and fish) - Higher density of grocery stores was associated with lower consumption FV, higher consumption of SSB, and higher consumption of unhealthy fats. Disadvantaged participants had more food stores and grocery stores within 1 mile - Affordability (price) was not associated with food intake. For the disadvantaged group, average cost of a Staple Food Basket was less expensive at the closest store, but more expensive at the closest grocery store and the preferred store respectively - Increased availability of healthy food items at the closest grocery store was associated with lower consumption of SSB - The disadvantaged group did not have a significantly greater number of available healthy food items at the closest food store or at the preferred store, but they did have fewer available healthy items at the closest grocery store
de Menezes et al. [69] Mixed methods	*N* = 2944 adults, aged 20 years & older, mean age 56.8 years *N* = 336 food stores	- Food and vegetable food store audits - Consumer nutrition environment variables were assessed using the ESAO-S - The ESAO-S healthy food access was summarized by the HFSI	- Questions adapted from international surveillance systems used to assess daily FV consumption	- No associations found between FV intake and local grocery stores food availability, variety, quality, pricing, signage, and promotion - Both HFSI and specialized FV markets were positively associated with F&V intake, but not with FV quality

Table 2 (continued)

Author (Year)	Sample size (n)	Food Environment exposure (GIS Based and/or store audits)	Food choice outcome (Dietary intake)	Results
Duran et al. [73]	*N* = 1842 adults aged 20—59 years, mean age 36.5 years	- Community food environment measures included density of and proximity to supermarkets and fresh produce markets - Consumer environment measures included availability, price, quality, and variety of fresh FV and SSB, assessed using the ESAO-S	- Questionnaire- consumption of FV and SSB (≥ 5 days/week)	- Lower income individuals living in neighborhoods with lower density of supermarkets and fresh produce markets had statistically significantly lower FV consumption - FV availability was associated with a 41% increase in the prevalence of regular FV consumption. FV price was not associated with FV consumption - Price, supermarkets and fresh produce markets density or proximity were not associated with SSB consumption
Flint et al. [74]	*N* = 1263 adults, mean age 48 years *N* = 2 neighborhoods Both sites had two grocery stores & 55/56 convenience stores	- Consumer food environment assessed using NEMS	- Block FFQ—measured portions of FV consumed per day	- Consumer food environment measures (availability, price, quality, and marketing) was not associated with and FV consumption, neither in bivariate nor multivariate analyses - Participants who perceived their neighborhood to have more variety and higher quality grocery stores did not have a higher daily FV intake compared to those perceived their neighborhood to have little choice and low quality grocery stores - No difference in intake between participants who perceived neighborhood to have higher choice and higher quality of food available and those who perceived neighborhood to have low quality and little choice
Gao et al. [75]	*N* = 3634 adults, aged 45–84 years, mean age 60.3 (SD 9.5), 51.3% females	- GIS measures: 1. GIS-derived distance to the nearest favorable food store, 2. GIS-derived one- mile kernel density of favorable food stores, 3. survey-based measure of perception of healthy food availability, and 4. summary measure combining GIS-derived one-mile kernel density of favorable food stores and survey-based measure of participants' perception of healthy food availability	- Diet assessed using AHEI Index score	- Higher AHEI score was associated with shorter distance to nearest favorable stores, higher SES neighborhood, better perception of healthy food access, and higher composite score of healthy food environment

Table 2 (continued)

Author (Year)	Sample size (n)	Food Environment exposure (GIS Based and/or store audits)	Food choice outcome (Dietary intake)	Results
Glickman et al. [76]	*N* = 449 adults	- Food retail audits- data collected on availability, price and quality of healthful foods - PFRQ score calculated using audit adapted NEM-CS and BTG-COMP	- Three 24-h dietary recalls: Average HEI-2010 score, average SSB intake, and average FV intake	- No associations between PFRQ and HEI-2010 scores for participants who shop further from home - An increase of one unit in PFRQ score was associated with a 14.7-point increase in HEI-2010 score for residents who shopped close to home - No association between PFRQ and FV and SSB consumption. Higher quality proximate food retail was associated with improvements in diet
Haynes-Maslow et al. [80]	*N* = 201 adults	- Self-reported FV access was measured using three neighborhood perceived access questions adapted from previous studies - Food outlet density (within 1 mile of participants home)	- FV intake (cups per day) was assessed using the 10-item National Cancer Institute FV screener	- Positive correlation between perceived access to FV variety and of supermarkets within 1 mile of a participant's home - Positive association between perception based FV access measures and objective measures (food outlet density within 1 mile of participants home) - No association between perception-based measures (convenience, variety, and quality) and FV intake - Association between access to super-centers within a mile of participants' houses and lower self-reported intake of FV - Participant's FV intake decreased by 0.61 cups per day when there were more supermarkets within a mile of their home
Karpyn et al. [85]	*N* = 29 supermarkets *N* = 31 corner stores *N* = 796 adults	- GIS based measures- supermarkets within a two-mile buffer corner stores within both three-square-mile study areas - Nutrition environments in supermarkets and cornerstores using NEMS-S and NEMS-CS tools. Both types of retail outlets were scored on availability, price, and quality of both healthier and less-healthy food items	- 24-h dietary recall: HEI score and fruit consumption subscore, and vegetable consumption subscore)	- Store quality and perceived neighborhood food availability was positively related to vegetable consumption sub scores
Leonard et al. [88]	*N* = 298 neighborhood residents	- Access to food sources calculated in ArcMap using straight-line distances between the respondent's address and the location of food sources	- Neighborhood (Perceived Good Access) and the number of meals prepared at home in a typical week	- Residents living closer to fresh food sources consumed more FV, while those living closer to FF restaurants consumed less FV

Table 2 (continued)

Author (Year)	Sample size (n)	Food Environment exposure (GIS Based and/or store audits)	Food choice outcome (Dietary intake)	Results
LeDoux & Vojnovic [87]	*N* = 258 households	- ESRI Network Analyst in ArcMap 10.1 used to measure accessibility. Distance from resident's house to nearest store category	- Respondents were asked to recall separately their typical daily, weekly, and monthly servings of soda, fruit juice, sweets, salty snacks, FV	- Closer proximity (quarter mile = 402 m) to a supermarket was associated with increased intake of both healthy and unhealthy food groups - Short and medium (half mile) proximity to FF outlets was associated with lower FV consumption - Lower FV consumption when there are more FF outlets within a quarter and half-mile (402 and 805 m), respectively
Pessoa et al. [91]	*N* = 5611 adults, aged 18 years and older, mean age 39.7 years	- Density of supermarkets and hypermarkets, density of mini markets, grocery stores and warehouses, density of healthy food outlets (stores and open-air markets specialized in selling FV), density of restaurants and density of unhealthy food outlets (bars, snack bar and food trucks/trailers)	- Questions were used to estimate the daily frequency of fruit intake. FV intake score	- High income neighborhood and higher density of healthy food outlets associated with higher FV intake scores - High density of unhealthy food outlets was associated with lower FV intake score
Rummo et al. [93]	*N* = 3299 adults	- GIS used to capture all food outlets within a 5-mile radius of each participant - Availability of food stores: calculated the count of each type of food resource within a 3 km distance along the street network around participant homes	- Questionnaire used to calculate Priori diet quality score - Food groups: fruits vegetables, whole grains, processed meats, snacks, desserts, SSBs and Artificially sweetened beverages (ASBs)	- For participants with lower individual-level income, the availability of neighborhood convenience stores was associated with lower diet quality - The percentage of neighborhood convenience stores relative to total food stores and restaurants was negatively associated with whole grain consumption; these associations were stronger at lower (vs higher) individual-level income - No associations between FV and processed meat consumption and community nutrition measures - Consumption of SSBs and ASBs and number of SSBs and ASBs consumed were not associated with neighborhood convenience stores' availability
Sharkey et al. [94]	*N* = 1409 adults	- Two measures of potential spatial access: proximity (distance to the nearest location) and coverage (number of traditional FF restaurants, non-traditional FF outlets, and all FF opportunities from each respondent's residence within 1, 3 or 5 miles). All participants were geocoded to their residence	- Questionnaire—Weekly consumption of FF meals	- FF meals were consumed less frequently when proximity from a FF restaurant, non-traditional FF outlet, or all FF outlets was greater - Closer distance and greater coverage were associated with more frequent consumption of FF meals by women than men

Table 2 (continued)

Author (Year)	Sample size (n)	Food Environment exposure (GIS Based and/or store audits)	Food choice outcome (Dietary intake)	Results
Thornton et al. [51]	*N* = 1399 women *N* = 45 neighborhoods *N* = 134 food stores	- Community nutrition environment: locations of greengrocers, major supermarkets, and FF restaurants in and immediately surrounding the neighborhoods - GIS was used for geocoding of participants and food stores. Proximity- distance between each participant's household location and the nearest store of each type (greengrocer, supermarket, FF restaurant). Density-count of each store type within 3 km of road network distance from each participant's household. Opening hours measures were calculated for each store type - Consumer nutrition environment: store audits on the availability and price of 15 commonly consumed fruits and 23 vegetables in 134 stores, identified as being within the boundaries of the 45 neighborhoods	- Questionnaire—FV and FF consumption	- FV prices were lower in greengrocers in highly disadvantaged neighborhoods, but operating hours and availability were more restricted compared to other neighborhoods - Residents in high-disadvantaged neighborhoods were more likely to live further from a FF restaurant and have lower density and variety of chains than those in low-disadvantaged neighborhoods - Fruit consumption was not associated with neighborhood-level disadvantage - Participants in high disadvantaged neighborhoods were significantly less likely to consume two or more servings of vegetables per day - A greater density of greengrocers and supermarkets in the neighbourhoods of frequent vegetable consumers, as well as a greater variety of vegetables in greengrocers, were factors contributing to their frequent consumption of vegetables - Prices in both greengrocers and supermarkets were positively associated with consumption of FV
Thornton et al. [96]	*N* = 932 women, mean age 33.3 (SD 7.6) years	- GIS—count of FF restaurants within a 3 km road distance	- Two questions on FF consumption	- Women with moderate or low confidence in shopping for healthy food had significantly lower odds of rarely consuming FF in comparison with women with the highest confidence - Women who live more than 1.6 km from their nearest supermarket are significantly less likely to consume FF infrequently compared to women living within 0.8 km from their nearest supermarket
Thornton et al. [97]	*N* = 4335 women, mean age 34 years	- Geocoding household addresses of participants. ArcGIS 9. 3, used to identify and calculate the number of chain supermarkets and greengrocers within a 2 km road network distance from each individual's household location	- Self-reported FV consumption (servings per day)	- Store access within 2 km may moderate the association between vegetable consumption and cooking confidence, though evidence is weak ($P = 0.062$)

Table 2 (continued)

Author (Year)	Sample size (n)	Food Environment exposure (GIS Based and/or store audits)	Food choice outcome (Dietary intake)	Results
Waters et al. [102]	*N* = 813 residents *N* = 483 food outlets (295 restaurants & 188 stores)	- Availability of healthy food in food outlets was assessed by the NEMS-S and NEMS-R. Data from store audits used to calculate a healthy food availability score - All food outlets were geocoded and mapped in ArcGIS 10.0 to determine proximal food environment to food outlets	- Self-reported FV intake (cups/day) was assessed using the National Cancer Institute's FV short screener	-No association between FV intake and healthy food availability in food outlets
Williams et al. [103]	*N* = 355 women, mean age 49.5 (SD 10.89) years	- Supermarkets and FV store's locations and participants addresses were geocoded in the GIS ArcView 3.3	- Two questions on FV consumption (servings/day)	- High fruit consumers were mainly women of older age, dieting to lose weight, preferred fruit, and perceived that more healthy food options were available, and that fruit cost less
Zhao et al. [105]	*N* = 228 women, aged 18—44 years	- Consumer food environment aspects price, availability, marketing, and product placement assessed using an instrument combining the NEMS and the Bridging the Gap Food Store Observation Form, audits. The NEMS-P was used to assess participants' perceptions of the consumer food environment	- Self-reported FV consumption (cups/day) using 6 item FFQ	- In the multivariable regression analyses no significant association between any measure of the consumer food environment (price, availability, marketing, and product placement) and fruit intake was found - Vegetable intake was associated only with marketing in the consumer food environment. Greater Healthy food marketing exposure was associated with approximately 0.24 cups increase in vegetables consumed per day by participants

ASB Artificially sweetened beverages (fruit drinks, soft drinks, and water)
AHEI Alternative healthy eating index
BTG-COMP Bridging the gap community obesity measures
ESAO-Ss Obesogenic environment study food store observation tool
FFQ Food frequency questionnaire
FV Fruits and vegetables
GIS Geographic information system
HEI Healthy eating index
HFSI Healthy food store index
NEMS Nutrition environment measures survey
NEMS-C Nutrition environment measures survey corner store
NEMS-P Perceived nutrition environment survey
NEMS-R Nutrition environment measures survey restaurant
SEP Socioeconomic position
SES Socioeconomic status
SSB Sugar-sweetened beverages

80], and one study found no association between accessibility to supermarkets or green grocers and vegetable consumption [75]. Living near a fresh food source was associated with higher FV consumption [70]. A greater density of greengrocers and supermarkets was associated with frequent consumption of vegetables[51]. Living close to a FF restaurant [87, 88], and a higher density of grocery stores [70], supercenters and supermarkets [80] and unhealthy food stores such as bars, snack bars and food trucks within neighborhoods were associated with lower FV intake [91].

A cross-sectional study in the USA found an association between closer proximity to a supermarket and higher intake of both healthy and unhealthy food groups respectively [87]. Another study in the USA reported no association between living in closer proximity to grocery store and consumption of healthy proteins like beans, chicken and fish, but higher density of grocery stores was associated with eating unhealthy fats [70].

With regards to SSB, one study in the USA reported that closer proximity to and higher density of grocery stores were associated with greater consumption of SSB [70], while another USA study showed no association between proximity to healthy food stores and SSB consumption [76]. Although availability of convenience stores was associated with lower diet quality in low-income individuals in four USA cities it was not associated with SSB consumption [93]. Also, a Brazilian study reported that proximity to and density of supermarkets and fresh produce were not associated with SSB consumption [73].

Five studies assessed the association between community food environment and FF consumption. Living further away from a FF restaurant (including traditional, non-traditional or all FF) [94] or a healthy food source such as a supermarket [96] was associated with lower FF consumption. Highly disadvantaged neighborhoods in comparison to low disadvantaged neighborhoods had lower density and variety of FF restaurants [51].

Community food environment and overall diet quality

Closer proximity to healthy food stores was associated with higher HEI scores [76], and closer proximity to supermarkets was associated with higher AHEI scores [75].

Consumer food environment and consumption of healthy and unhealthy foods

A Brazilian study found no relationship between grocery stores and FV intake however, better access to healthy foods in stores and specialized FV markets was associated with greater FV intake [69]. In contrast, a study in rural USA found no association between healthy food availability and FV intake [102]. In another USA study, perceived neighborhood food availability was associated with higher vegetable consumption [85]. An Australian study reported that higher perception of healthy food availability and perceived lower cost of fruit was associated with high fruit consumption [103]. A USA study reported a negative association between availability of healthy food in stores and SSB consumption [70]. An Australian study reported that prices in both greengrocers and supermarkets were positively associated with consumption of FV[51]. Affordability (price) was reported not to be associated with overall food intake [70] and FV and SSB consumption [73], while marketing was positively associated with vegetable consumption [105]. Perceived greater variety of stores and quality of local grocery stores was not associated with consumption of FV [74].

Barriers and facilitators for access to healthy food in resource-poor communities

Qualitative studies

Table 3 shows the barriers and facilitators for access to healthy food in resource-poor communities as reported in nine qualitative and eleven mixed method studies. In resource-poor communities, high food costs were cited as the main barrier to healthy food access [60, 62, 71, 78, 79, 81, 82, 86, 92, 95, 98, 104]. The second major barrier to healthy food access was transportation (lack of public transportation or car ownership) [61, 62, 77, 79, 81, 82, 84, 90, 92, 95]. Seven studies reported geographic access as barrier to healthy food access [61, 71, 81, 84, 89, 92, 95]. Five studies reported the presence of unhealthy food stores such as corner /convenience stores and FF restaurants as barrier to healthy food access [77, 79, 82, 89, 95]. A lack of healthy food availability [60, 104], the presence of unhealthy foods in various stores [71, 77] and lack of quality and variety FV [79, 81, 104] were perceived as barriers to healthy food access in the consumer food environment. Two studies reported that living in a food desert was a barrier to healthy food access [100, 104].

In terms of store type, supermarkets, discount stores, large grocery stores and traditional stores, farmers markets and street vendors/ FV stands were perceived as major facilitators for healthy food access in resource poor communities [71, 72, 84, 86, 98, 100]. Three studies reported that lower food cost in food stores such as supermarkets, discount stores was a facilitator for healthy food access in resource poor communities [71, 82, 86]. Consumer food environment characteristics such as in-store availability of healthy foods [71], quality [77], marketing and sales [83] and variety [90] were also perceived as facilitators for healthy food access.

Table 3 Barriers and facilitators for healthy food access in resource poor communities identified in qualitative and mixed methods

Author (Year)	Themes	Barriers & Supporting quote or data	Facilitators & Supporting quote or data
Alkon et al. [60]	1. How do people think about food access?	- Neighborhood's underdevelopment - Lack of control over the food stores in neighborhoods - Lack of fresh food in their neighborhoods - Price is the primary barrier to food access	N/A
Andress & Fitch [61]	1. Structure of place, external food environment	- Geography of place created barriers getting to and from grocery stores and other sources of food - Lack of car ownership and no public transportation	N/A
Bardenhagen et al. [62] Mixed methods	1. Transportation challenges 2. Cost of healthy eating	- Distance and cost are a large barrier to accessing healthy foods - Transportation is one of the largest barriers to accessing healthy food - Higher cost of healthy foods - High food prices may hinder the use of farmers markets *"Everything is more expensive here. It's very much a third-world mentality."*	- Interest in locally grown food *"More and more people in the region want to know where their food supply is coming from, but low-income people can't always pay the price"*
Diez et al. [71] Mixed methods	1. Community food environment 2. Consumer food environment	Community food environment - Accessibility-related aspects ('poor access built environment obstacles') - Unhealthy foods within food stores, bars and restaurants perceived to negatively influence diets Consumer food environment - Unhealthy food presence - Cost barriers *"It's the same thing with the organic food shops, they sell very healthy products, but they are quite expensive … quite expensive. Very healthy, but not affordable."*	Community food environment - Small, specialized stores offered a wide variety of healthy foods **"***Neighborhood food stores have lots of fruits and vegetables."* Consumer food environment - Availability of organic and dietetic food products
Diez et al. [72]	1. Food stores	N/A	- Small traditional food stores *"We have to protect these stores against other retail types such as supermarkets or street markets, especially in terms of places where you can by fresh food."* - Presence of street markets offering a wide variety of affordable fresh foods
Gravina et al. [77]	1. Unhealthy eating behaviors 2. Retail transformation 3. Healthy eating	Unhealthy eating behaviors - Presence and affordability of FF and sugary food *"Fast food is not hygienic and healthy, but it is often cheaper and easier to get or consume."* Retail transformation - Greater amount of convenience stores	Healthy eating - High quality of the foods offered by merchants in neighborhood

Table 3 (continued)

Author (Year)	Themes	Barriers & Supporting quote or data	Facilitators & Supporting quote or data
Haynes-Maslow et al. [79]	1. Community-level barriers	- Cost barrier to purchasing fresh FV *"What we need to eat — and what we want to eat — the price is a big part of it. When you have lower-income families, they usually don't introduce fruit and vegetables into their children's body because it costs so much. So, if there were... if there was a price where everybody could afford it, then everybody could have it."* - Transport was a barrier to purchasing FV, especially for the elderly or those who did not own a vehicle - Lack of quality FV in the community *"I tell them, "Look, these apples are rotten." They're pretty on the outside, but they're rotten. So, they gave me another one... that was rotten, as well."* - Lack of variety of FV in grocery stores in the community *"You can get vegetables but not the variety of vegetables that you might want."* - Changing food environment – Farm markets and roadside stands declined, and FF restaurants in the community increased *"He had an old truck and he sold vegetables out of his truck... for me, I don't see him no more... but that would be nice if we had somebody who would come around with vegetables."*	N/A
Harbers et al. [78]	1. Environmental Determinants of Food Choice	- Increasing prices of fresh FV *"But if I see that snacks are cheap, and that fresh food is only getting more expensive... And if you only receive social assistance benefits. That is just undoable."* - Marketing strategies and food product placement in the supermarket perceived as tempting and encouraged unhealthy food purchases *"They should put this on more products. So, if you are in front of the crisps shelf, you can think, well, I can take Lays because that is easy. But that then you have an alternative next to it, from which you can see, well, it does actually provide less calories and it is just as tasty."*	N/A
Hendrickson et al. [81] Mixed methods	N/A	- Lack of transportation - Lower quality and higher food prices in urban community - Distance and cost to go to stores for rural residents Rural residents, 85–90% drive to food stores Urban residents, 40–60% walk and 15–30% take the bus - Healthy food choices not affordable within communities and participants believed that people in their community were food insecure	N/A

Table 3 (continued)

Author (Year)	Themes	Barriers & Supporting quote or data	Facilitators & Supporting quote or data
Holston et al. [82] Mixed methods	1. Store Choice: 1.1 Outshopping Convenience Stores/Dollar Stores	- Participants perceived cost as a barrier to providing healthy foods for their families Convenience Stores/Dollar Stores - No participants viewed convenience stores as a viable option for acquiring food	- Outshopping- having to leave the parish to find lower prices and better quality - Ways of Acquiring Food All focus groups reported using a variety of built, cultivated, and wild environments to acquire food - Facilitators other than the grocery store - Gardening - Fishing and hunting
Jiang et al. [83] Mixed methods	N/A	N/A	- The key factors to contributing to consumption of FV were accessibility and affordability, while living accommodations were least important factor - Lower FV prices In addition to lowering FV prices, participants suggested stores have more sales or discounts on FV and donate fruit and vegetables to seniors. Participants suggested that food stores should *"have a clearance section," "lower prices or (have) more sales on fruits and vegetables,"* and *"sell fruits and vegetables that are less satisfying in quality cheaper."* - Sales and discounts on FV - In store marketing strategies Participants recommended stores improve the presentation and placement of FV. Participants suggested that food stores "keep them [fruit and vegetables] close to the door" and "*display them nicely so [customers] want to buy them.*" *"Farmer's markets should open for longer time through the season."*
Jillcott et al. [84]	1. Farmers market 2. Supermarkets 3. Discount supercenters	- Farmers market is far away from residence and transportation is needed to access them. Fresh food markets need to be closer to residence	- Supermarkets-high quality meats, lower food costs, convenient locations - Discount supercenters – offered lower food prices
Ko et al. [86] Mixed methods	1. Perceived accessibility of fresh produce 2. Food store preference	- Perceived accessibility of fresh produce accessibility was dependent on farming seasons which impacts seasonal prices	- Large grocery stores chosen based on food quality, price, and nearest location to their home
Libman [89] Mixed methods	N/A	- Lack of food availability in the neighborhood, means residents have to go outside neighborhood to get affordable healthy foods - Greater presence of convenience stores & FF in low-income communities compared to higher income communities	N/A
MacNell et al. [90] Mixed methods	1. Food prices 2. Freshness and variety 3. Access to transportation	- Lack of transportation	- Lower prices - Freshness and variety

Table 3 (continued)

Author (Year)	Themes	Barriers & Supporting quote or data	Facilitators & Supporting quote or data
Rodriguez & Grahame [92] Mixed methods	1. Cost 2. Transportation 3. Access to services 4. Education and information	- Cost: primary factor in food choice. Proximity to stores also complicated the cost of food, more affordable stores were further away from the community - Transportation: lack of public transportation or personal vehicle, difficult terrain to walk, physical disability and transportation costs - Access to services: Lack of access to services such as WIC, food pantry or DPW affects food access - Education and information: no internet access meant inability to retrieve money-saving coupons, recipes, or information regarding health concerns. Lack of information available about where they could use food stamps or access fresh food	N/A
Tach & Amorim [95]	1. Grocery Shopping: Choice within Constraint 2. Alternative Food Acquisition Strategies	- Economic Constraint: High food cost - Geographic Constraint: Distance affected accessible stores especially for residents without cars - Alternative Food Acquisition Strategies: Corner stores with high prices and low quality foods. No presence of farmers markets - Opening of high-quality stores in neighborhoods – participants perceived these as overpriced	- Economic Constraint: Participant using strategies such as buying from multiple stores, buying in bulk, or buying store brands - Geographic Constraint: Car owners can travel further to stores that are cheaper or offer higher-quality products - Charitable Donations: charitable food sources including nonprofit food pantries and programs and food distribution events at nearby churches, schools, and public housing projects
Valdez et al. [98] Mixed methods	1. Access to FV 2. Affordability of FV	- Affordability of FV: most (65%) reported that "healthy food options like FV are too expensive in retail stores *"It would be nice to be able to have a store that you can actually afford to go to...even the dollar store isn't the dollar store anymore."*	- Living in an agricultural setting with access to farmers and workers and mobile fruit vendors Survey respondents agreed with the statement *"A large selection of fruits and vegetables is available in my neighborhood"* and *"The fruits and vegetables in my neighborhood are of high quality." "You can buy vegetables all over the place."* - FV stands and flea markets, as opposed to retail stores, were good sources for cheap produce
Walker et al. [100] Mixed methods	N/A	- Neighborhood store closure in food oasis *"The bad economy leads to poor neighborhoods and store closings. Poor neighborhoods end up losing the stores and now we need more neighborhood stores."* - Food desserts: In food desserts, food was perceived as necessary for survival however macro-level factors influencing food purchasing *"Eating junk food is what I can afford."* *"Corporate taking advantage of the consumer (by offering smaller food quantities for more money)"*	- Food oasis participants had access to organic foods, resources such as Catholic Charity, Salvation Army, senior coupons for farmer's market, SNAP and WIC vouchers *"Organic food stores have decent prices and good quality."* *"Shopping frequently for fresh produce."*

Table 3 (continued)

Author (Year)	Themes	Barriers & Supporting quote or data	Facilitators & Supporting quote or data
Zenk et al. [104]	1. Material 2. Economic	- Material barriers: lack of a full-service supermarket in the neighborhood. Lack of store maintenance was associated with poor quality food. Neighborhood stores had low stock and variety of some foods (including fresh produce) and foods were of a poor quality. According to women, stores had expired canned and packaged foods, wilted fresh FV, and moldy spoiled meats - Economic barriers: high food prices at both small local stores and supermarkets	N/A

FV Fruits and vegetables
FF Fast food
SNAP Supplemental nutrition assistance program
WIC Women, infants, and children

Two studies in the USA reported that food assistance from non-profit organizations and government programs such as the Supplemental Nutrition Assistance Program (SNAP) and Women, Infants, and Children (WIC) increased healthy food access for residents in communities [95, 100]. Individual strategies such as gardening, fishing and hunting [82], purchasing from various sources, buying in bulk and buying store brands [95] also enabled healthy food access.

Quantitative studies

Table 4 shows the barriers and facilitators for healthy food access in resource poor communities as reported in five quantitative and three mixed method studies. Living further away from grocery stores [63, 68, 99] and shorter operating hours of healthy food stores [67] were associated with poor healthy food access. Barriers to healthy food access include in-store high food prices [63, 99], unavailability of healthy foods [68] and product placement and promotion of unhealthy food items [64]. Access to healthy food was also limited by a lack of access to a car or lack of transportation [65] as well as neighborhood crime and safety issues [68, 99]. Facilitators for healthy food access include public markets [64], vehicle ownership [65], in-store prices [66], access to fresh produce and public transportation [101].

Discussion

This scoping review provides an overview of the evidence on adult food choices in association with the local retail food environment and barriers and facilitators for food access in resource-poor communities. Literature shows that food environments may differ across communities, neighborhoods, cities and countries [34]. In contrast to previous reviews that focused on the food environment in different countries, this review focused on studies that reported on low-income communities/neighborhoods and/or low-income households. Results on associations between food choice (dietary outcomes) and the local retail food environment were inconsistent. Numerous studies have stated that heterogeneity of measurement tools for the community and consumer food environment contribute to difficulty with interpreting study outcomes [8, 29, 32, 40, 43]. The standardization of measures to assess the food environment is therefore needed. Recent systematic reviews on food environment and diet in various settings also reported inconclusive findings [10, 35]. Similarly, also to other reviews, mostly cross-sectional studies were included and only two longitudinal studies were included in the present review. This scoping review shows that in resource-poor communities, cost, transportation, limited geographic access, and the presence of unhealthy food stores are the main barriers for access to healthy food. Facilitators that enable access to healthy food include store types such as supermarkets, large grocery stores and farmers markets, lower in-store food prices, food assistance programs, access to transportation, in-store availability, quality, and marketing of healthy food.

Many studies included in this review measured accessibility and availability of food stores within neighborhoods, and consumption of FV and SSB respectively were the most frequently studied dietary outcome. Other reviews have also reported that FV intake was the most common outcome measure [10, 28]. It has been postulated that accessibility to FV stores may influence consumption of FV [29]. In the present review, there was no association found between accessibility and FV intake, while retail food environments were associated with SSB consumption. This review has found little evidence to suggest that in resource-poor communities lower FF consumption is associated with inaccessibility and lack of FF restaurants. These findings suggest that greater access to FF restaurants may encourage unhealthy food choices that are contrary to dietary recommendations that aim to promote healthier food choices [27]. A few studies in the present review reported findings on the association between affordability, price, variety, marketing, quality, and placement (shelf space for healthier food products and unhealthy snacks and drinks), perceived consumer environment and food choices. No studies included in the scoping review reported on the association between food promotion (signage, in-store advertising, health/education materials near food products) and food choices.

In this scoping review, cost and transportation were identified as the two major barriers for access to healthy food in resource-poor communities. It is well known that cost is a barrier to healthy diets worldwide [106]. The availability of transportation allows residents to shop anywhere they can access healthy foods, even if these foods aren't readily available in their neighborhood [107]. This scoping review further shows that lower food prices and store types such as supermarkets, discount stores, large grocery stores and traditional stores, farmers markets and street vendors/ FV stands were considered major facilitators to healthy food access. Food pricing policies such as taxes, price manipulations of SSB, energy dense, low nutrient or high in added sugars or saturated fats and food subsidies on FV can promote healthy diets [106]. A systematic review reported that pricing interventions used in high- and middle-income countries positively affect consumer behavior and improve purchasing and consumption of healthy foods and beverages [108]. Another systematic review found, however, that while policies and FV subsidies are being implemented and supermarkets are becoming more common among

Table 4 Barriers and facilitators for healthy food access in resource poor communities identified in quantitative studies

Author (Year)	Food Environment exposure (GIS Based and/or store audits)	Results	Barriers & Supporting quote	Facilitators & Supporting quote
Breyer & Voss-Andrea [63]	- Healthful foods market basket survey biased on USDA Thrifty plan - Affordability index	- Store distance increases nonlinearly as affordability index declines, showing a negative correlation between affordability index and proximity to the nearest affordable store - On average, 1.6 miles (2.9 km) travel distance between a low-cost store and nearest grocery store; 65% of participants lived in either extreme or moderate food mirages	- High food prices - Proximity	N/A
Bridle-Fitzpatrick [64] Mixed methods	- Global positioning system (GPS) used to map food outlets in neighborhoods - Price index	- More unhealthy food stores in low- and middle-income communities compared to the high- income community - Greater exposure and access to fresh FV, SSBs and obesogenic snacks in low- and middle-income communities compared to the high-income community - Lowest-income community had the second highest prices for FV, eggs and dairy, and grains and other basic staples - Packaged snacks and SSBs prices were lowest in the lowest-income community - Photos used by participants to describe the food environment showed a high presence of SSBs and packaged snacks in their communities. Participants also stated that these unhealthy foods drew their attention	- High food prices - Displays and promotions for packaged snacks and soft drinks The racks of sweet and salty snacks *"called my attention"* or *"were most visible."* The store "has almost nothing of healthy food."	- Public market Regarding the public market *"because it is cheaper.… You can get a little bit of different vegetables for a low price."*
Burns & Inglis [65]	- GIS modelling used to measure access to supermarket and FF and transport networks	-—More advantaged areas had closer access to supermarkets, less advantaged areas had closer access to FF outlets	- No car access	- Car access
Cassady et al. [66]	- Thrifty food plan market basket - 2005 Dietary guidelines market basket	- Both cities had significantly lower average total prices for thrifty food plan baskets of FV compared to retailers in middle- and high-income neighborhoods - Stores located in very low income neighborhoods and low income neighborhoods had similar FV prices. Low-income households would have to allocate 70% of their food budget to FV to meet the 2005 dietary guidelines	N/A	- Price

Table 4 (continued)

Author (Year)	Food Environment exposure (GIS Based and/or store audits)	Results	Barriers & Supporting quote	Facilitators & Supporting quote
Chen et al.[67]	1. Spatial food access 2. Temporal food access 3. Spatiotemporal food access	- Lower SES neighborhoods have better spatial access but poorer temporal access than higher SES neighborhoods - Disadvantaged tracts have slightly more spatiotemporal advantage in food access	- Limited temporal access i.e., shorter healthful store operating hours	N/A
Childs & Lewis [68] Mixed methods	- Number of food stores available within an eight kilometer radius of neighborhood and store survey	- The least readily available food type in the survey was fresh fruit and vegetable - The most readily available foods were processed and canned foods: protein; non-dessert dairy; canned/frozen vegetables; grains and bread; and canned/frozen fruits - In Cherry Hill, 73% of respondents perceived FF to be more readily available than fresh foods - 50% of respondents said that a grocery store in the neighborhood would improve food access in the community - Travel time to the supermarket for most participants was 6–15 min; for some it was 30 min	- Lack of financial resources - Lack of stores carrying nutritionally appropriate food - Limited mobility due to the physical and built environment-long distance to travel to stores - Neighborhood crime - Time of individuals	Vehicle ownership *"When grocery stores open here, they are overpriced and never stocked with anything of value."* *"They could improve in having meat, fruits and vegetables that aren't spoiled."* *"To open up a store that will be well stocked with quality food, healthy food and value conscious."*
Vallianatos et al. [99] Mixed methods	- GIS mapping number the type of retail food outlets - Thrifty food plan- assessing availability and affordability of healthful foods	N/A	- Food is perceived to be expensive - Far distance to nearest supermarket means residence spend a lot of money on transport and gasoline (for car owners) and this causes reliance on convenience stores or other small stores near their homes - Violent crime makes it difficult for residents to shop after dark - FF can be easily purchased in the neighborhoods and outside school grounds	N/A
Wang & Qiu [101]	N/A	- Negative relationship between private vehicle access and number of food stores - Neighborhoods with a higher unemployment rate and residents who walk primarily to stores had a 0.42 and 0.14 likelihood of more super-markets and local grocery stores, respectively,	N/A	- Disadvantaged groups had higher access to fresh food sources - Public transport use

FV Fruits and vegetables

FF Fast food

GIS Geographic information system

resource-poor communities in an attempt to change diets positively [109], supply and demand issues have prevented the expected change [110]. Therefore, increasing proximity does not necessarily result in consumers purchasing and consuming more healthy foods. Sawyer and colleagues stated that for change in unhealthy food environments, creative strategies that support household finances at individual level and transform societal behavior to encourage healthy food production, supply and intake are needed [34].

In this scoping review, convenience/corner stores were also identified as a barrier to healthy food access in resource poor communities. Also, higher neighborhood density of convenience stores was shown to be associated with poor quality diets [93]. To encourage healthier food choices, stores can implement various in-store marketing, placement and pricing strategies as reported in studies conducted in the USA, Australia, and Canada [111–114]. For example, stores can allocate more shelf space to display healthy foods, have more refrigerators to store FV, improve the exterior of the store to improving community perception, and assist with promotion and marketing of healthier foods (using shelf labels, call out messages, food and beverage price discounts, placing healthier foods instead of unhealthy foods at eye level or in checkout areas) [111–114]. In the USA, nutrition assistance programs such as SNAP and WIC were reported to increase healthy food access for residents in resource-poor communities [95, 100], and encouraging convenience/corner stores to accept nutrition assistance program benefits may improve healthy food access [106, 108, 109]. Various USA based non-profit organizations, community organizations, and local governments have developed interventions to increase access to healthy foods by modifying existing stores to be healthier food outlets [115].

The present study had several strengths and limitations. To ensure a transparent, reproducible review process and to guide the reporting of results (synthesis), we followed the PRISMA-SCR guidelines. A strict eligibility criterion was followed, and selection and data extraction of studies were done by two reviewers to minimize selection bias. Only published peer-reviewed studies were included whilst grey literature was excluded. The use of peer-reviewed literature may lead to publication bias because studies with null or negative association may not have been published. However, to minimize bias, nine databases were used to search for literature. Restrictions on the publication language is a limitation as articles that were not written in English were potentially excluded. No formal appraisal was conducted since the purpose of a scoping review is to describe evidence, not to assess its quality. The lack of appraisal may have resulted in inclusion of studies with poor methodological quality. The present study included mostly cross-sectional studies therefore we cannot determine a causal relationship between local retail food environment and food choices. Research using longitudinal study designs have been recommended to account for changes in the food environment over time and to improve the quality of evidence [31, 45]. Most studies included in the present review were conducted in the USA, Brazil, and Australia therefore these findings cannot be generalized for other regions. It is recommended that more studies be conducted in European, Asian, and African communities for more evidence on the relationship between local retail food environment and adult food choices.

Conclusions

The present scoping review found confounding evidence on the relationship between adult food choices and the local retail food environment. Inconclusive findings may be partly due to heterogeneity in measures of food environment exposures. Nonetheless, store types such as supermarkets, large grocery stores and farmers markets, lower in-store food prices and food assistance programs were identified as the main facilitators to healthy food access in resource poor-communities, while high food cost and lack of transportation were identified as the major barriers. Interventions to improve the retail food environment and access to healthy food are mostly based in the USA, Canada, and Australia [116, 117]. Regionally specific interventions to improve healthy food access need to be developed. Evidence on food choices within the context of the retail food environment in countries in Asia and Africa is lacking, and research in these regions are needed to enable the develop of interventions to improve access to healthy food [35, 50].

Abbreviations

AHEI	Alternative healthy eating index
ASB	Artificially sweetened beverages
BTG-COMP	Bridging the gap community obesity measures
ESAO-S	Obesogenic environment study food store observation tool
FF	Fast food
FFQ	Food frequency questionnaire
FV	Fruits and vegetables
GIS	Geographic information system
HEI	Healthy eating index
HFSI	Healthy food store index
NEMS	Nutrition environment measures survey
NEMS-C	Nutrition environment measures survey corner store
NEMS-P	Perceived nutrition environment survey
NEMS-R	Nutrition environment measures survey restaurant
PCC	Population, concept and context
PRISMA-ScR	Preferred reporting items for systematic reviews and meta-analyses extension for scoping reviews
SEP	Socioeconomic position
SES	Socioeconomic status
SNAP	Supplemental nutrition assistance program
SSB	Sugar-sweetened beverages

SES	Socioeconomic status
TIABs	Titles and abstracts
WIC	Women, infants, and children

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-023-15996-y.

Additional file 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist.

Additional file 2: Table S1. Database search strategies.

Additional file 3: **Table S2**. Data extraction form.

Acknowledgements
Not applicable.

Authors' contributions
SSM, JH, EK, MF conceptualized the study and designed the manuscript. SSM was responsible for conducting the searches, drafting the manuscript and prepared Figs. 1–2. SSM and TL were responsible for the screening, selection, and data extraction of the studies. SSM with the guidance of MF prepared Tables 1, 2, 3, 4. All authors edited and gave input of the draft and approved the final version of the manuscript.

Funding
The work reported herein was made possible through funding by the South African Medical Research Council through its Division of Research Capacity Development under the Internship Scholarship Programme from funding received from the South African National Treasury. The content hereof is the sole responsibility of the authors and does not necessarily represent the official views of the SAMRC or the funders.

Availability of data and materials
The data supporting the conclusions of this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interest.

Author details
[1]Non-Communicable Diseases Research Unit, South African Medical Research Council, Cape Town, South Africa. [2]School of Public Health, Faculty of Community and Health Sciences, University of the Western Cape, Cape Town, South Africa. [3]Department of Dietetics and Nutrition, University of the Western Cape, Cape Town, South Africa. [4]Division of Chemical Pathology, Department of Pathology, Faculty of Medicine and Health Sciences, University of Stellenbosch, Tygerberg Hospital, Cape Town, South Africa. [5]Centre of Excellence for Nutrition, North-West University, Potchefstroom, South Africa.

Received: 23 November 2022 Accepted: 26 May 2023
Published online: 06 June 2023

References

1. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, Mullany EC, Abate KH, Abbafati C, Abebe Z, et al. Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the global burden of disease study 2017. Lancet. 2019;393:1958–72.
2. Global Panel on Agriculture and Food Systems for Nutrition (GloPAN). Food systems and diets: Facing the challenges of the 21st century. 2016. London, UK. https://glopan.org/sites/default/files/ForesightReport.pdf. Accessed 19 Jul 2020.
3. World Health Organization (WHO). Noncommunicable diseases. 2022. https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases. Accessed 30 Sept 2022
4. Food and Argiculture Organization (FAO): The state of food security and nutrition in the world 2021. In. Rome: FAO; 2021. https://www.fao.org/3/cb4474en/cb4474en.pdf. Accessed 25 Aug 2022.
5. High Level Panel of Experts on Food Security and Nutrition (HLPE). Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. In. Edited by HLPE. Rome; 2017. https://www.fao.org/3/i7846e/i7846e.pdf . Accessed 10 Mar 2022.
6. Swinburn B, Sacks G, Vandevijvere S, Kumanyika S, Lobstein T, Neal B, Barquera S, Friel S, Hawkes C, Kelly B, et al. INFORMAS (International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support): overview and key principles. Obes Rev. 2013;14(Suppl 1):1–12.
7. Food and Argiculture Organization (FAO): Influencing food environments for healthy diets. In. Rome: FAO; 2016. https://www.fao.org/3/i6484e/i6484e.pdf. Accessed 11 Oct 2019.
8. Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: concepts and measures. Am J Health Promot. 2005;19:330–3.
9. Centers for Disease Control and Prevention. Healthier food retail: an action guide for public health practitioners. 2014. U.S. Department of Health and Human Services. Atlanta. https://www.cdc.gov/nccdphp/dnpao/state-local-programs/pdf/healthier-food-retail-guide-full.pdf Accessed 28 Jun 2020.
10. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: a systematic review. Health Place. 2012;18(5):1172–87.
11. Charreire H, Casey R, Salze P, Simon C, Chaix B, Banos A, Badariotti D, Weber C, Oppert JM. Measuring the food environment using geographical information systems: a methodological review. Public Health Nutr. 2010;13:1773–85.
12. Black C, Moon G, Baird J. Dietary inequalities: what is the evidence for the effect of the neighbourhood food environment? Health Place. 2014;27:229–42.
13. Yamaguchi M, Praditsorn P, Purnamasari SD, Sranacharoenpong K, Arai Y, Sundermeir SM, Gittelsohn J, Hadi H, Nishi N. Measures of perceived neighborhood food environments and dietary habits: a systematic review of methods and associations. Nutrients. 2022;14:1788.
14. Sobal J, Bisogni CA, Devine CM, Jastran M: A conceptual model of the food choice process over the life course. In: The psychology of food choice. edn.: Cabi Wallingford UK; 2006: 1–18.
15. Larson N, Story M. A review of environmental influences on food choices. Ann Behav Med. 2009;38(Suppl 1):S56-73.
16. Turner C, Aggarwal A, Walls H, Herforth A, Drewnowski A, Coates J, Kalamatianou S, Kadiyala S. Concepts and critical perspectives for food environment research: a global framework with implications for action in low- and middle-income countries. Glob Food Sec. 2018;18:93–101.
17. Mah CL, Cook B, Rideout K, Minaker LM. Policy options for healthier retail food environments in city-regions. Can J Public Health. 2016;107(Suppl 1):5343.
18. Herforth A, Ahmed S. The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. Food Secur. 2015;7:505–20.
19. Hawkes C, Smith TG, Jewell J, Wardle J, Hammond RA, Friel S, Thow AM, Kain J. Smart food policies for obesity prevention. Lancet. 2015;385:2410–21.
20. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: policy and environmental approaches. Annu Rev Public Health. 2008;29:253–72.
21. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012;70:3–21.
22. Kant AK, Graubard BI. Secular trends in the association of socio-economic position with self-reported dietary attributes and biomarkers in the US population: National Health and Nutrition Examination Survey

(NHANES) 1971–1975 to NHANES 1999–2002. Public Health Nutr. 2007;10:158–67.
23. Minaker LM, Shuh A, Olstad DL, Engler-Stringer R, Black JL, Mah CL. Retail food environments research in Canada: a scoping review. Can J Public Health. 2016;107(Suppl 1):5344.
24. Hilmers A, Hilmers DC, Dave J. Neighborhood disparities in access to healthy foods and their effects on environmental justice. Am J Public Health. 2012;102:1644–54.
25. Zenk SN, Powell LM. US secondary schools and food outlets. Health Place. 2008;14:336–46.
26. Xin J, Zhao L, Wu T, Zhang L, Li Y, Xue H, Xiao Q, Wang R, Xu P, Visscher T, et al. Association between access to convenience stores and childhood obesity: a systematic review. Obes Rev. 2021;22(Suppl 1):e12908.
27. Morland K, Diez Roux AV, Wing S. Supermarkets, other food stores, and obesity: the atherosclerosis risk in communities study. Am J Prev Med. 2006;30:333–9.
28. Giskes K, van Lenthe F, Avendano-Pabon M, Brug J. A systematic review of environmental factors and obesogenic dietary intakes among adults: are we getting closer to understanding obesogenic environments? Obes Rev. 2011;12:e95–106.
29. Evans A, Banks K, Jennings R, Nehme E, Nemec C, Sharma S, Hussaini A, Yaroch A. Increasing access to healthful foods: a qualitative study with residents of low-income communities. Int J Behav Nutr Phys Act. 2015;12:55.
30. Kim M, Budd N, Batorsky B, Krubiner C, Manchikanti S, Waldrop G, Trude A, Gittelsohn J. Barriers to and facilitators of stocking healthy food options: viewpoints of Baltimore City small storeowners. Ecol Food Nutr. 2017;56:17–30.
31. Grimm KAML, Scanlon KS. Centers for Disease Control and prevention (CDC): access to healthier food retailers - United States. MMWR Surveillance Summary. 2011;62(Suppl 3):20–6.
32. Ohri-Vachaspati P, DeWeese RS, Acciai F, DeLia D, Tulloch D, Tong D, Lorts C, Yedidia M. Healthy food access in low-income high-minority communities: a longitudinal assessment-2009-2017. Int J Environ Res Public Health. 2019;16:13.
33. Dubowitz T, Heron M, Bird CE, Lurie N, Finch BK, Basurto-Dávila R, Hale L, Escarce JJ. Neighborhood socioeconomic status and fruit and vegetable intake among whites, blacks, and Mexican Americans in the United States. Am J Clin Nutr. 2008;87:1883–91.
34. Sawyer ADM, van Lenthe F, Kamphuis CBM, Terragni L, Roos G, Poelman MP, Nicolaou M, Waterlander W, Djojosoeparto SK, Scheidmeir M, et al. Dynamics of the complex food environment underlying dietary intake in low-income groups: a systems map of associations extracted from a systematic umbrella literature review. Int J Behav Nutr Phys Act. 2021;18:96.
35. Westbury S, Ghosh I, Jones HM, Mensah D, Samuel F, Irache A, Azhar N, Al-Khudairy L, Iqbal R, Oyebode O. The influence of the urban food environment on diet, nutrition and health outcomes in low-income and middle-income countries: a systematic review. BMJ Glob Health. 2021;6:10.
36. Bivoltsis A, Cervigni E, Trapp G, Knuiman M, Hooper P, Ambrosini GL. Food environments and dietary intakes among adults: does the type of spatial exposure measurement matter? a systematic review. Int J Health Geogr. 2018;17:19.
37. Wilkins E, Radley D, Morris M, Hobbs M, Christensen A, Marwa WL, Morrin A, Griffiths C. A systematic review employing the GeoFERN framework to examine methods, reporting quality and associations between the retail food environment and obesity. Health Place. 2019;57:186–99.
38. An R, He L, Shen MSJ. Impact of neighbourhood food environment on diet and obesity in China: a systematic review. Public Health Nutr. 2020;23:457–73.
39. Osei-Assibey G, Dick S, Macdiarmid J, Semple S, Reilly JJ, Ellaway A, Cowie H, McNeill G. The influence of the food environment on overweight and obesity in young children: a systematic review. BMJ Open. 2012;2:e001538.
40. Zhou P, Li R, Liu K. The neighborhood food environment and the onset of child-hood obesity: a retrospective time-trend study in a mid-sized city in China. Front Public Health. 2021;9:688767.
41. Zhou Q, Zhao L, Zhang L, Xiao Q, Wu T, Visscher T, Zhao J, Xin J, Yu X, Xue H, et al. Neighborhood supermarket access and childhood obesity: a systematic review. Obes Rev. 2021;22 Suppl 1(Suppl 1):e12937.
42. Li Y, Luo M, Wu X, Xiao Q, Luo J, Jia P. Grocery store access and childhood obesity: a systematic review and meta-analysis. Obes Rev. 2021;22 Suppl 1(Suppl 1):e12945.
43. Jia P, Luo M, Li Y, Zheng JS, Xiao Q, Luo J. Fast-food restaurant, unhealthy eating, and childhood obesity: a systematic review and meta-analysis. Obes Rev. 2021;Suppl 1(Suppl 1):e12944.
44. Fleischhacker SE, Evenson KR, Rodriguez DA, Ammerman AS. A systematic review of fast food access studies. Obes Rev. 2011;12:e460–71.
45. Antonio G, Mohansrinivasa C. Exploring the relationship between the fast food environment and obesity rates in the US vs . abroad: a systematic review. J Obes Weight Loss Ther. 2017;8:1–17.
46. Harbers MC, Beulens JWJ, Rutters F, de Boer F, Gillebaart M, Sluijs I, van der Schouw YT. The effects of nudges on purchases, food choice, and energy intake or content of purchases in real-life food purchasing environments: A systematic review and evidence synthesis. Nutr J. 2020;19:103.
47. Engler-Stringer R, Le H, Gerrard A, Muhajarine N. The community and consumer food environment and children's diet: a systematic review. BMC Public Health. 2014;14:522.
48. da Costa Peres CM, Gardone DS, Costa BVL, Duarte CK, Pessoa MC, Mendes LL. Retail food environment around schools and overweight: a systematic review. Nutr Rev. 2020;78:841–56.
49. Williams J, Scarborough P, Matthews A, Cowburn G, Foster C, Roberts N, Rayner M. A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. Obes Rev. 2014;15:359–74.
50. Turner C, Kalamatianou S, Drewnowski A, Kulkarni B, Kinra S, Kadiyala S. Food environment research in low- and middle-income countries: a systematic scoping review. Adv Nutr. 2020;11:387–97.
51. Thornton LE, Crawford DA, Ball K. Neighbourhood-socioeconomic variation in women's diet: the role of nutrition environments. Eur J Clin Nutr. 2010;64:1423–32.
52. Blake CE, Frongillo EA, Warren AM, Constantinides SV, Rampalli KK, Bhandari S. Elaborating the science of food choice for rapidly changing food systems in low-and middle-income countries. Glob Food Sec. 2021;28:100503.
53. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. 2005;8:19–32.
54. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169:467–73.
55. Madlala S, Hill J, Kunneke E, Faber M. Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review protocol. BMJ Open. 2021;11:e044904.
56. Joanna Briggs Institute: Joanna Briggs Institute reviewers' manual: 2014 Edition. In.: Joanna Briggs Institute Adelaide; 2014.
57. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev. 2016;5:210.
58. McHugh ML. Interrater reliability: the kappa statistic. Biochem Med. 2012;22:276–82.
59. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implement Sci. 2010;5:69.
60. Alkon A, Block D, Moore K, Gillis C, DiNuccio N, Chavez N, Alkon AH, Block D, Moore K, Gillis C, et al. Foodways of the urban poor. Geoforum. 2013;48:126–35.
61. Andress L, Fitch C. Juggling the five dimensions of food access: perceptions of rural low income residents. Appetite. 2016;105:151–5.
62. Bardenhagen C, Pinard C, Pirog R, Yaroch A. Characterizing rural food access in remote areas. J Community Health. 2017;42:1008–19.
63. Breyer B, Voss-Andreae A. Food mirages: Geographic and economic barriers to healthful food access in Portland. Oregon Health & Place. 2013;24:131–9.
64. Bridle-Fitzpatrick S. Food deserts or food swamps?: A mixed-methods study of local food environments in a Mexican city. Soc Sci Med. 2015;142:202–13.

65. Burns C, Inglis A, Burns CM, Inglis AD. Measuring food access in Melbourne: access to healthy and fast foods by car, bus and foot in an urban municipality in Melbourne. Health Place. 2007;13:877–85.
66. Cassady D, Jetter KM, Culp J. Is price a barrier to eating more fruits and vegetables for low-income families? J Am Diet Assoc. 2007;107:1909–15.
67. Chen X, Clark J, Chen X, Clark J. Measuring space-time access to food retailers: a case of temporal access disparity in franklin county. Ohio Prof Geogr. 2016;68:175–88.
68. Childs J, Lewis LR. Food deserts and a southwest community of Baltimore City. Food Cult Soc. 2012;15:395–414.
69. de Menezes M, Roux A, Costa B, Lopes A, de Menezes MC, Roux AVD, de Lima Costa BV, Souza Lopes AC. Individual and food environmental factors: association with diet. Public Health Nutr. 2018;21:2782–92.
70. Diehl J, Heard D, Lockhart S, Main D, Diehl JA, Heard D, Lockhart S, Main DS. Access in the food environment: A health equity approach reveals unequal opportunity. JPER. 2020;40:69–81.
71. Diez J, Valiente R, Ramos C, Garcia R, Gittelsohn J, Franco M, Diez J, Valiente R, Ramos C, Garcia R, et al. The mismatch between observational measures and residents' perspectives on the retail food environment: a mixed-methods approach in the Heart Healthy Hoods study. Public Health Nutr. 2017;20:2970–9.
72. Díez J, Conde PM, Urtasun M, López R, Carrero JL, Gittelsohn J, Franco M. in M, Urtasun M, López R, Carrero JL, Gittelsohn J, Franco M: Understanding the local food environment: A participatory photovoice project in a low-income area in Madrid, Spain. Health & Place. 2017;43:95–103.
73. Duran A, de Almeida S, Latorre M, Jaime P, Duran AC, de Almeida SL. Latorre MdRDO, Jaime PC: The role of the local retail food environment in fruit, vegetable and sugar-sweetened beverage consumption in Brazil. Public Health Nutr. 2016;19:1093–102.
74. Flint E, Cummins S, Matthews S, Flint E, Cummins S, Matthews S. Do perceptions of the neighbourhood food environment predict fruit and vegetable intake in low-income neighbourhoods? Health Place. 2013;24:11–5.
75. Gao X, Engeda J, Moore LV, Auchincloss AH, Moore K, Mujahid MS. Longitudinal associations between objective and perceived healthy food environment and diet: The Multi-Ethnic Study of Atherosclerosis. Soc Sci Med. 2022;292:N.PAG-N.PAG.
76. Glickman AR, Clark JK, Freedman DA. A relational approach to evaluate food environments finds that the proximate food environment matters for those who use it. Health Place. 2021;69:102564.
77. Gravina L, Jauregi A, Estebanez A, Fernández-Aedo I, Guenaga N, Ballesteros-Peña S, Díez J, Franco M: Residents' perceptions of their local food environment in socioeconomically diverse neighborhoods: A photovoice study. Appetite. 2020;147:N.PAG-N.PAG.
78. Harbers MC, Middel CNH, Stuber JM, Beulens JWJ, Rutters F, van der Schouw YT. Determinants of food choice and perceptions of supermarket-based nudging interventions among adults with low socioeconomic position: The SUPREME NUDGE Project. Int J Environ Res Public Health. 2021;18:11.
79. Haynes-Maslow L, Parsons SE, Wheeler SB, Leone LA. A qualitative study of perceived barriers to fruit and vegetable consumption among low-income populations, North Carolina, 2011. Prev Chronic Dis. 2013;10:E34–E34.
80. Haynes-Maslow L, McGuirt J, Trippichio G, Armstrong-Brown J, Ammerman A, Leone L. Examining commonly used perceived and objective measures of fruit and vegetable access in low-income populations and their association with consumption. Transl Behav Med. 2020;10:1342–9.
81. Hendrickson D, Smith C, Eikenberry N, Hendrickson D, Smith C, Eikenberry N. Fruit and vegetable access in four low-income food deserts communities in Minnesota. Agric Hum Values. 2006;23:371–83.
82. Holston D, Stroope J, Greene M, Houghtaling B, Holston D, Stroope J, Greene M, Houghtaling B. Perceptions of the food environment and access among predominantly black low-income residents of rural Louisiana communities. Int J Environ Res Public Health. 2020;17:15.
83. Jiang Q, Francis SL, Chapman-Novakofski KM, Wilt M, Carbone ET, Cohen NL. Perceived environmental supports for fruit and vegetable consumption among older adults in the US. Nutr Health. 2021;27:309–19.
84. Jilcott S, Hurwitz J, Moore J, Blake C, Jilcott SB, Hurwitz J, Moore JB, Blake C. Qualitative Perspectives on the use of traditional and nontraditional food venues among middle- and low-income women in eastern North Carolina. Ecol Food Nutr. 2010;49:373–89.
85. Karpyn A, Young C, Collier Z, Glanz K, Karpyn A, Young CR, Collier Z, Glanz K. Correlates of healthy eating in urban food desert communities. Int J Environ Res Public Health. 2020;17:17.
86. Ko L, Enzler C, Perry C, Rodriguez E, Marisal N, Linde S, Duggan C, Ko LK, Enzler C, ra et al: Food availability and food access in rural agricultural communities: use of mixed methods BMC Public Health. 2018;18:634.
87. LeDoux TF, Vojnovic I. Examining the role between the residential neighborhood food environment and diet among low-income households in detroit. Michigan Appl Geogr. 2014;55:9–18.
88. Leonard T, McKillop C, Carson J, Shuval K, Leonard T, McKillop C, Carson JA, Shuval K. Neighborhood effects on food consumption. J Behav Exp Econ. 2014;51:99–113.
89. Libman K. Has New York City fallen into the local trap? Public Health. 2015;129:310–7.
90. MacNell L, Elliott S, Hardison-Moody A, Bowen S, MacNell L, Elliott S, Hardison-Moody A, Bowen S. Black and Latino urban food desert residents' perceptions of their food environment and factors that influence food shopping decisions. J Hunger Environ Nutr. 2017;12:375–93.
91. Pessoa MC, Mendes LL, Gomes CS, Martins PA, Velasquez-Melendez G. Food environment and fruit and vegetable intake in a urban population: a multilevel analysis. BMC Public Health. 2015;15:1–8.
92. Rodriguez R, Grahame K, Rodriguez RM, Grahame KM. Understanding food access in a rural community an ecological perspective. Food Cult Soc. 2016;19:171–94.
93. Rummo P, Meyer K, Boone-Heinonen J, Jacobs D, Kiefe C, Lewis C, Steffen L, Gordon-Larsen P, Rummo PE, Meyer KA, et al. Neighborhood availability of convenience stores and diet quality: findings from 20 years of follow-up in the coronary artery risk development in young adults study. Am J Public Health. 2015;105:E65–73.
94. Sharkey JR, Johnson CM, Dean WR, Horel SA. Association between proximity to and coverage of traditional fast-food restaurants and non-traditional fast-food outlets and fast-food consumption among rural adults. Int J Health Geogr. 2011;10:37–47.
95. Tach L, Amorim M, Tach L, Amorim M. Constrained, convenient, and symbolic consumption: neighborhood food environments and economic coping strategies among the urban poor. J Urban Health. 2015;92:815–34.
96. Thornton L, Jeffery R, Crawford D, Thornton LE, Jeffery RW, Crawford DA. Barriers to avoiding fast-food consumption in an environment supportive of unhealthy eating. Public Health Nutr. 2013;16:2105–13.
97. Thornton LE, Lamb KE, Tseng M, Crawford DA, Ball K. Does food store access modify associations between intrapersonal factors and fruit and vegetable consumption? Eur J Clin Nutr. 2015;69:902–6.
98. Valdez Z, Ramírez AS, Estrada E, Grassi K, Nathan S. Community perspectives on access to and availability of healthy food in rural, low-resource. Latino Communities Prev Chronic Dis. 2016;13:1–11.
99. Vallianatos M, Azuma AM, Gilliland S, Gottlieb R. Food access, availability, and affordability in 3 Los Angeles communities, Project CAFE, 2004–2006. Prev Chronic Dis. 2010;7:A27.
100. Walker R, Fryer C, Butler J, Keane C, Kriska A, Burke J, Walker RE, Fryer CS, Butler J, Keane CR, et al. Factors influencing food buying practices in residents of a low-income food desert and a low-income food oasis. J Mix Methods Res. 2011;5:247–67.
101. Wang H, Qiu F. Fresh food access revisited. Cities. 2016;51:64–73.
102. Waters C, Zoellner J, Estabrooks P, Hill J, Waters CN, Zoellner JM, Estabrooks PA, Hill JL. Is the availability of healthy foods related to fruit and vegetable consumption in a rural, health-disparate region? J Hunger Environ Nutr. 2018;13:289–303.
103. Williams L, Ball K, Crawford D. Why do some socioeconomically disadvantaged women eat better than others? An investigation of the personal, social and environmental correlates of fruit and vegetable consumption. Appetite. 2010;55:441–6.
104. Zenk S, Odoms-Young A, Dallas C, Hardy E, Watkins A, Hoskins-Wroten J, Holl L, Zenk SN, Odoms-Young AM, et al. "You Have to Hunt for the Fruits, the Vegetables": Environmental barriers and adaptive strategies to acquire food in a low-income African American neighborhood. Health Educ Behav. 2011;38:282–92.
105. Zhao A, McGowan C, Zenk S, Kershaw K, Zhao AW, McGowan CC, Zenk SN, Kershaw KN. Associations of the consumer food environment with eating behaviours and BMI. Public Health Nutr. 2020;23:3197–203.

106. Herforth A, Bai, Y., Venkat, A., Mahrt, K., Ebel, A. & Masters, W.A.: Cost and affordability of healthy diets across and within countries. Background paper for the state of food security and nutrition in the world 2020. FAO Agricultural Development Economics Technical Study No. 9. In. Rome: FAO; 2020. https://www.fao.org/3/cb2431en/cb2431en.pdf Accessed 4 Oct 2021.
107. Liu JL, Han B, Cohen DA. Beyond neighborhood food environments: distance traveled to food establishments in 5 US Cities, 2009–2011. Prev Chronic Dis. 2015;12:E126.
108. Gittelsohn J, Trude A, Kim H. Pricing strategies to encourage availability, purchase, and consumption of healthy foods and beverages: a systematic review. Prev Chronic Dis. 2017;14:E107.
109. Olstad DL, Ancilotto R, Teychenne M, Minaker LM, Taber DR, Raine KD, Nykiforuk CIJ, Ball K. Can targeted policies reduce obesity and improve obesity-related behaviours in socioeconomically disadvantaged populations? A systematic review Obes Rev. 2017;18:791–807.
110. Allcott H, Diamond R, Dubé J-P, Handbury J, Rahkovsky I, Schnell M. Food deserts and the causes of nutritional inequality. Q J Econ. 2019;134:1793–844.
111. The Food Trust: Healthy Corner Store Initiative Overview. 2014. https://thefoodtrust.org/wp-content/uploads/2022/07/healthy-corner-store-overview.original.pdf. Accessed 18 Jun 2019.
112. Ferguson M, O'Dea K, Holden S, Miles E, Brimblecombe J. Food and beverage price discounts to improve health in remote Aboriginal communities: Mixed method evaluation of a natural experiment. ANZJPH. 2017;41:32–7.
113. Hobin E, Bollinger B, Sacco J, Liebman E, Vanderlee L, Zuo F, Rosella L, L'Abbe M, Manson H, Hammond D. Consumers' response to an on-shelf nutrition labelling system in supermarkets: evidence to inform policy and practice. Milbank Q. 2017;95:494–534.
114. Meghan L. Exploring sales data during a healthy corner store intervention in Toronto: The Food Retail Environments Shaping Health (FRESH) project. HPCDP. 2017;37:342.
115. Gittelsohn J, Laska MN, Karpyn A, Klingler K, Ayala GX. Lessons learned from small store programs to increase healthy food access. Am J Health Behav. 2014;38:307–15.
116. Mah CL, Luongo G, Hasdell R, Taylor NGA, Lo BK. A systematic review of the effect of retail food environment interventions on diet and health with a focus on the enabling role of public policies. Curr Nutr Rep. 2019;8:411–28.
117. Luongo G, Skinner K, Phillipps B, Yu Z, Martin D, Mah CL. The retail food environment, store foods, and diet and health among indigenous populations: a scoping review. Curr Obes Rep. 2020;9:288–306.

Publisher's Note

CHAPTER 5: MANUSCRIPT TWO

Chapter 5 was published as a peer-reviewed research article: Madlala SS, Hill J, Kunneke E, Kengne AP, Peer N, Faber M. Dietary Diversity and its Association with Nutritional Status, Cardiometabolic Risk Factors and Food Choices of Adults at Risk for Type 2 Diabetes Mellitus in Cape Town, South Africa. *Nutrients*. 2022; 14(15):3191. https://doi.org/10.3390/nu14153191

5.1 Summary

This paper describes the association between DD and nutritional status, cardiometabolic risk factors and food choices of 693 adults, 25-65 years old, at risk for T2DM. Findings show that 70.4% of participants had low DD (< 5 food groups). DD was not associated with nutritional status (BMI and WHR) or cardiometabolic risk factors except for serum TG and high DD that correlated with unhealthy food choices.

5.2 Contribution to the thesis

This paper contributes to the second objective of the thesis: To determine the relationship of DD with nutritional status (anthropometric status), cardiometabolic risk factors (plasma glucose levels and serum lipids) and food choices of adults at risk of T2DM in resource-poor communities around Cape Town. Results provide insight into whether the DDS indicator is associated with health outcomes or intake of unhealthy foods and inform on the usefulness of the DDS as a tool in NCD research.

5.3 Contribution of the candidate

The candidate designed the study with input from the supervisor and co-supervisors. The candidate cleaned the extracted data (Appendix 7- dietary questionnaire), conducted the data analysis with assistance from the supervisor, data interpretation and wrote the first draft. The supervisor and co-supervisors provided critical input on the draft, subsequent drafts, and the comments from the journal's peer-review process. The candidate led the submission process, including the revised version. The reviewer comments and author responses are available in Appendix 8. This research was presented as a poster at the International Congress of Dietetics (ICD) 2021 conference: 1-3 September 2021. The Abstract, "Dietary diversity and its association with weight status and food choices of females at risk of diabetes in resource-poor

communities", was published in the ICD Abstract Book (South African Journal of Clinical Nutrition 2021; 34(3).

We recently noticed that Figure 4 on pages 15-16 in the published article is incorrect. The correct figure was included in the original manuscript that was submitted to the journal, but unfortunately an error occurred during the revision process. In the published article, all values in the text are based on the original (correct) Figure 4, and the Discussion and Conclusion are not affected. An email to the editor has been sent with the corrigendum to Nutrients (Appendix 9). The correct figure is attached after the article.

nutrients

MDPI

Article

Dietary Diversity and its Association with Nutritional Status, Cardiometabolic Risk Factors and Food Choices of Adults at Risk for Type 2 Diabetes Mellitus in Cape Town, South Africa

Samukelisiwe S. Madlala [1,2,*], Jillian Hill [1], Ernesta Kunneke [3], Andre P. Kengne [1,4], Nasheeta Peer [1,4] and Mieke Faber [1,3]

[1] Non-Communicable Diseases Research Unit, South African Medical Research Council, Cape Town 7505, South Africa
[2] School of Public Health, Faculty of Community and Health Sciences, University of the Western Cape, Bellville 7535, South Africa
[3] Department of Dietetics and Nutrition, University of the Western Cape, Bellville 7535, South Africa
[4] Department of Medicine, University of Cape Town, Cape Town 7935, South Africa
* Correspondence: samukelisiwe.madlala@mrc.ac.za

Abstract: In South Africa, the nutrition transition has led to unhealthy diets lacking variety, contributing to the rise in overweight, obesity and diet-related noncommunicable diseases. Using baseline screening data of the South African Diabetes Prevention Programme (SA-DPP) study, this study aims to determine the relationship of dietary diversity (DD) with nutritional status, cardiometabolic risk factors and food choices of adults at risk of type 2 diabetes in resource-poor communities around Cape Town. Data of 693 adults, 25–65 years old were analysed. This included socio-demographic information, anthropometric measurements, biochemical assessments, food groups consumed the previous day and consumption frequency of certain foods to reflect food choices. The Minimum Dietary Diversity for Women (MDD-W) indicator was calculated; 70.4% of participants had low DD (<5 food groups). Low DD was associated with elevated serum triglycerides [AOR: 1.49, 95% CI (1.03, 2.15) $p = 0.036$]. The DD score was positively correlated (although weak) with the unhealthy food score ($r = 0.191$, $p = 0.050$) and sugary food score ($r = 0.139$, $p < 0.01$). Study participants at risk of diabetes consumed a diet low in DD; however, DD was not associated with nutritional status or cardiometabolic risk factors except for serum triglycerides.

Keywords: dietary diversity; nutritional status; food choices; adults; diabetes risk; cardiometabolic; South Africa

Citation: Madlala, S.S.; Hill, J.; Kunneke, E.; Kengne, A.P.; Peer, N.; Faber, M. Dietary Diversity and its Association with Nutritional Status, Cardiometabolic Risk Factors and Food Choices of Adults at Risk for Type 2 Diabetes Mellitus in Cape Town, South Africa. *Nutrients* **2022**, *14*, 3191. https://doi.org/10.3390/nu14153191

Academic Editor: Didac Mauricio

Received: 24 June 2022
Accepted: 17 July 2022
Published: 4 August 2022

1. Introduction

Recent estimates show that seven out of ten leading causes of death worldwide are non-communicable diseases (NCDs), with type 2 diabetes mellitus (hereafter referred to as diabetes) being a key contributor to global mortality [1]. The global burden of diabetes is substantial with 537 million people between 20 and 79 years having diabetes [2]. In Africa, an estimated 24 million people had diabetes in 2017 [2]. South Africa has the largest population of people with diabetes in sub-Saharan Africa, with approximately 4.2 million people between the ages of 20 and 79 years with diabetes [2]. Diabetes is the sixth leading cause of death in South Africa [3]; accounting for 7% of NCD-related mortality [4]. Diabetes frequently clusters with overweight/obesity and dyslipidaemia, and all are common risk factors for cardiovascular diseases (CVDs) [5]. The increased incidence of diabetes and other NCDs in South Africa is influenced by urbanisation leading to lifestyle changes such as the uptake of unhealthy diets and physical inactivity. This contributes to the development of overweight/obesity and subsequent diabetes [6].

Quality diets are associated with adequate intake of micro- and macronutrients, healthy dietary patterns, and reduced risk of diet-related diseases. Diet quality consists

of four components namely adequacy, moderation, balance and variety [7]. Consuming a variety of nutritious foods is recommended globally through food-based dietary guidelines (FBDGs) [8]. While validated dietary diversity (DD) indicators can be used as a proxy for micronutrient adequacy [9], DD scores can also be used to reflect the variety of nutritious food in the diet. Whilst diverse diets are said to prevent chronic diseases [10], research on DD measures and health outcomes has yielded conflicting results. Some studies suggest that DD is associated with reduced risk for the development of NCDs [11–13], while others showed DD to be associated with overweight and obesity in adults and the occurrence of NCDs [14,15]. According to an American Heart Association science advisory, greater DD is not associated with better diet quality and healthy weight status [16]. Some studies showed DD to be associated with higher intakes of processed foods, refined grains and sugar-sweetened beverages (SSB) and lower intakes of unrefined foods, fish, fruits and vegetables [14,16]. In contrast, a study in young female adults showed that high DD was associated with consumption of healthy foods and lower consumption of high fat foods and refined grains [17]. The lack of clarity on the definition for DD and how it is measured across various settings could have contributed to the inconsistent findings across studies. Moreover, there is a wide variety of DD measures which differ in terms of food groups selected, food items counted and reference periods [16,18]. There is a need to develop better indicators that measure healthy, unhealthy and imbalanced DD. Such indicators would assist in addressing the burden of malnutrition especially in low-income populations [18].

South Africa is classified as an upper middle-income country, and the ongoing nutrition transition has led to a significant rise in the consumption of processed foods, soft drinks and fast foods [19]; simultaneously, the adult population in general consume a diet low in variety [20,21]. The lack of dietary diversity among the population may be due to various factors such as low incomes and unemployment, which may limit vulnerable population groups having access to a variety of healthy foods [21]. The widespread intake of cheap unhealthy foods contributes to high overweight and obesity rates and subsequently to NCDs which are the main disease burden in South Africa [20,22]. Within this context, the aim of this study was to determine DD and its association with nutritional status (anthropometric status), cardiometabolic risk factors (plasma glucose levels and serum lipids) and food choices (intake of unhealthy foods and food practices) in adults at risk of type 2 diabetes.

2. Materials and Methods

2.1. Study Design and Population

This is a cross-sectional study using baseline screening data collected between August 2017 and July 2019 among 25–65-year-old Black and Mixed ancestry adults enrolled in the South African Diabetes Prevention Programme (SA-DPP). The SA-DPP is a cluster randomised control trial with the aim to prevent the progression of pre-diabetes to diabetes in resource poor communities in the Cape Town metropolis of the Western Cape province in South Africa. The methods of the SA-DPP have been described elsewhere [23]. Briefly, Geographical Information Systems mapping was used to randomly select households within 16 suburbs/townships to identify potential participants. When the random sampling was proving to be unsuccessful, self-selection sampling was used to recruit participants in the townships [23]. The townships and suburbs were chosen based on previous studies that showed that those who are resource poor and at high risk of diabetes are located in these areas [24,25]. The average household monthly income for Cape Town residents is R3500 ($230.94) [26]. Poor urban households in Cape Town spend one-third of their total household income on food. In 2021 the unemployment rate in the Western Cape province was reported as 21.6% [27]. In Cape Town, the Black population has the highest unemployment rate (31.0%) followed by the Mixed-ancestry population (23.5%) [28].

2.2. Ethics

The baseline survey of the SA-DPP was approved by the ethics committee of the South African Medical Research Council (approval no. EC018-7/2015). The present study is part of a PhD study, which was approved by the University of the Western Cape Biomedical Research Ethics Committee (approval no. BM20/1/1).

2.3. Diabetes Risk Screening

Diabetes risk screening was done in two phases. Phase one involved risk screening of community members, whereby trained fieldworkers took anthropometric and blood pressure (BP) measurements and administered a short questionnaire (age, gender, ethnicity, previous diagnosis of diabetes and medical family history). In this phase, risk of diabetes was determined using the African Diabetes Risk Score (ADRS), which is based on age, body mass index (BMI), hypertension and waist circumference (WC) [23]. Participants identified as being at high risk were invited to participate in the second phase which was conducted at the research clinic at the Non-communicable Diseases Research Unit of the South African Medical Research Council.

The second phase involved a more comprehensive assessment to identify those at high risk of developing diabetes, including oral glucose tolerance tests (OGTTs). Anthropometric and BP measurements were repeated by trained fieldworkers. Blood samples for glucose and lipids were collected by a qualified nurse from each participant after a 10 h overnight fast. Participants completed an interviewer-administered questionnaire that included socio-demographic information, personal and family medical history, dietary history, alcohol and tobacco use. Eligible participants had to be 25–65 years old, fluent in English and/or Afrikaans or IsiXhosa, able to give informed consent and willing to participate in the intervention trial. Individuals previously diagnosed with diabetes, bedridden, pregnant/breastfeeding and those receiving either cancer and/or tuberculosis treatment (current or during the past 3 months) were excluded.

2.4. Socio-Demographic and Behavioural Risk Factors

Socio-demographic data included participant age, gender, ethnicity, education level, employment status, type of housing and household income. The participants were asked about their use of tobacco and alcohol consumption (WHO STEPwise surveillance questionnaire) [29].

2.5. Anthropometric Measurements

Anthropometric measurements were taken twice by trained fieldworkers according to standard procedure [30]. Anthropometric measurements included weight (kg), height (cm), WC (cm) and hip circumference (HC) (cm). Participants were weighed using the UC-321 Precision health scale wearing light clothing and without shoes. Weight was recorded in kilograms to the nearest 0.1 kg. Standing height was measured using a portable SECA Leicester height measure. Participants were requested to stand up straight, feet flat and head in the Frankfort horizontal plane position. The WC measurement was taken midway between the lower border of lowest rib and upper border of iliac crest/pelvic bone using a SECA 201 flexible measuring tape. The HC measurement was measured around the widest portion of the buttocks, with the tape measure parallel to the floor. Height, WC and HC measurements were recorded to the nearest 0.1 cm.

Weight and height measurements were used to calculate BMI [weight (kg)/height $(m)^2$]. This was categorised as either underweight (BMI < 18.5 kg/m^2), normal weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2) or obese (BMI $\geq$ 30 kg/m^2) [31]. Waist-to-hip ratio (WHR) was calculated by dividing the WC by the HC. According to the World Health Organisation (WHO) a normal WHR is 0.90 cm or less for males and 0.85 cm or less for females [32].

2.6. Biomedical Indicators

Fasting blood samples were taken for glucose and lipid levels, followed by a standard OGTT using 75 g glucose load diluted in 250 mL of water administered to participants and blood sample taken after 120 min. Blood samples were analysed at the PathCare laboratories for 2-h OGTT, glycated haemoglobin (HbA1c), serum total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C). The enzymatic hexokinase method was used to determine plasma glucose levels (Beckman AU, Beckman Coulter, Cape Town, South Africa). The HbA1c was measured using high performance liquid chromatography (Biorad Variant Turbo, Bio-Rad, Johannesburg, South Africa). Enzymatic colorimetric methods were used to measure HDL-C and TG. The LDL-C was calculated using the Friedewalds formula.

Glycaemic status was defined according to the 1998 WHO definition [33]. Normoglycemia was defined as fasting plasma glucose (FPG) $\leq$ 6 mmol/L and 2 h glucose load < 7.8 mmol/L; and high-risk for developing type 2 diabetes (prediabetes) as FPG 6.1–7 mmol/L and 2-h glucose load $\geq$ 7.8–11.1 mmol/L. Diabetes was defined as FPG > 7 mmol/L and/or 2-h glucose load > 11.1 mmol/L. Abnormal blood lipid profile was defined as TC $\geq$ 5 mmol/L, HDL-C < 1.2 mmol/L, LDL-C $\geq$ 3 mmol/L and TG > 1.5 mmol/L [34].

2.7. Food Groups Consumed and Dietary Diversity

Dietary diversity of study participants was assessed using the Minimum Dietary Diversity for Women (MDD-W) [9]. The MDD-W is a validated population-level indicator for women of reproductive age and reflects the micronutrient adequacy component of diet quality [9]. There is no DD measure available that has been validated specially for men or older women, and the MDD-W indicator has been used as measure of DD in studies with both men and women of all ages [35–37]. The MDD-W as measure of DD was therefore used in this study, regardless of age and gender. Participants were asked to recall all foods and drinks consumed the previous day and night, which were then allocated to pre-defined food groups. Dietary diversity was based on the 10 food groups of the MDD-W. The 10 food groups were namely: (1) grains, roots and tubers, (2) pulses (beans, peas and lentils), (3) nuts and seeds, (4) dairy, (5) meat, poultry and fish, (6) eggs, (7) dark green leafy vegetables, (8) other vitamin A rich fruits and vegetables, (9) other vegetables and (10) other fruits [9]. For each food group, a score of 1 was given if at least one food item within the food group was consumed in the preceding 24 h, and a score of 0 was given if no food item within the food group was consumed. The scores of the 10 food groups were summed to obtain the DD score. Participants with a DD score < 5 were classified as having low DD and those with DD scores $\geq$ 5 were classified as having adequate DD [9]. In addition, participants were categorised into quintiles based on the DD score, and food groups consumed by at least 50% of participants within each quintile were determined. An unhealthy food subscale score was calculated by summing the scores of five unhealthy food groups consumed in the preceding 24 h. These food groups were: (1) oils and fats, (2) sweets, (3) savoury and fried snacks, (4) SSB and (5) biscuits, and cakes and confectionery. The unhealthy food score could therefore range from 0–5.

2.8. Food Choices and Practices

Frequency of intake over the past seven days was recorded for unhealthy foods such as processed meat, food covered with pastry or crumbs, food deep-fried in oil/fat, butter, ghee, fat, margarine or oil, mayonnaise or salad dressing, cookies, sweets, snacks, salty foods, sugar-sweetened cold drink, food from fast food outlets excluding beverages and fried food bought from street vendors. Frequency of intake of fruit juice, fruits and vegetables over the past seven days was also recorded. Frequency of consumption was recorded as none, 1–3 times, 4–6 days and every day. A sugary food score was calculated based on the frequency of consumption for three foods, namely cookies, sweets and SSB. For each of these three foods, frequency of consumption was scored as none = 0, 1–3 times = 2,

4–6 times = 5 and every day = 7. The scores for the three foods were summed to get a total sugary food score, which could range from 0–21. The score was then recategorised into food frequency categories; 0 = none, 1–6 = 1–3 times/week, and 7–21 = at least 4 times/week.

The main reasons preventing daily intake of fruit and vegetables respectively were recorded. Participants reported food preferences concerning eating red meat with or without fat, eating chicken with or without the skin, adding salt to food, and the amount of margarine, butter or fat usually spread on bread, crackers or scones.

2.9. Statistical Analysis

Data were analysed using the statistical software package IBM SPSS for Windows version 27 (Armonk, New York, NY, USA). The Kolmogorov–Smirnov test and visual inspection of histograms, normal Q-Q plots and box plots were used to test for normality of the data distribution. Continuous variables are presented as means and standard deviations for normally distributed variables and as median and interquartile range for non-normally distributed variables. Categorical variables are presented as counts and percentages. Differences between groups were tested using the Mann Whitney U test for continuous variables that were not normally distributed, and the Pearson chi-square test for categorical variables using Bonferroni corrections. Since the data were not normally distributed, Spearman correlation analysis was done to determine the relationship of the DD score with the unhealthy food and sugary food scores, respectively. Binary and multinomial logistic regression analyses were used to calculate odds ratios (OR) and 95% confidence intervals (95% CI) for the associations between DD (low vs. adequate) as the independent variable, and dependent variables BMI (normal weight vs. overweight and obese), WHR (normal vs. high), glycaemic status (normoglycaemia vs. prediabetes vs. diabetes), TC (normal vs. elevated), HDL-C (normal vs. low), LDL-C (normal vs. elevated) and TG (normal vs. elevated). Adjusted OR (AOR) were calculated by adjusting for gender and ethnicity (model 1), and gender, ethnicity and age (model 2). All statistical tests were considered significant at $p < 0.05$.

3. Results

3.1. Socio-Demography and Behavioural Risk Factors

Baseline data were available for 700 participants, but seven participants were excluded due to incomplete/missing data. Data analysis was therefore based on 693 participants. The mean age of the study participants was 50.9 ± 9.1 years. The majority of the participants (n = 488, 70.4%) consumed a diet of low DD (fewer than 5 food groups) and 205 (29.6%) consumed a diet of adequate DD (at least 5 food groups). Table 1 shows the sociodemographic characteristics of the total study sample and for the two DD categories. Most participants were female (81.1%). Unemployment was high (43.7%), and the majority (71.6%) had low household incomes [≤R3200 (US $200.27)]. Most participants consumed alcohol (63.9%) and a quarter smoked tobacco. Participants with low DD vs. adequate DD had less formal schooling (<grade 12; 86.0% vs. 79.9%) were less likely to live in built formal unit/privately owned housing (32.2% vs. 42.9%) and had lower household income [≤R 3200 (US $200.27); 75.4% vs. 62.6%].

Table 1. Socio-demographic characteristics and behavioural risk factors of the study sample across dietary diversity categories.

Variable	Total (n = 693)	DD Score < 5 (n = 488)	DD Score ≥ 5 (n = 205)	p Value [a]
Number of participants	693 (100)	488 (70.4)	205 (29.6)	
Age, years, n (%)				0.117
25–44 years	155 (22.4)	119 (24.4)	36 (17.6)	
45–54 years	256 (36.9)	179 (36.7)	77 (37.6)	
55–65 years	282 (40.7)	190 (38.9)	92 (44.9)	

Table 1. *Cont.*

Variable	Total (n = 693)	DD Score < 5 (n = 488)	DD Score ≥ 5 (n = 205)	p Value [a]
Gender, n (%)				0.151
Male	131 (18.9)	99 (20.3)	32 (15.6)	
Female	562 (81.1)	389 (79.7)	173 (84.4)	
Ethnicity [b], n (%)				0.392
Mixed-Ancestry	281 (40.7)	193 (39.6)	88 (43.1)	
Black	410 (59.3)	294 (60. 4)	116 (56.9)	
Marital status [b], n (%)				0.495
Single	217 (31.5)	161 (33.2)	56 (27.5)	
Married	296 (43.0)	202 (41.6)	94 (46.1)	
Divorced	72 (10.4)	53 (10.9)	19 (9.3)	
Widowed	64 (9.3)	43 (8.9)	21 (10.3)	
Other [c]	40 (5.8)	26 (5.4)	14 (6.9)	
Education level [b], n (%)				**0.038**
<Grade 12	580 (84.2)	419 (86.0)	161 (79.7)	
≥Grade 12	109 (15.8)	68 (14.0)	41 (20.3)	
Occupation, n (%)				0.445
Employed	237 (35.0)	161 (33.6)	76 (38.2)	
Unemployed [d]	296 (43.7)	216 (45.1)	80 (40.2)	
Pensioner/Disability grant	145 (21.4)	102 (21.3)	43 (21.6)	
Type of housing, n (%)				**0.024**
Built formal unit/privately owned	244 (35.4)	157 (32.2)	87 (42.9) *	
Council/core house	273 (39.6)	199 (40.9)	74 (36.5)	
Informal shack/shelter/hostel/other	173 (25.1)	131 (26.9)	42 (20.7)	
Monthly household income, n (%)				**<0.001**
R0–R3200	494 (71.6)	367 (75.4)	127 (62.6) *	
R3201–R6400	117 (17.0)	77 (15.8)	40 (19.7)	
R6401–R51200	79 (11.4)	43 (8.8)	36 (17.7) *	
Alcohol consumption during last 12 months, n (%)				0.165
≥5 days per week	4 (0.6)	3 (0.6)	1 (0.5)	
1–4 days per week	59 (8.5)	49 (10.0)	10 (4.9)	
Seldom (≤3 days per month)	187 (27.0)	131 (26.8)	56 (27.3)	
None	443 (63.9)	305 (62.5)	138 (67.3)	
Smoking status, n (%)				0.391
Non-smoker	519 (74.9)	361 (74.0)	158 (77.1)	
Smoker	174 (25.1)	127 (26.0)	47 (22.9)	

Data presented as n (%). DD—dietary diversity. [a] Chi-square test used for categorical variables, [b] Missing data were observed for some participants n = 4; [c] Other includes living as married; [d] Unemployed includes students and homemakers. * Significant difference between DD score categories at $p < 0.05$ level. Bold p value-significant at $p < 0.05$ & $p < 0.001$ level.

3.2. Dietary Diversity Food Groups

Food groups consumed the previous day are presented in Figure 1. Of the 10 healthy food groups, the most consumed food groups were grains/roots/tubers (97.1% of participants) and meat/poultry/fish (82.8%). The least consumed food groups were dark-green leafy vegetables (5.2%), nuts and seeds (7.9%) and pulses (12.1%). A significant difference was noted between the two DD categories for all food groups except for grains/root/tubers; a higher proportion of participants with DD score ≥ 5 consumed foods from the different food groups. Regarding unhealthy food groups, a higher percentage of participants with adequate DD in comparison to those with low DD consumed oils and fats (54.9% vs. 70.2%) and sweets (19.9% vs. 30.7%) during the recall period (Shown in Figure 2). Spearman correlation analysis showed a weak positive relationship between the DD score and the unhealthy foods score (r = 0.191, p = 0.050).

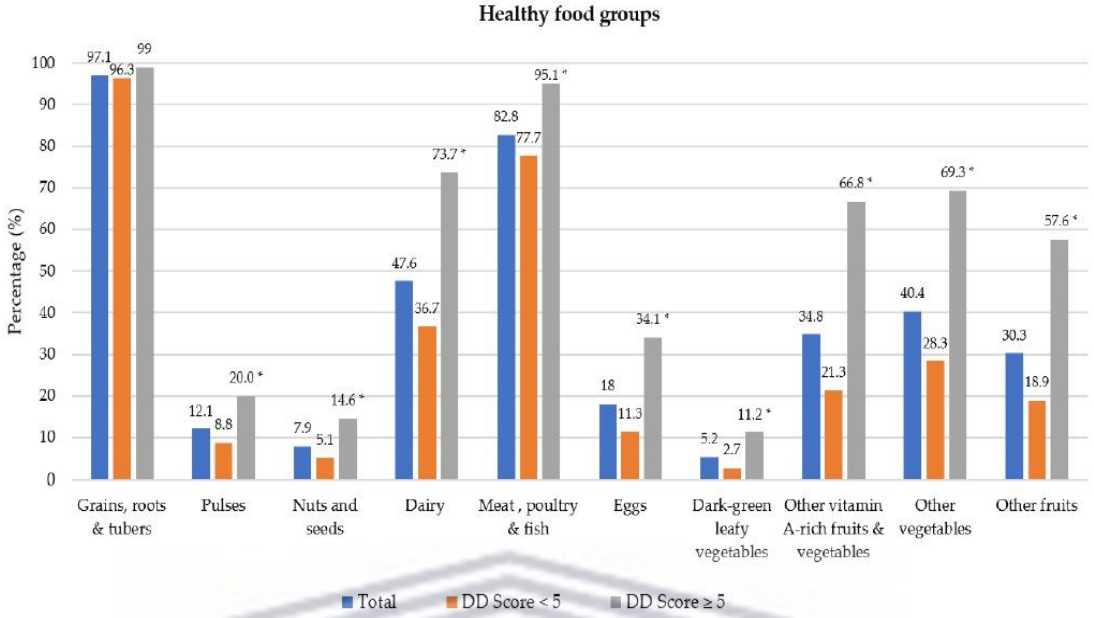


Figure 1. Percentage of participants who consumed healthy food groups the previous day by dietary diversity (DD) score categories. * Significant difference between DD score categories at $p < 0.001$ level, Chi-square test.

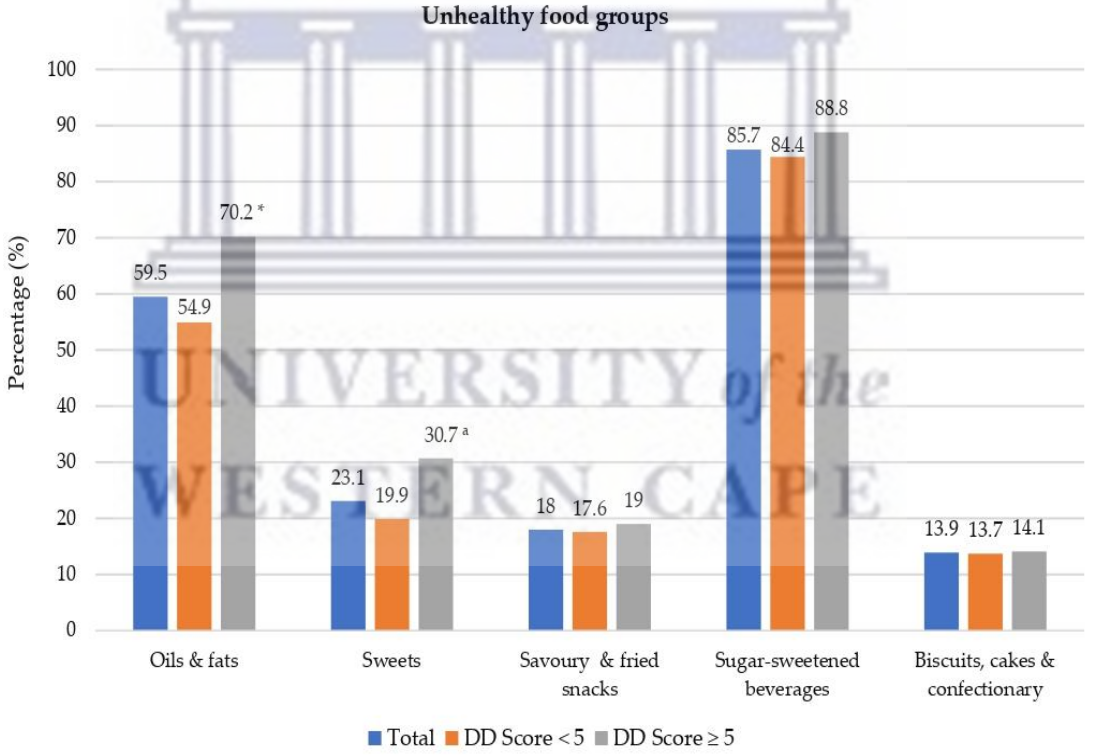


Figure 2. Percentage of participants who consumed unhealthy food groups the previous day dietary diversity (DD) score categories. * Significant difference between DD score categories at $p < 0.001$ level, Chi-square test. [a] Significant difference between DD score categories at $p < 0.05$ level, Chi-square test. Sugar-sweetened beverages include tea/coffee with sugar, cool drink, fruit juice, flavoured water and energy drink.

Table 2 shows the food groups that were predominantly consumed (by at least 50% of participants) within each DD score quintile. Grains/roots/tubers and meat/poultry/fish were the only two food groups that were consumed by at least 50% of participants in the two lowest DD quintiles. As DD increased, dairy became predominant, followed by other vitamin A-rich fruits and vegetables, and other vegetables. Other fruit and eggs were predominantly consumed in the highest DD quintile only.

Table 2. Food groups consumed by more than 50% of participants per dietary diversity score quintile for the total study sample.

Quintile 1 (1–2 Groups) (n = 128)	Quintile 2 (3 Food Groups) (n = 175)	Quintile 3 (4 Food Groups) (n = 185)	Quintile 4 (5 Food Groups) (n = 139)	Quintile 5 (≥ 6 Food Groups) (n = 66)
Grains/roots/tubers Meat/poultry/fish	Grains/roots/tubers Meat/poultry/fish	Grains/roots/tubers Meat/poultry/fish Dairy	Grains/roots/tubers Meat/poultry/fish Dairy Other vitamin A-rich fruits and vegetables * Other vegetables	Grains/roots/tubers Meat/poultry/fish Dairy Other vitamin A-rich fruits and vegetables Other vegetables Other fruits Eggs

* Other than dark green leafy vegetables.

3.3. Food Choices

The frequency of consumption of selected foods was used to reflect food choices. Figure 3 shows the frequency of consumption of selected unhealthy foods. Participants with adequate DD more frequently consumed foods covered with pastry/crumbs, butter/ghee/margarine/oil (at least four times/week), cookies, sweets and salty foods (1–3 times/week) than participants with low DD. The Spearman correlation test showed a weak positive relationship between the DD score and the sugary food score (r = 0.139, $p < 0.01$).

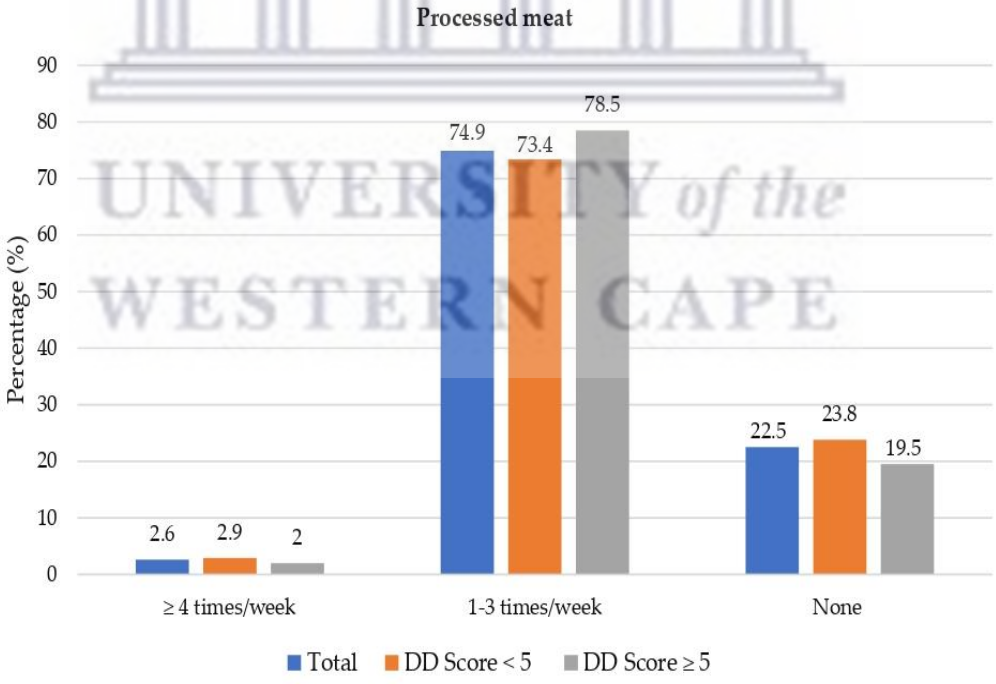


Figure 3. *Cont.*

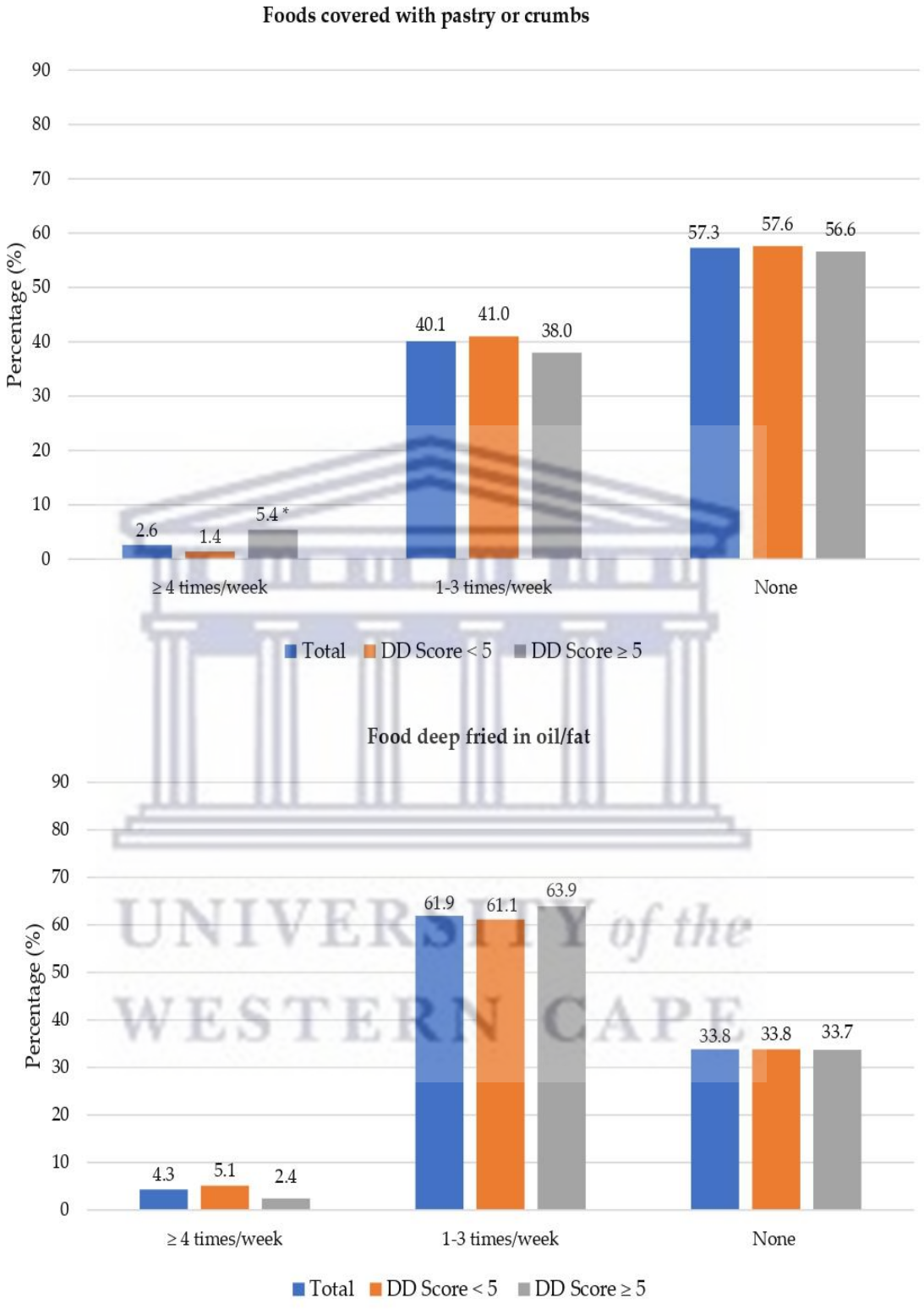


Figure 3. *Cont.*

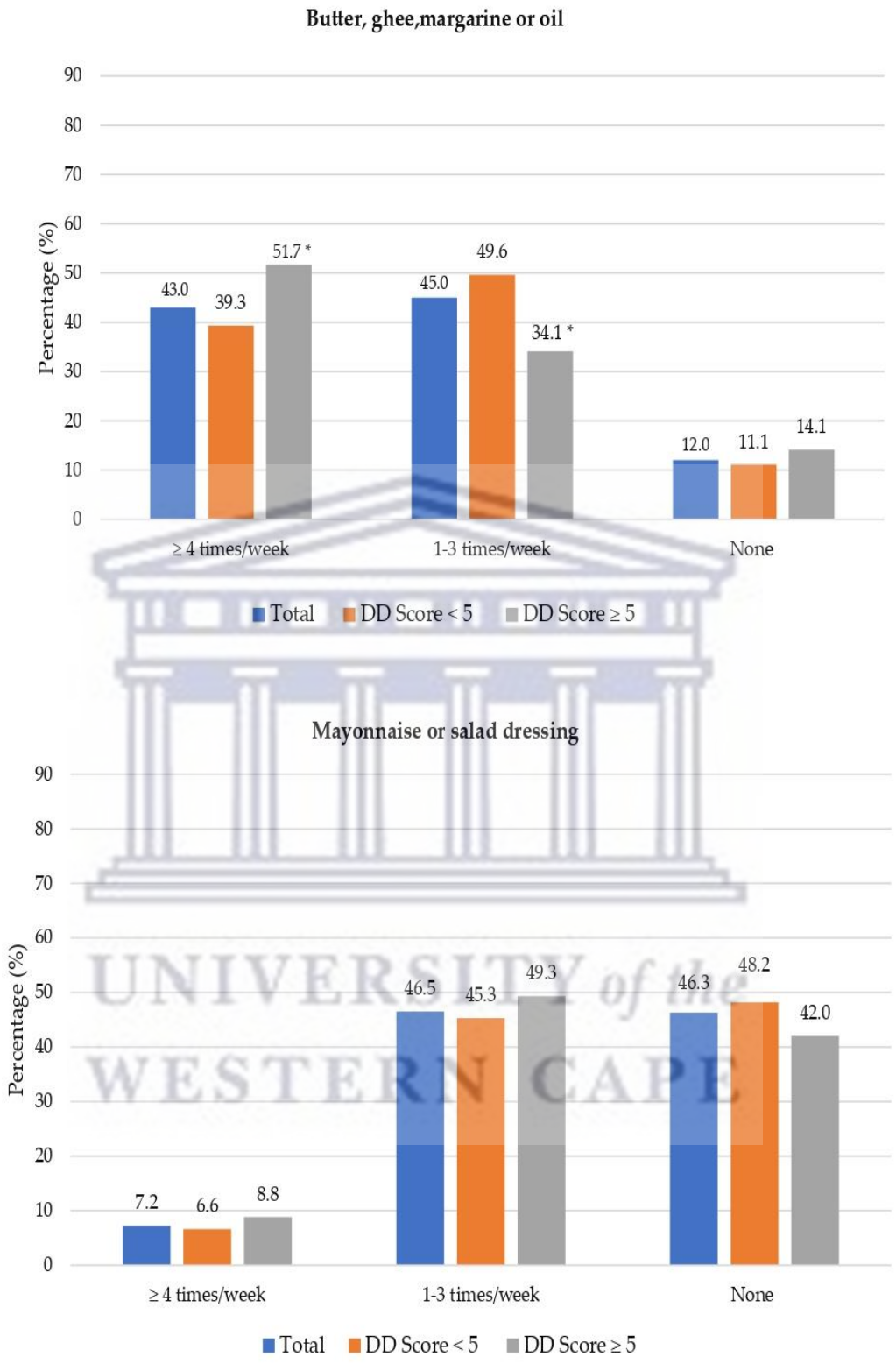


Figure 3. *Cont.*

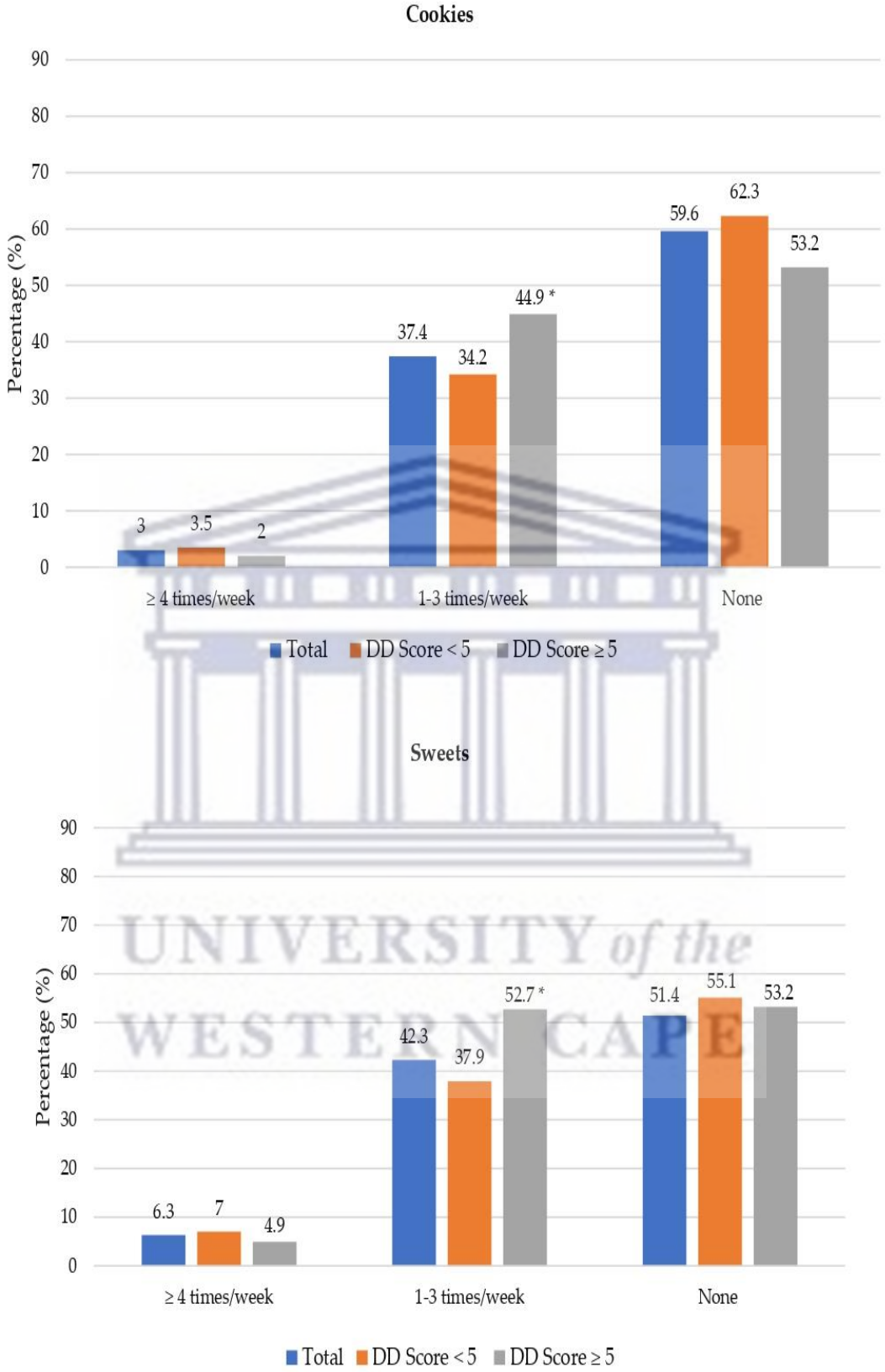


Figure 3. *Cont.*

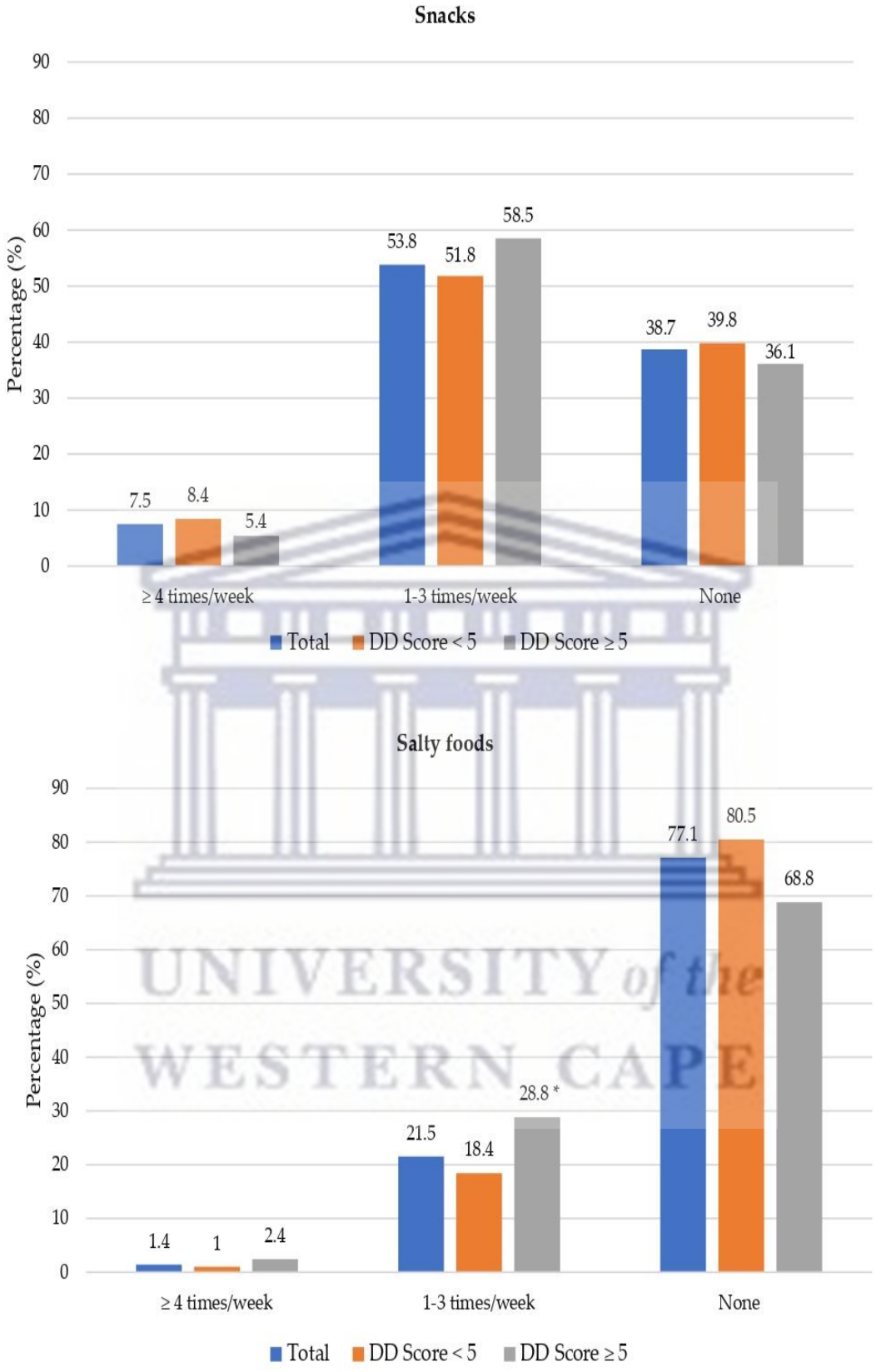


Figure 3. *Cont.*

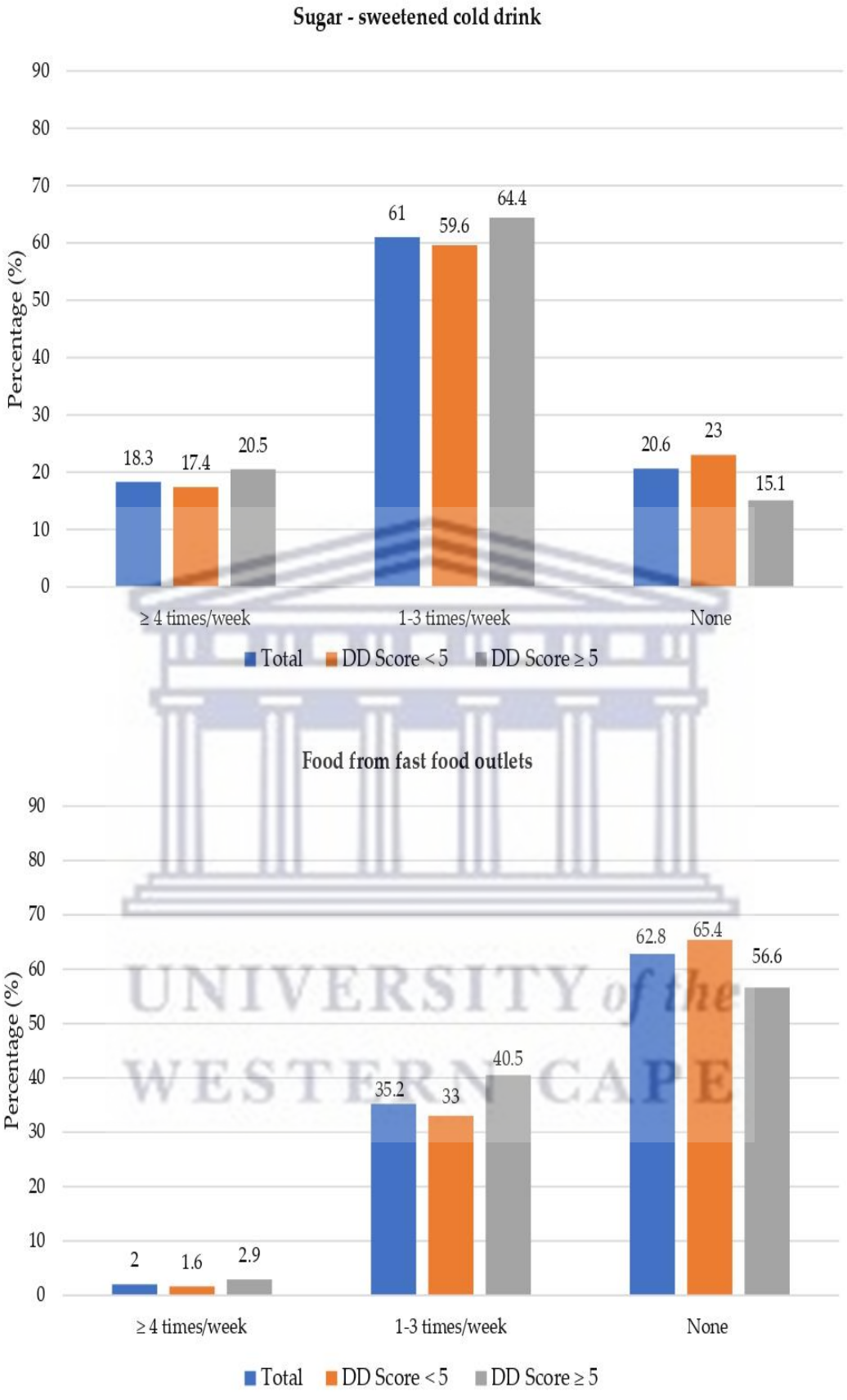


Figure 3. *Cont.*

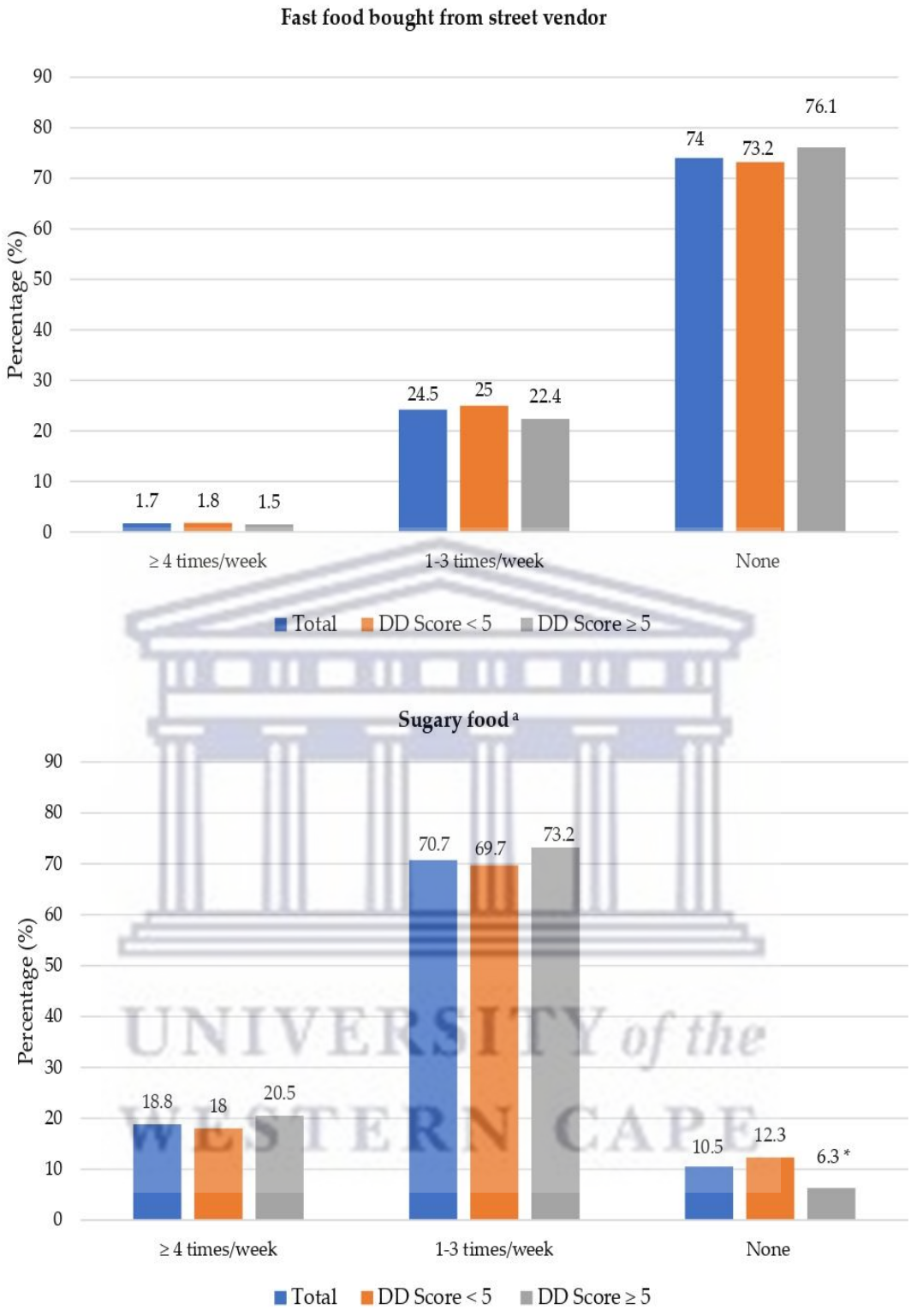


Figure 3. Frequency intake of selected unhealthy foods by dietary diversity (DD) score categories. * Significant difference between DD score categories at $p < 0.05$ level; [a] Based on a calculated sugary food score.

Figure 4 shows the frequency of consumption of fruit juice, and fresh and vegetables. Participants with adequate DD more frequently consumed fruit juice (1–3 times/week) than participants with low DD (45.4% vs. 33.4%). Fresh fruit was consumed at least

4 times/week by significantly more participants with adequate DD compared to those with low DD (41.5% vs. 25.6%). Overall, 23.5% (n = 163) participants consumed fresh fruit and 40.1% (n = 278) consumed vegetables daily (data not shown in table). Of the 693 participants, 42.6% did not eat fruit and 28.6% did not eat vegetables daily because of financial constraints. A higher percentage of participants with low DD compared to those with adequate DD reported financial constraints as barrier for daily intake of fruits (47.1% vs. 31.7%) and vegetables (32.0% vs. 20.5%) (Supplementary Table S1).

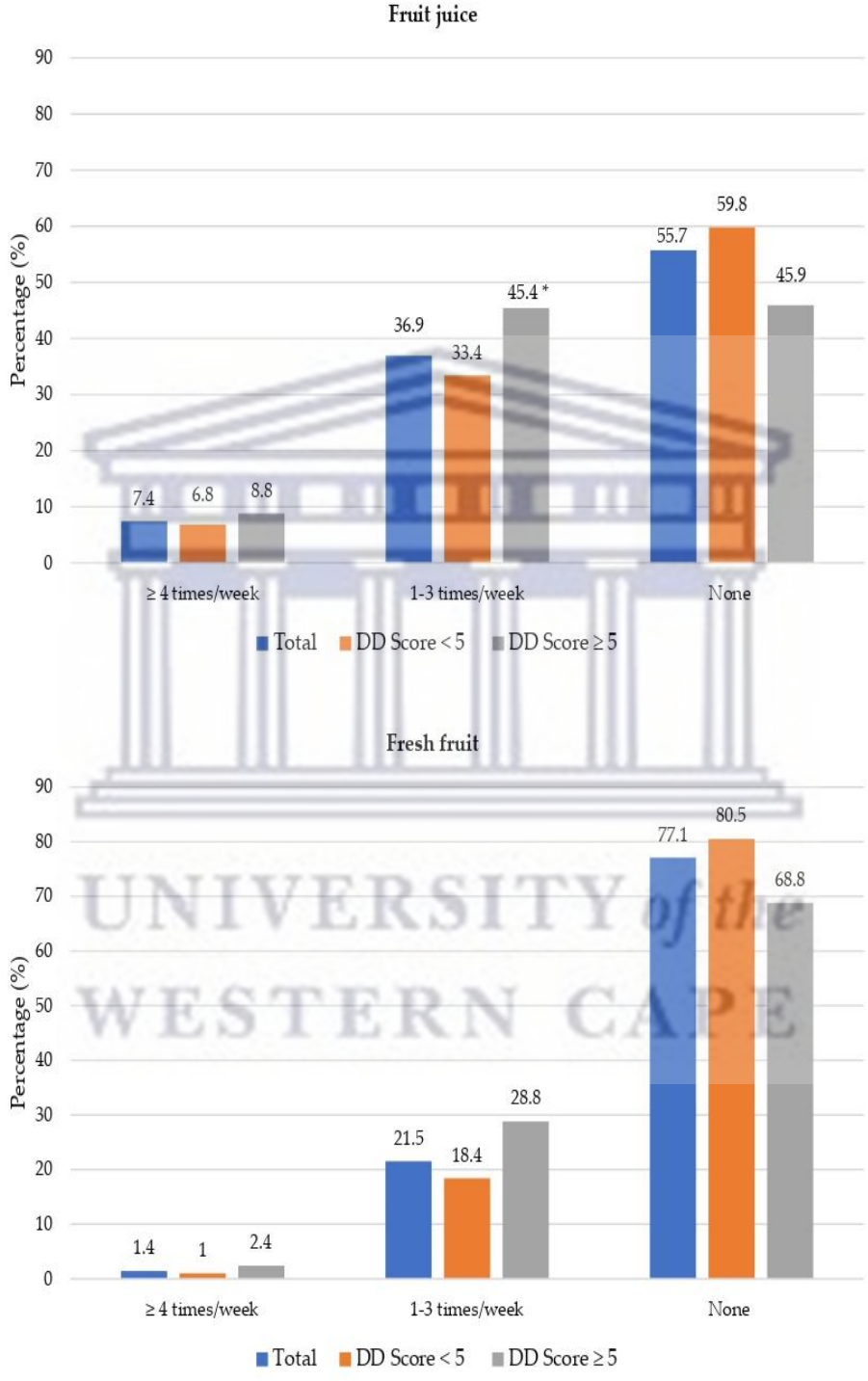


Figure 4. *Cont.*

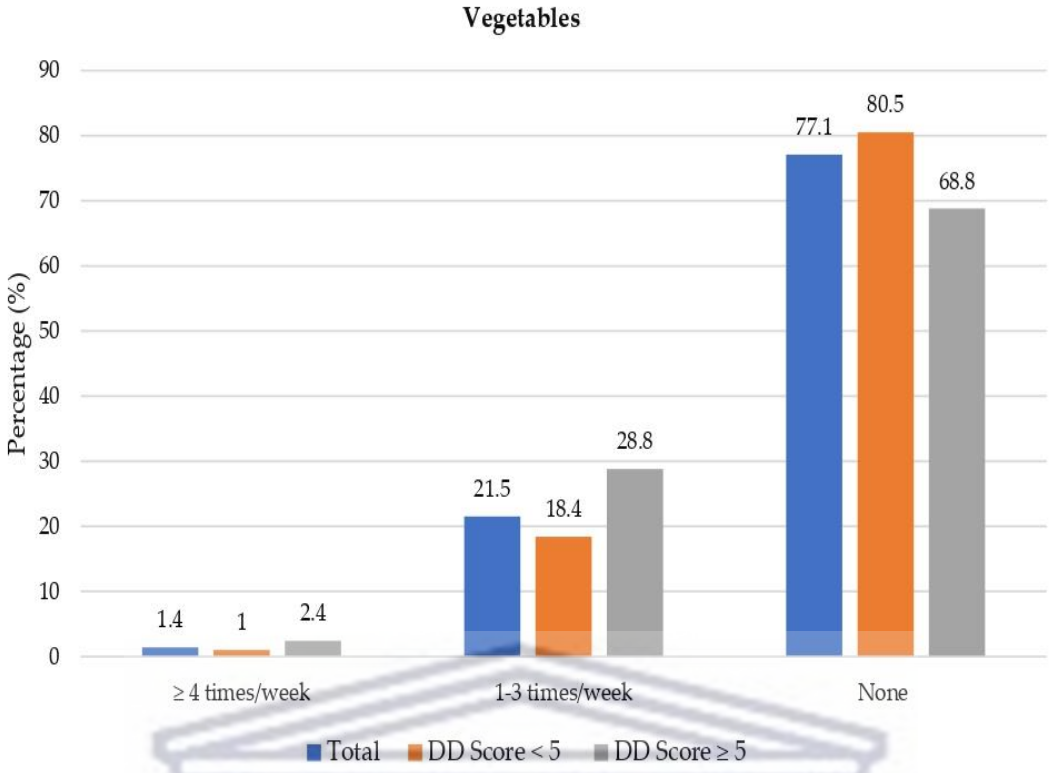


Figure 4. Frequency intake of fruit juice, fresh fruit and vegetables by dietary diversity (DD) score categories. * Significant difference between DD score categories at $p < 0.05$ level.

None of the food practices differed significantly between the DD categories except for eating chicken with skin (low DD 60.0%, adequate DD 51.7%) (Supplementary Table S2).

3.4. Nutritional Status and Cardiometabolic Risk Factors

3.4.1. Nutritional Status

The median BMI was 35.6 kg/m^2 in the overall sample, and higher in women (36.9 kg/m^2) than men (28.6 kg/m^2); $p < 0.05$ (Table 3). Hip circumference measurements were not taken for the first 60 participants enrolled in the SA-DPP study; and therefore, WHR data are only available for 633 participants. The median WHR for males was 0.96 (0.93–1.00) and 0.91 (0.85–0.97) for females (Supplementary Table S3). Obesity, defined by BMI and WHR, at 77.1% and 75.3%, respectively, was high.

3.4.2. Cardiometabolic Risk Factors

The prevalence of diabetes, prediabetes and normoglycemia was 10.3%, 16.8% and 72.9% respectively (Table 3). The prevalence elevated TC, LDL-C and TG was 48.0%, 55.4% and 33.8%, respectively. Approximately 40.1% of participants had low HDL-C. Nutritional status and cardiometabolic risk factors per gender and ethnicity groups are presented in Supplementary Tables S3 and S4 respectively.

Crude and multivariable adjusted ORs and 95% CIs for the association of low DD (score < 5) with nutritional status and cardiometabolic risk factors are presented in Table 4. Unadjusted binary and multivariable logistic regression showed no significant associations between DD and any of the nutritional status or cardiometabolic risk factors. After adjusting for gender and ethnicity, participants with low DD were 1.45 times more likely to have elevated TG concentrations [AOR: 1.45; 95% CI (1.03, 2.15); $p = 0.048$]; this association remained significant after additionally adjusting for age [AOR: 1.49, 95% CI (1.03, 2.15); $p = 0.036$].

Table 3. Nutritional status and cardiometabolic risk factors for the total study sample and the two dietary diversity categories respectively.

Variable	Total (n = 693)	DD Score < 5 (n = 488)	DD Score ≥ 5 (n = 205)	p Value [a]
Gender				
Male	131 (18.9)	99 (20.3)	32 (15.6)	0.151
Female	562 (81.1)	389 (79.7)	173 (84.4)	
Ethnicity				
Mixed ancestry	281 (40.7)	193 (39.6)	88 (43.1)	0.392
Black	410 (59.3)	294 (60.4)	116 (56.9)	
BMI	35.6 (30.5–40.5)	35.6 (30.6–40.9)	35.4 (30.4–39.5)	0.579
Normal weight (18.5–24.9 kg/m^2)	29 (4.2)	19 (3.9)	10 (4.9)	0.827
Overweight (25.0–29.9 kg/m^2)	128 (18.6)	91 (18.7))	37(18.2)	
Obese (≥30 kg/m^2)	533 (77.2)	377 (77.4)	156 (76.8)	
Total	690 (100)	487 (100)	203 (100)	
WHR	0.91 (0.86–0.97)	0.93 (0.87–0.97)	0.91 (0.85–0.97)	0.192
Normal [b]	156 (24.7)	100 (22.5)	56 (29.8)	0.053
High [c]	476 (75.3)	344 (77.5)	132 (70.2)	
Total	681 (100)	444 (100)	188 (100)	
Glycaemic status	6.0 (5.0–7.4)	5.9 (4.9–7.3)	6.1 (5.1–7.8)	0.643
Normoglycemia (FPG ≤ 6 and 2-h glucose < 7.8 mmol/L)	496 (72.9)	358 (74.7)	138 (68.7)	0.211
Prediabetes (FPG 6.1– 7 mmol/L and 2-h glucose ≥ 7.8–11.1 mmol/L)	114 (16.8)	77 (16.1)	37 (18.4)	
Diabetes (FPG > 7 mmol/L and 2-h glucose > 11.1 mmol/L)	70 (10.3)	44 (9.2)	26 (12.9)	
Total	680 (100)	479 (100)	201 (100)	
TC	4.9 (4.3–5.7)	4.9 (4.2–5.8)	5.0 (4.3–5.6)	0.783
Normal (<5 mmol/L)	451 (66.2)	255 (53.1)	99 (49.3)	0.356
Elevated (≥5 mmol/L)	230 (38.0)	225 (46.9)	102 (50.7)	
Total	681 (100)	480 (100)	201 (100)	
HDL-C	1.2 (1.1–1.4)	1.2 (1.1–1.4)	1.2 (1.1–1.4)	0.645
Normal (≥1.2 mmol/L)	272 (40.1)	192 (40.2)	80 (39.8)	0.929
Low (<1.2 mmol/L)	407 (59.9)	286 (59.8)	121 (60.2)	
Total	679 (100)	478 (100)	201 (100)	
LDL-C	3.1 (2.5–3.8)	3.1 (2.5–3.8)	3.1 (2.5–3.7)	0.856
Normal (<3 mmol/L)	81 (29.1)	215 (45.0)	88 (43.8)	0.774
Elevated (≥3 mmol/L)	197 (70.1)	263 (55.0)	113 (56.2)	
Total	679 (100)	478 (100)	201 (100)	
TG	1.3 (0.9–1.7)	1.3 (0.9–1.7)	1.2 (0.9–1.5)	0.402
Normal (≤1.5 mmol/L)	451 (66.2)	307 (64.0)	144 (71.6)	0.053
Elevated (>1.5 mmol/L)	230 (33.8)	173 (36.0)	57 (28.4)	
Total	681 (100)	480 (100)	201 (100)	

Data presented as median (interquartile range: IQR) or n (%). DD—dietary diversity; BMI—body mass index; WHR—waist-to-hip ratio; FPG—fasting plasma glucose; HDL-C—high density lipoprotein cholesterol; LDL-C—low density lipoprotein cholesterol; TG—triglyceride. [a] Chi-square test used for categorical variables and Spearman correlation for continuous variables, [b] Normal WHR: males ≤ 0.90 cm and females ≤ 0.85 cm, [c] High WHR: males > 0.90 cm and females > 0.85 cm.

Table 4. Odds ratios (95% confidence interval) of associations between low dietary diversity and nutritional status and cardiometabolic risk factors.

Variable	Crude Model OR (95% CI)	p Value	Model 1 AOR (95% CI)	p Value	Model 2 AOR (95% CI)	p Value
BMI						
Normal weight (18.5–24.9 kg/m^2)	1		1		1	
Overweight and obese (≥25.0 kg/m^2)	1.27 (0.58, 2.78)	0.550	1.58 (0.69, 3.62)	0.280	1.24 (0.53, 2.94)	0.619

Table 4. *Cont.*

Variable	Crude Model OR (95% CI)	*p* Value	Model 1 AOR (95% CI)	*p* Value	Model 2 AOR (95% CI)	*p* Value
WHR						
Normal [a]	1		1		1	
High [b]	1.46 (0.99, 2.14)	0.054	1.49 (0.99, 2.21)	0.052	1.45 (0.97, 2.16)	0.071
Glycaemic status						
Normoglycemia (FPG ≤ 6 and 2-h glucose < 7.8 mmol/L)	1		1		1	
Prediabetes (FPG 6.1–7 and 2-h glucose ≥ 7.8–11.1 mmol/L)	0.80 (0.52, 1.24)	0.325	0.80 (0.52, 1.23)	0.337	0.82 (0.52, 1.31)	0.416
Diabetes (FPG > 7 and 2-h glucose > 11.1 mmol/L)	0.65 (0.39, 1.10)	0.109	0.63 (0.37, 1.07)	0.088	0.59 (0.34, 1.03)	0.062
TC						
Normal (<5 mmol/L)	1		1		1	
Elevated (≥5 mmol/L)	0.86 (0.62, 1.19)	0.357	0.87 (0.62, 1.22)	0.425	0.94 (0.66, 1.33)	0.715
HDL-C						
Normal (≥1.2 mmol/L)	1		1		1	
Low (<1.2 mmol/L)	0.99 (0.70, 1.38)	0.929	1.03 (0.73, 1.44)	0.882	1.09 (0.78, 1.55)	0.601
LDL-C						
Normal (<3 mmol/L)	1		1		1	
Elevated (≥3 mmol/L)	0.95 (0.68, 1.33)	0.774	0.99 (0.69, 1.39)	0.937	1.06 (0.74, 1.50)	0.760
TG						
Normal (≤1.5 mmol/L)	1		1		1	
Elevated (>1.5 mmol/L)	1.42 (0.99, 2.04)	0.054	1.45 (1.00, 2.09)	**0.048**	1.49 (1.03, 2.15)	**0.036**

OR—odds ratio, 95% CI—95% confidence interval, 1—reference. Model 1: adjusted for gender and ethnicity, Model 2: adjusted for gender, ethnicity and age. DD—dietary diversity, BMI—body mass index; WHR—waist-to-hip ratio; FPG—fasting plasma glucose; HDL-C—high density lipoprotein cholesterol; LDL-C—low density lipoprotein cholesterol; TG—triglyceride. [a] Normal WHR: males ≤ 0.90 cm and females ≤ 0.85 cm, [b] High WHR: males > 0.90 cm and females > 0.85 cm. Bold *p* value-significant at $p < 0.05$ level.

4. Discussion

This study highlights that most study participants residing in resource-poor communities in Cape Town consumed a diet with low variety. Notably, participants with low DD had lower household incomes and less formal schooling. Participants with adequate DD, however, reported more frequent consumption of unhealthy foods such as foods covered in pastry or crumbs cookies, sweets and salty foods. The only cardiovascular risk factor associated with low DD was elevated TGs.

In total, 70.4% of the study participants consumed fewer than 5 of the 10 healthy food groups the previous day, indicating that DD was generally low, which is consistent with the findings of other South African cross-sectional studies [20,21]. A national study showed that lower living standards (measured by degree of urbanisation, services and asset ownership) are associated with low DD [23]. Moreover, a South African study showed that healthier foods are generally less affordable than unhealthy foods [38]. Considering that in South Africa cost is the main factor influencing food choices when grocery shopping [20], together with the high unemployment rate of 35.3% [39] and high reliance on social grants (45.5% of households [40]), improving DD in resource-poor settings may be challenging. In an attempt to assist low-income households in spending less of their income on food, the South African government has VAT zero-rated 19 basic foodstuffs [41]. Although fruit and vegetables are VAT zero-rated, cost remains a barrier for frequent consumption [42].

Grains/roots/tubers and meat/poultry/fish were the two most consumed food groups and were the only predominantly consumed food groups in the two lowest DD score quintiles. Similar results were reported in a national study that determined DD in South Africans aged 16 years and older [21]. Our findings are further supported by a study that was done in formal and informal settings in Johannesburg, South Africa [43]. Comparatively, however, opposite results have been reported for other countries in Africa. For example, in a study in Nigeria, cereal and vegetables were reported as the most consumed food groups [44], while in Tanzania the most consumed food groups were cereals, vegetables, legumes, nuts and seeds, and fruit [45]. Due to rapid urbanisation and the

nutrition transition, dietary intake in South Africa has shifted from traditional diets rich in fibre, lean meats, legumes, vegetables and fruits to more westernised diets that include energy dense, refined and ready prepared foods and less vegetables and fruits [46]. Food consumption data between 1994 and 2012 showed that in South Africa there was an increase in the consumption of meat, fats and oils, soft drinks, sweet and savoury snacks, while consumption of vegetables decreased [47].

Fruits and vegetables were predominantly consumed by participants in the two highest DD score quintiles only, and cost was the main barrier for daily consumption. Vegetables and fruit are amongst the least consumed food groups in South Africa [48], and per capita intake thereof is approximately 200 g [20], which is half the WHO recommendation of at least 400 g per day to protect against various NCDs [49]. Low intake of fruits accounted for two million global deaths and 65 million disability adjusted life years in 2017 [50]. Although daily consumption of fruits and vegetables is recommended, cost (affordability) has been cited as a major barrier for daily consumption not only in South Africa [42,51,52] but globally as well [42].

Adequate DD based on healthy foods was also associated with consumption of several unhealthy foods, and the DD score correlated positively with the sugary foods score. Similar findings were reported in an American cohort study which showed adequate DD to be associated with intakes of nutrient-dense foods such as fruits, vegetables and whole grains, as well as unhealthy foods such as processed meats, salty snacks and SSB [53]. In South Africa, unhealthy processed foods such as fried foods, fast food, salty snacks and processed meats are regularly consumed [54]. These foods are generally inexpensive and therefore more accessible and preferable to low-income households [20], and this has contributed to unhealthy diets, overweight/obesity and NCDs [46]. In 2012, Igumbor and colleagues argued that a development plan by the South African government to improve accessibility, affordability and acceptability of healthy foods and limiting the availability, discouraging the advertising and increasing the cost of unhealthy foods including soft drinks, packaged foods and snacks is warranted [55]. There are currently several legislations, regulations and policies in South Africa that aim to reduce the incidence of NCDs. For instance, the regulation on sodium reductions, a levy on salt substitutes and levy on SSBs [56], aim to decrease salt and sugar consumption as well as the prevalence of hypertension, heart disease, overweight and diabetes among the public.

Although our study found no association between DD and BMI status or WHR, previous studies have yielded contrasting results. Some studies have shown a positive association [57], another an inverse association [17] and a recent systematic review and meta-analysis reported that eight out of 16 studies found no association between DD and BMI status [58]. We found no associations between DD and the cardiometabolic risk factors, except for TG. Our finding that low DD was associated with elevated TG concentrations is similar to a cross-sectional study in Iranian adults [17]. There are many factors other than DD that may influence serum TG concentrations, such as consumption of sugary food and drinks, saturated and trans-fats, refined grains, high energy foods as well as alcohol [59] and overweight and obesity and tobacco use [60].

Our study included only participants with existing diabetes risk, most had low DD and almost all were either overweight or obese; this could have contributed to the lack of associations of DD with nutritional status and most of the cardiometabolic risk factors. The differences in our findings from other studies may also be attributable to the different study populations, dietary assessment methods and tools used to measure DD [18]. Dietary diversity indicators were developed mostly to be used as population-level proxy indicators and are based on a variety of healthy foods, but do not take less healthy foods into account. Dietary diversity indicators therefore do not reflect overall quality of the diet [18] and therefore their usefulness in NCD research may be limited. Although a diverse diet may be beneficial to health outcomes, studies show inconsistent results on the association of DD indicators with health outcomes. The recently developed Global Diet Quality Score (GDQS) is a more comprehensive population-level metric for both nutrient adequacy and

diet-related NCD risk [61] may be a more suitable tool; however, the GDQS has not yet been validated in South Africa.

A strength of this study is that it includes a relatively large sample size to test for associations. The present study had several limitations that are important to note. The cross-sectional study design examined associations and therefore cannot determine causal relationships. Dietary diversity was based on the MDD-W score, which has not been validated for men and older women. Dietary data were based on self-report, and therefore, may be subject to error and recall bias. All participants included in the study were deemed at risk for diabetes on screening. The results can only be applied to adults at risk for diabetes living in resource-poor settings and cannot be generalised to the general population.

5. Conclusions

The findings of the study demonstrate that a high proportion of individuals from resource poor communities who were at risk for diabetes on screening consumed a diet with low variety. Overall, DD was not associated with nutritional status and cardiometabolic risk factors, except for the association of low DD with increased likelihood of elevated TGs. Adequate DD was associated with both healthy and unhealthy food choices, which further highlights the need to consider both healthy and unhealthy foods when constructing measures of dietary diversity.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/nu14153191/s1, Table S1: Main reasons preventing eating fruits and vegetables every day per dietary diversity score category. Table S2: Food preference fat on meat and poultry, salt in food and use of margarine, butter & fat as spread according to ethnicity according to dietary diversity score category. Table S3: Nutritional status and cardiometabolic risk factors of participants according to gender and dietary diversity categories. Table S4: Nutritional status and cardiometabolic risk factors of participants according to ethnicity and dietary diversity categories.

Author Contributions: S.S.M., J.H., E.K. and M.F. conceptualised the present study. A.P.K. is the principal investigator of SA-DPP. S.S.M. conducted the data analysis, data interpretation and drafted the manuscript. J.H. was involved in the SA-DPP study baseline data collection. M.F. supervised the data analysis and contributed to the interpretation and drafting of the manuscript. N.P., A.P.K., M.F. contributed to the editing and revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: The work reported herein was made possible through funding by the South African Medical Research Council (SAMRC) through its Division of Research Capacity Development under the Internship Scholarship Programme from funding received from the South African National Treasury (grant number: Not Applicable). The content hereof is the sole responsibility of the authors and does not necessarily represent the official views of the SAMRC or the funders. The SA-DPP study was funded by the SAMRC through baseline allocation to the Non-Communicable Diseases Research Unit.

Institutional Review Board Statement: The SA-DPP study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of the South African Medical Research Council (approval no. EC018-7/2015). The present study is part of a PhD study, which was approved by the University of the Western Cape Bio-medical Research Ethics Committee (approval no. BM20/1/1).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data used for this study are from baseline evaluation of the ongoing SA-DPP and are not available for sharing until trial completion.

Acknowledgments: The authors thank the SA-DPP investigators, staff, and trial participants for their hard work and dedication to the trial.

Conflicts of Interest: The authors declare no conflict of interest. Written permission to utilise the data was obtained from APK, the principal investigator of the SA-DPP cluster randomised control trial.

References

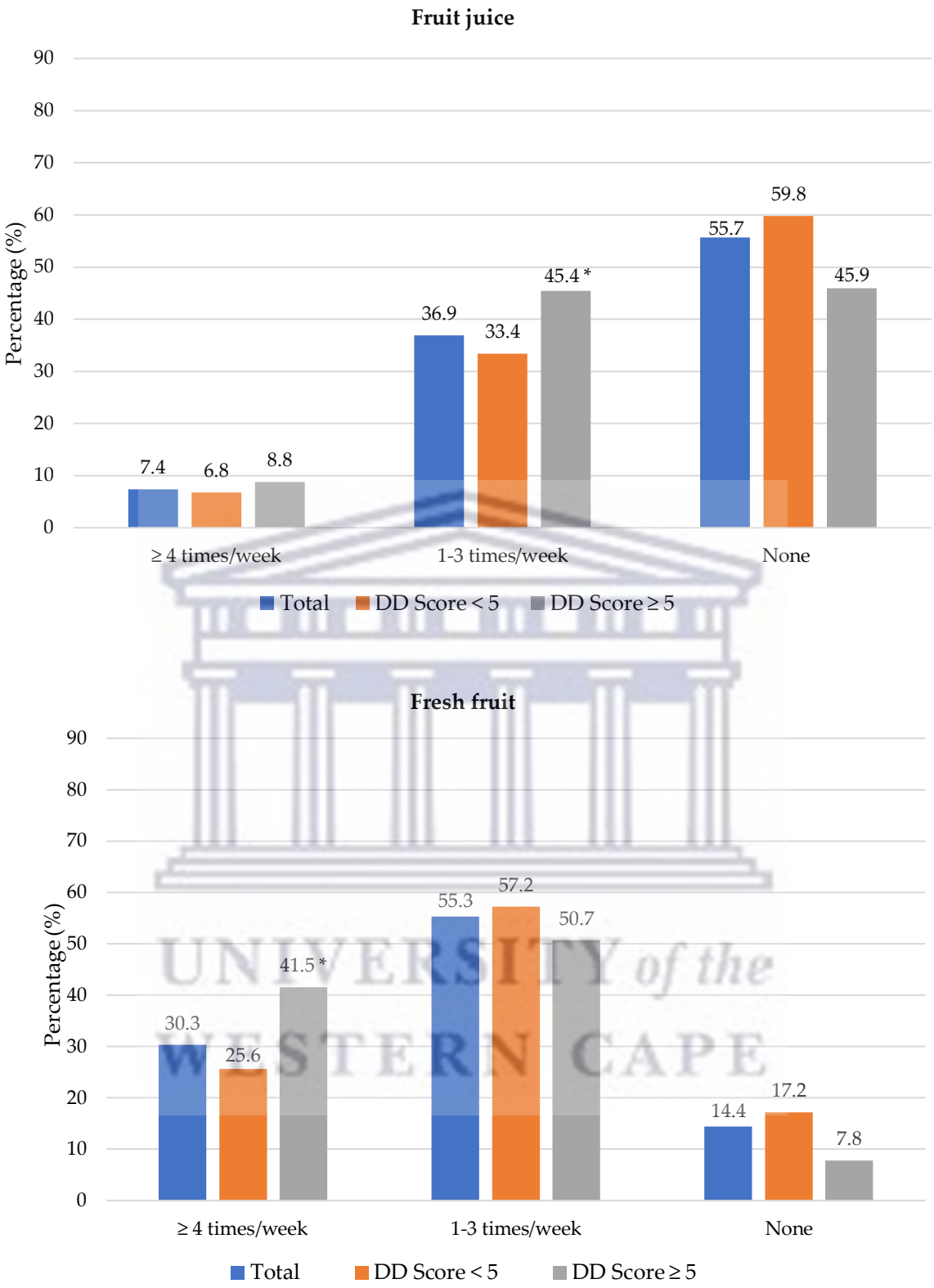
1. World Health Organization. The Top 10 Causes of Death. Available online: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death (accessed on 14 January 2021).
2. International Diabetes Federation. *IDF Diabetes Atlas*, 10th ed.; IDF: Brussels, Belgium, 2021. Available online: https://diabetesatlas.org/atlas/tenth-edition/ (accessed on 22 February 2022).
3. Pillay-van Wyk, V.; Msemburi, W.; Laubscher, R.; Dorrington, R.E.; Groenewald, P.; Glass, T.; Nojilana, B.; Joubert, J.D.; Matzopoulos, R.; Prinsloo, M.; et al. Mortality trends and differentials in South Africa from 1997 to 2012: Second National Burden of Disease Study. *Lancet Glob. Health* **2016**, *4*, e642–e665. [CrossRef]
4. Non-Communicable Diseases (NCD) Country Profiles. Available online: https://www.who.int/nmh/publications/ncd-profiles-2018/en/ (accessed on 28 September 2020).
5. Leon, B.M.; Maddox, T.M. Diabetes and cardiovascular disease: Epidemiology, biological mechanisms, treatment recommendations and future research. *World J. Diabetes* **2015**, *6*, 1246–1258. [CrossRef] [PubMed]
6. Pheiffer, C.; Pillay-van Wyk, V.; Joubert, J.D.; Levitt, N.; Nglazi, M.D.; Bradshaw, D. The prevalence of type 2 diabetes in South Africa: A systematic review protocol. *BMJ Open.* **2018**, *8*, e021029. [CrossRef] [PubMed]
7. Alkerwi, A. Diet quality concept. *Nutrition* **2014**, *30*, 613–618. [CrossRef]
8. Herforth, A.; Arimond, M.; Álvarez-Sánchez, C.; Coates, J.; Christianson, K.; Muehlhoff, E. A global review of food-based dietary guidelines. *Adv. Nutr.* **2019**, *10*, 590–605. [CrossRef]
9. FAO and FHI 360. *Minimum Dietary Diversity for Women: A Guide for Measurement*; FAO: Rome, Italy, 2016. Available online: http://www.fao.org/3/a-i5486e.pdf (accessed on 23 March 2020).
10. McCullough, M.L.; Feskanich, D.; Stampfer, M.J.; Giovannucci, E.L.; Rimm, E.B.; Hum, F.B.; Spiegelman, D.; Hunter, D.J.; Colditz, G.A.; Willett, W.C. Diet quality and major chronic disease risk in men and women: Moving toward improved dietary guidance. *Am. J. Clin. Nutr.* **2002**, *76*, 1261–1271. [CrossRef]
11. Fanelli Kuczmarski, M.; Brewer, B.C.; Rawal, R.; Pohlig, R.T.; Zonderman, A.B.; Evans, M.K. Aspects of dietary diversity differ in their association with atherosclerotic cardiovascular risk in a racially diverse US adult population. *Nutrients* **2019**, *11*, 1034. [CrossRef]
12. Farhangi, M.A.; Jahangiry, L. Dietary diversity score is associated with cardiovascular risk factors and serum adiponectin concentrations in patients with metabolic syndrome. *BMC Cardiovasc. Disord.* **2018**, *18*, 68. [CrossRef]
13. Kapoor, D.; Iqbal, R.; Singh, K.; Jaacks, L.M.; Shivashankar, R.; Sudha, V.; Anjana, R.M.; Kadir, M.; Mohan, V.; Ali, M.K.; et al. Association of dietary patterns and dietary diversity with cardiometabolic disease risk factors among adults in South Asia: The CARRS study. *Asia Pac. J. Clin. Nutr.* **2018**, *27*, 1332–1343.
14. Zhang, Q.; Chen, X.; Liu, Z.; Varma, D.S.; Wan, R.; Zhao, S. Diet diversity and nutritional status among adults in southwest China. *PLoS ONE* **2017**, *12*, e0172406. [CrossRef]
15. Vadiveloo, M.; Dixon, L.B.; Parekh, N. Associations between dietary variety and measures of body adiposity: A systematic review of epidemiological studies. *Br. J. Nutr.* **2013**, *109*, 1557–1572. [CrossRef] [PubMed]
16. de Oliveira Otto, M.C.; Anderson, C.A.M.; Dearborn, J.L.; Ferranti, E.P.; Mozaffarian, D.; Rao, G.; Wylie-Rosett, J.; Lichtenstein, A.H. Dietary diversity: Implications for obesity prevention in adult populations: A science advisory from the American Heart Association. *Circulation* **2018**, *138*, e160–e168. [CrossRef] [PubMed]
17. Azadbakht, L.; Esmaillzadeh, A. Dietary diversity score is related to obesity and abdominal adiposity among Iranian female youth. *Public Health Nutr.* **2011**, *14*, 62–69. [CrossRef] [PubMed]
18. Verger, E.; Le Port, A.; Borderon, A.; Bourbon, G.; Moursi, M.; Savy, M.; Mariotti, F.; Martin-Prevel, Y. Dietary diversity indicators and their associations with dietary adequacy and health outcomes: A systematic scoping review. *Adv. Nutr.* **2021**, *12*, 1659–1672. [CrossRef]
19. Claasen, N.; van der Hoeven, M.; Covic, N. *Food Environments, Health and Nutrition in South Africa*; Working Paper 34; PLAAS, UWC and Centre of Excellence on Food Security: Cape Town, South Africa, 2016.
20. Shisana, O.; Labadarios, D.; Rehle, T.; Simbayi, L.; Zuma, K.; Dhansay, A.; Reddy, P.; Parker, W.; Hoosain, E.; Naidoo, P.; et al. *South African National Health and Nutrition Examination Survey (SANHANES-1)*; HSRC Press: Cape Town, South Africa, 2013. Available online: http://www.hsrc.ac.za/uploads/pageNews/72/SANHANES-launch%20edition%20(online%20version).pdf (accessed on 19 January 2020).
21. Labadarios, D.; Steyn, N.P.; Nel, J. How diverse is the diet of adult South Africans? *Nutr. J.* **2011**, *10*, 33. [CrossRef]
22. Statistic South Africa. *Mortality and Causes of Death in South Africa: Findings from Death Notification, Statistical Release P0309.3*; Stats SA: Pretoria, South Africa, 2018. Available online: https://www.statssa.gov.za/publications/P03093/P030932018.pdf (accessed on 15 November 2021).
23. Hill, J.; Peer, N.; Jonathan, D.; Mayige, M.; Sobngwi, E.; Kengne, A.P. Findings from community-based screenings for type 2 diabetes mellitus in at risk communities in Cape Town, South Africa: A pilot study. *Int. J. Environ. Res. Public Health.* **2020**, *17*, 2876. [CrossRef]
24. Erasmus, R.T.; Soita, D.J.; Hassan, M.S.; Blanco-Blanco, E.; Vergotine, Z.; Kengne, A.P.; Matsha, T.E. High prevalence of diabetes mellitus and metabolic syndrome in a South African coloured population: Baseline data of a study in Bellville, Cape Town. *S. Afr. Med. J.* **2012**, *102*, 841–844. [CrossRef]

25. Peer, N.; Steyn, K.; Lombard, C.; Lambert, E.V.; Vythilingum, B.; Levitt, N.S. Rising diabetes prevalence among urban-dwelling black South Africans. *PLoS ONE* **2012**, *7*, e43336. [CrossRef]
26. Statistics South Africa. *Quarterly Labour Force Survey (QLFS): Quarter 3: 2019. Statistical Release P0211*; Stats SA: Pretoria, South Africa, 2019. Available online: https://www.statssa.gov.za/publications/P0211/P02113rdQuarter2019.pdf (accessed on 17 May 2020).
27. Statistics South Africa. *Quarterly Labour Force Survey, Quarter 4: 2020, Statistical Release P0211*; Stats SA: Pretoria, South Africa, 2021. Available online: http://www.statssa.gov.za/publications/P0211/P02114thQuarter2020.pdf (accessed on 1 July 2021).
28. Battersby, J. The Food desert as a concept and policy tool in African Cities: An opportunity and a risk. *Sustainability* **2019**, *11*, 458. [CrossRef]
29. World Health Organization. *WHO STEPS Surveillance Manual*; WHO: Geneva, Switzerland, 2020. Available online: https://cdn.who.int/media/docs/default-source/ncds/ncd-surveillance/steps/steps-manual_f0075411-1e6d-46ef-85be-fe826d2b9c47.pdf?sfvrsn=c281673d_5 (accessed on 8 April 2021).
30. Centers for Disease Control and Prevention. National Health and Nutrition Examination Survey: Anthropometry Procedures Manual. 2011. Available online: https://www.cdc.gov/nchs/data/nhanes/nhanes_11_12/Anthropometry_Procedures_Manual.pdf (accessed on 9 June 2020).
31. NHLBI Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Obesity in Adults (US). *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*; National Heart, Lung, and Blood Institute: Bethesda, ML, USA, 1998. Available online: https://www.ncbi.nlm.nih.gov/books/NBK2003/ (accessed on 8 April 2020).
32. World Health Organisation. *Waist Circumference and Waist–Hip Ratio: Report of a WHO Expert Consultation*; WHO: Geneva, Switzerland, 2008. Available online: https://apps.who.int/iris/bitstream/handle/10665/44583/9789241501491_eng.pdf;jsessionid=4BC2C8AC2200A99B4ED62DD43B5A0EAC?sequence=1 (accessed on 3 August 2020).
33. World Health Organization. *Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications*; WHO: Geneva, Switzerland, 1999.
34. Klug, E.; Raal, F.J.; Marais, A.D.; Smuts, C.M.; Schamroth, C.; Jankelow, D.; Blom, D.J.; Webb, D.A. South African dyslipidaemia guideline consensus statement: 2018 update A joint statement from the South African Heart Association (SA Heart) and the Lipid and Atherosclerosis Society of Southern Africa (LASSA). *S. Afr. Med. J.* **2018**, *108*, 973–1000. [CrossRef]
35. Zhang, J.; Liang, D.; Zhao, A. Dietary diversity and the risk of fracture in adults: A prospective study. *Nutrients* **2020**, *12*, 3655. [CrossRef] [PubMed]
36. Fung, T.T.; Isanaka, S.; Hu, F.B.; Willett, W.C. International food group–based diet quality and risk of coronary heart disease in men and women. *Am. J. Clin. Nutr.* **2018**, *107*, 120–129. [CrossRef] [PubMed]
37. Morseth, M.S.; Grewal, N.K.; Kaasa, I.S.; Hatloy, A.; Barikmo, I.; Henjum, S. Dietary diversity is related to socioeconomic status among adult Saharawi refugees living in Algeria. *BMC Public Health* **2017**, *17*, 621. [CrossRef] [PubMed]
38. Temple, N.; Steyn, N. Food prices and energy density as barriers to healthy food patterns in Cape Town, South Africa. *J. Hunger. Environ. Nutr.* **2009**, *4*, 203–213. [CrossRef]
39. Statistics South Africa. *Quarterly Labour Force Survey (QLFS), 4th Quarter 2021*; Stats SA: Pretoria, South Africa, 2022. Available online: http://www.statssa.gov.za/publications/P0211/P02114thQuarter2021.pdf (accessed on 12 April 2022).
40. South African Social Security Agency. *Annual Report. Department of Social Development*; SASSA: Pretoria, South Africa, 2021. Available online: https://www.sassa.gov.za/statistical-reports/Documents/Annual%20Report%20-%202021.pdf (accessed on 12 April 2022).
41. Mbunyuza, L. Zero Rated and Exempt Supplies. National Department of Treasury. 2008. Available online: https://static.pmg.org.za/docs/Zero-rated%20and%20exempt%20supplies.pdf (accessed on 14 March 2022).
42. Miller, V.; Yusuf, S.; Chow, C.K.; Dehghan, M.; Corsi, D.J.; Lock, K.; Popkin, B.; Rangarajan, S.; Khatib, R.; Lear, S.A.; et al. Availability, affordability, and consumption of fruits and vegetables in 18 countries across income levels: Findings from the Prospective Urban Rural Epidemiology (PURE) study. *Lancet Glob. Health.* **2016**, *4*, e695–e703. [CrossRef]
43. Drimie, S.; Faber, M.; Vearey, J.; Nunez, L. Dietary diversity of formal and informal residents in Johannesburg, South Africa. *BMC Public Health* **2013**, *13*, 911. [CrossRef]
44. Mekonnen, D.A.; Trijsburg, L.; Achterbosch, T.; Brouwer, I.D.; Kennedy, G.; Linderhof, V.; Ruben, R.; Talsma, E.F. Food consumption patterns, nutrient adequacy, and the food systems in Nigeria. *Agric. Food Econ.* **2021**, *9*, 16. [CrossRef]
45. Ochieng, J.; Afari-Sefa, V.; Lukumay, P.J.; Dubois, T. Determinants of dietary diversity and the potential role of men in improving household nutrition in Tanzania. *PLoS ONE* **2017**, *12*, e0189022. [CrossRef]
46. Nnyepi, M.S.; Gwisai, N.; Lekgoa, M.; Seru, T. Evidence of nutrition transition in Southern Africa. *Proc. Nutr. Soc.* **2015**, *74*, 478–486. [CrossRef]
47. Ronquest-Ross, L.C.; Vink, N.; Sigge, G. Food consumption changes in South Africa since 1994. *S. Afr. J. Sci.* **2015**, *111*, 1–12. [CrossRef]
48. Mchiza, Z.J.; Steyn, N.P.; Hill, J.; Kruger, A.; Schönfeldt, H.; Nel, J.; Wentzel-Viljoen, E. A Review of dietary surveys in the adult South African population from 2000 to 2015. *Nutrients* **2015**, *7*, 8227–8250. [CrossRef] [PubMed]
49. World Health Organisation. *Fact Sheet: Healthy Diet*; WHO: Geneva, Switzerland, 2018. Available online: www.who.int/news-room/fact-sheets/detail/healthy-diet (accessed on 20 May 2019).

50. Health effects of dietary risks in 195 countries, 1990–2017: A systematic analysis for the Global Burden of Disease Study 2017. *Lancet* **2019**, *393*, 1958–1972. [CrossRef]
51. Faber, M.; Wenhold, F.A.; Laurie, S.M. Dietary diversity and vegetable and fruit consumption of households in a resource-poor peri-urban South Africa community differ by food security status. *Ecol. Food Nutr.* **2017**, *56*, 62–80. [CrossRef] [PubMed]
52. Okop, K.J.; Ndayi, K.; Tsolekile, L.; Sanders, D.; Puoane, T. Low intake of commonly available fruits and vegetables in socio-economically disadvantaged communities of South Africa: Influence of affordability and sugary drinks intake. *BMC Public Health* **2019**, *19*, 940. [CrossRef]
53. de Oliveira Otto, M.C.; Padhye, N.S.; Bertoni, A.G.; Jacobs, D.R., Jr.; Mozaffarian, D. Everything in moderation—Dietary diversity and quality, central obesity and risk of diabetes. *PLoS ONE* **2015**, *10*, e0141341. [CrossRef]
54. National Department of Health (NDoH) SSASS; South African Medical Research Council (SAMRC); ICF. *South Africa Demographic and Health Survey 2016*; NDoH, Stats SA; SAMRC: Pretoria, South Africa; ICF: Rockville, ML, USA, 2019. Available online: https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf (accessed on 29 March 2022).
55. Igumbor, E.U.; Sanders, D.; Puoane, T.R.; Tsolekile, L.; Schwarz, C.; Purdy, C.; Swart, R.; Durão, S.; Hawkes, C. "Big Food," the Consumer Food Environment, Health, and the Policy Response in South Africa. *PLoS Med.* **2012**, *9*, e1001253. [CrossRef]
56. National Department of Health. National Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2020–2025. Available online: https://www.sancda.org.za/wp-content/uploads/2020/05/17-May-2020-South-Africa-NCD-STRATEGIC-PLAN_For-Circulation.pdf (accessed on 8 March 2022).
57. Qorbani, M.; Mahdavi-Gorabi, A.; Khatibi, N.; Ejtahed, H.-S.; Khazdouz, M.; Djalalinia, S.; Sahebkar, A.; Esmaeili-Abdar, M.; Hasani, M. Dietary diversity score and cardio-metabolic risk factors: An updated systematic review and meta-analysis. *Eat. Weight. Disord.* **2022**, *27*, 85–100. [CrossRef]
58. Salehi-Abargouei, A.; Akbari, F.; Bellissimo, N.; Azadbakht, L. Dietary diversity score and obesity: A systematic review and meta-analysis of observational studies. *Eur. J. Clin. Nutr.* **2016**, *70*, 1–9. [CrossRef]
59. Rico-Campà, A.; Martínez-González, M.A.; Alvarez-Alvarez, I.; Mendonça, R.d.D.; de la Fuente-Arrillaga, C.; Gómez-Donoso, C.; Bes-Rastrollo, M. Association between consumption of ultra-processed foods and all cause mortality: SUN prospective cohort study. *BMJ* **2019**, *365*, l1949. [CrossRef]

60. Zhang, A.; Yao, Y.; Xue, Z.; Guo, X.; Dou, J.; Lv, Y.; Shen, L.; Yu, Y.; Jin, L. A Study on the Factors Influencing Triglyceride Levels among Adults in Northeast China. *Sci. Rep.* **2018**, *8*, 6388. [CrossRef]
61. Bromage, S.; Batis, C.; Bhupathiraju, S.N.; Fawzi, W.W.; Fung, T.T.; Li, Y.; Deitchler, M.; Angulo, E.; Birk, N.; Castellanos-Gutiérrez, A.; et al. Development and Validation of a Novel Food-Based Global Diet Quality Score (GDQS). *J. Nutr.* **2021**, *151*, 75S–92S. [CrossRef] [PubMed]

Correct Figure 4



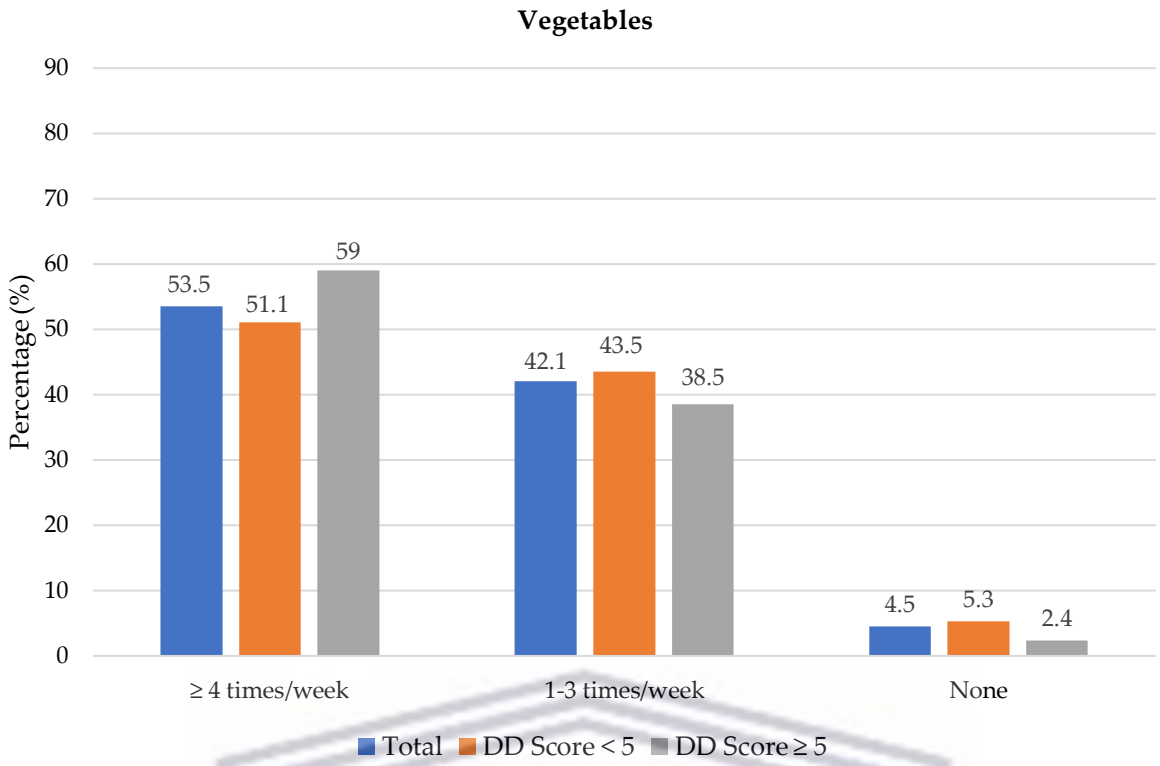


Figure 4. Frequency intake of fruit juice, fresh fruit and vegetables by dietary diversity (DD) score categories. * Significant difference between DD score categories at $p < 0.05$ level

CHAPTER 6: MANUSCRIPT THREE

Chapter 6 presents the research titled "Perceived barriers and enablers for consuming a diverse diet in women residing in resource-poor communities in Cape Town, South Africa: A qualitative study." The paper will be submitted for publication to *Public Health Nutrition* and has been written according to the journal's guidelines, except for continuous line numbers that will be inserted before submission.

6.1 Summary

This paper presents results from FGDs with 21 Mixed-ancestry and 24 Black female participants residing in 12 resource-poor communities in Cape Town. The participants' general eating habits, perceptions of the meaning of the term DD, health beliefs on DD, participant nutrition knowledge, and individual, social, physical, and societal factors affecting the consumption of a diverse diet and healthy food choices are described.

6.2 Contribution to the thesis

The contribution of this paper describes the third objective of the thesis: To explore the barriers and enablers for consuming a diverse diet in resource-poor communities in Cape Town, South Africa. The results provide insight into the challenges and opportunities resource-poor adults face in consuming a diverse diet and making healthy food choices.

6.3 Contribution of the candidate

The candidate developed the study protocol, FGD guide, food procurement questionnaire and the standard operating procedures (SOP) for conducting FGDs under the COVID-19 pandemic document in consultation with the supervisors and qualitative study expert. The candidate read and analysed transcripts and drafted the manuscript under supervisory guidance. All authors read, edited, and approved the final manuscript.

The supplementary material, translated FGD guide, translated food procurement questionnaire, SOP, and codebook are provided as Appendix 10-14. The candidate presented the protocol and preliminary results at the research meeting of the Non-Communicable Diseases Research Unit.

Perceived barriers and enablers for consuming a diverse diet in women residing in resource-poor communities in Cape Town, South Africa: A qualitative study.

Samukelisiwe S. Madlala[1,2], Jillian Hill[1], Ernesta Kunneke[3], Mieke Faber[1,3,4]

[1] Non-Communicable Diseases Research Unit, South African Medical Research Council, Cape Town 7505, South Africa

[2] School of Public Health, Faculty of Community and Health Sciences, University of the Western Cape, Bellville 7535, South Africa

[3] Department of Dietetics and Nutrition, University of the Western Cape, Bellville 7535, South Africa

[4] Centre of Excellence for Nutrition, North-West University, Potchefstroom, South Africa

Corresponding author: Samukelisiwe Madlala, South African Medical Research Council, Cape Town 7505, South Africa Samukelisiwe.Madlala@mrc.ac.za.

Short title: Barriers and enablers for consuming a diverse diet.

Acknowledgments: The authors thank the SA-DPP investigators, staff, and trial participants. The authors would like to thank Dr Anniza de Villiers for assisting with the development of the focus group discussion guide, Erica April for assisting with research administration, Samuel Sipango for transporting participants and translating the information sheet, consent form, questionnaire and guide into IsiXhosa, Tatum Lopes for note-taking, Zintle Nelani for facilitating the IsiXhosa focus groups, Sonja Mostert for facilitating Afrikaans focus groups, transcribing and translating, Phumeza Soci for transcribing and translating IsiXhosa focus group discussion recordings, and Jean Fourie for language editing.

Financial support: The work reported herein was made possible through funding by the South African Medical Research Council (SAMRC) through its Division of Research Capacity Development under the Internship Scholarship Programme from funding received from the South African National Treasury. The content hereof is the sole responsibility of the authors and does not necessarily represent the official views of the SAMRC or the funders. This research was carried out with the financial support of the SAMRC through the South African Diabetes Prevention Programme study's baseline allocation to the Non-Communicable Diseases Research Unit.

Conflict of interest: The authors declare no conflict of interest.

Authorship: S.S.M., J.H., E.K. and M.F. conceptualized the present study. S.S.M. was responsible for the guide and questionnaire development in collaboration with J.H. and M.F., note-taking, coding data, analysis and drafting the manuscript. J.H. was responsible for facilitating the focus groups and guiding the coding and analysis. M.F. contributed to the study design and supervised the study. J.H., E.K. and M.F. reviewed and edited the manuscript.

Ethical standards disclosure: This study forms part of a PhD thesis by publication that SM will submit at the University of the Western Cape for degree purposes. This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the University of the Western Cape Biomedical Research Ethics Committee (approval no. BM20/1/1). Written informed consent was obtained from all participants. The baseline survey of the SA-DPP was approved by the ethics committee of the South African Medical Research Council (approval no. EC018-7/2015).

Abstract

Objective: Perceived barriers and enablers for consuming a diverse diet in women residing in resource-poor communities in Cape Town, South Africa, were explored in this study.

Design: We used a qualitative study design. Data were collected from focus group discussions (FGDs) conducted in Afrikaans, IsiXhosa, and English, using a semi-structured guide. Additionally, data on food purchasing practices were collected using a short, structured questionnaire.

Setting: Twelve community sites in Cape Town, South Africa.

Participants: Study participants were selected through purposive sampling. Twenty-four Black and 21 Mixed-ancestry women (n=45) with a mean age of 49.7 ± 7.8 years.

Results: Fourteen FGDs were conducted with an average of three participants per FGD. Six themes were identified from the FGDs, which included nutrition knowledge, perceptions of dietary diversity and its impact on health, individual factors, and social, physical environment, and societal influences on food choices. Perceived barriers to consuming a diverse diet included financial constraints, high food prices and family taste preferences. Perceived enablers identified were individual taste preferences, access to food stores, community food aid and food-store specials. Proposed facilitators to achieving a diverse diet included budgeting, income generation activities, lowering food prices, and increasing community food aid.

Conclusions: This study provides insight into the factors influencing the consumption of diverse diets among people residing in resource-poor communities. Therefore, our findings could be used to inform the development of interventions aimed at assisting low-income individuals in consuming diverse diets and adhering to food-based dietary guidelines to reduce diet-related diseases.

Keywords

Adults, Dietary diversity, Food choices, Barriers, Enablers, Qualitative research

INTRODUCTION

Globally, unhealthy diets are one of the leading risk factors for non-communicable diseases (NCDs) among adults, accounting for 22% of mortality and 15% of disability-adjusted life years[1]. South Africa, an upper-middle-income country, is undergoing a rapid nutrition transition and lifestyle change from active to more sedentary. This transition has led to high consumption of sugar-sweetened beverages (SSBs), high-fat and energy-dense processed foods, fast food and street foods among South African populations[2]. In parallel with the change in diet and lifestyle, the prevalence of overweight and obesity is high, with more than 68% of women and 39% of men being overweight or obese[3]. South Africa also has a high prevalence of NCDs, accounting for 51% of mortality[4].

The intake of a variety of nutrient-dense foods is recommended globally through food-based dietary guidelines (FBDGs) for nutrient adequacy and disease prevention[5]. Dietary diversity (DD) is a component of diet quality. Poor dietary quality is associated with malnutrition and NCDs, such as cardiovascular disease, diabetes mellitus, some cancers, and mental health problems[6]. Monotonous diets, composed of starchy staple foods, have been associated with food insecurity and micronutrient deficiencies[7]. The South African FBDGs (SA-FBDGs), which were first published in 2003 and revised in 2012[8], encourage South Africans to "Enjoy a variety of foods"[9]. Yet, several studies, including a national one[10], have shown that South Africans lack variety in their diet[11-13].

Several structural, environmental, social and individual factors influence food choices and dietary habits[14]. Determinants of food choice include various factors, such as taste, cultural, social, psychological, and emotional factors (stress, attitude towards health, anxiety, depression), and hereditary and epigenetic factors[15, 16]. Food choice is also determined by marketing, food labelling and economic factors[15]. Socio-economic factors, such as education level, occupation, income, and residential area, influence food choice behaviours[16]. In addition, food choice is determined by physiological factors, such as hunger, satiety, and motivation to consume certain foods[15].

A healthy, diverse diet consists of a high intake of vegetables, fruits, whole grains, legumes, nuts and seeds and low or no intake of foods with added sugar, processed meats and SSBs[6, 7]. A healthy, diverse diet may be difficult to achieve for most South African population groups, as the current unemployment rate is 32.9%[17], and 55.5% of people live below the upper-bound poverty line[18]. Studies conducted in the United States of America (USA) and the United

Kingdom (UK) showed that low socio-economic status (SES) was associated with unhealthy diets, low purchasing and consumption of fruits and high purchasing of unhealthy foods[19-21]. Low SES may be associated with a lack of nutrition knowledge and not following dietary guidelines[22].

South African adults, in general, consume a diet with low variety[10, 11]. However, there is limited research on the factors influencing food choices and consumption of diverse diets, particularly among adults in low-income groups. For the development and effective implementation of interventions aimed at promoting diverse diets and better food choices, especially in resource-poor settings, understanding the factors that influence the consumption of these diets is essential. Therefore, we aimed to explore barriers and enablers for consuming a diverse diet in women residing in resource-poor communities in Cape Town, South Africa.

METHODS

Study design, setting and participants.

This qualitative study is affiliated with the South African Diabetes Prevention Programme (SA-DPP). The SA-DPP aimed to develop and evaluate a model for diabetes prevention for the South African population. The study sites for SA-DPP were selected based on previous studies that showed a relatively high prevalence of diabetes among adults from the Black and Mixed-ancestry groups residing in resource-poor areas[23, 24].

Baseline data for SA-DPP were collected for 700 Black and Mixed-ancestry adults (age 25-65 years) at risk of type 2 diabetes (T2DM), recruited from 16 resource-poor communities around Cape Town. Participants had a mean age of 50.9 ± 9.1 years, with 81.1% female, 59.3% Black, and 40.7% Mixed-ancestry[25]. Participants had low education levels (84.2% did not complete high school), 43.7% were unemployed, and 71.6% had a monthly household income below R3200 (±178.69$). Most participants (70.4%) consumed a diet with low variety. Results also showed that 42.6% of individuals did not consume fruit, and 28.6% did not consume vegetables daily because of financial constraints[25].

Data for the qualitative study were collected between November 2020 and February 2021. Purposive sampling was used to select participants previously included in the SA-DPP baseline study for participation in focus group discussions (FGDs). Because most baseline study participants were females (81.1%), males were excluded. Thus, eligibility criteria included females aged between 25 and 60 years and fluent in English, Afrikaans or IsiXhosa. They were recruited via telephone and invited to join. Participants came from 12 resource-poor

communities around Cape Town, South Africa: Athlone, Bongweni, Bonteheuwel, Crossroads, Gugulethu, Harare, Heideveld, Lavender Hill, Lotus River, Mfuleni, Retreat and Samora.

The aim was to recruit seven purposively selected participants per site, resulting in an expected sample size of 84. However, of the selected participants, 27 could not be reached on their cell phones, four refused participation, and eight were unavailable on the day of the FGD, resulting in a final sample size of 45.

Instrument development: focus group discussion guide

The FGD guide questions were developed using the constructs of two conceptual frameworks; the socio-ecological model (SEM)[26] and the health belief model (HBM)[27]. The SEM considers the multiple factors that influence behaviour. These factors include individual (intrapersonal), social environment (interpersonal), physical environment (community) and macrosystem (society, government and public policy)[26]. The HBM is used to explain and predict the health behaviours of individuals[27].

The semi-structured FGD guide was developed in English in consultation with qualitative research experts. Three main domains were explored using semi-structured questions, 1) perception of healthy and unhealthy food; 2) understanding of DD and perceptions of DD on health; and 3) barriers, enablers, and facilitators for consuming a diverse diet and food choices.

In the context of this study, enablers are factors that assist individuals in acquiring healthy food choices, and facilitators are potential strategies and solutions to overcoming barriers to consuming diverse diets. In addition, a short, structured food procurement questionnaire was developed to gather information on cooking and purchasing decision-making, the primary food store used to make food purchases, reasons for the choice of primary food store, the main store where fruits and vegetables (FV) are purchased, and mode of transportation to get to food stores. Based on studies on enablers and facilitators, food purchasing data were collected to complement FGD data and provide context for interpretation.

The FGD guide and food procurement questionnaire were translated into Afrikaans and IsiXhosa by native Afrikaans and IsiXhosa speakers. The FGD guide and questionnaire (Supplementary Files 1 and 2) were pilot tested to determine their appropriateness concerning the study objective and whether the population group understood the questions. The FGD guide was piloted in two focus groups of eight participants (two Mixed-ancestry and six Black participants). After the piloting, the FGD guide was revised to include an exercise to gain clarity on the participants' understanding of DD, a question on possible facilitating factors for

consuming a diverse diet and questions on experiences and impact of the coronavirus disease (COVID-19) pandemic on food choices.

Data collection

Focus group discussions were held in person at the South African Medical Research Council, Non-Communicable Diseases Research Unit seminar room to ensure the privacy and comfort of participants. The sessions lasted between 45 and 90 minutes and were audio recorded. The FGDs were conducted by two Afrikaans-speaking facilitators (JH and a registered dietitian) and one IsiXhosa-speaking facilitator (a registered dietitian) trained in qualitative data collection methods. Thus, the FGDs were inclusive of all participants regardless of their language.

All information about the study, such as the purpose and objective, was provided in an information sheet. At the beginning of each FGD, the facilitator introduced the purpose of the study and obtained written consent from participants to participate and audio-record the discussions. The facilitator then asked an icebreaker question, "how would you describe what you eat?" to assist participants in focusing on the eating topic (healthy eating and diverse diets).

A note taker was present at each FGD session to take notes on the discussion. Despite challenges with recruiting participants as the study was conducted during the second wave of the COVID-19 pandemic, data saturation was achieved after 14 FGDs. At the end of each FGD, the participants were asked to complete the short, self-administered food procurement questionnaire with assistance from the facilitator. This information was obtained to support the FGD data and give more context to the participants' experiences. Participants received a supermarket voucher as reimbursement for participating in the FGDs.

Trustworthiness was ensured by 1) conducting focus groups in the participants' language (Afrikaans/IsiXhosa), 2) using a quality digital recorder, 3) having a debriefing session with the research team after each FGD, 4) taking discussion notes, 5) keeping an audit trail of the coding process and 6) using the Standards for Reporting Qualitative Research checklist to report findings[28] (Supplementary File 3).

Research team characteristics and reflexivity

The first author (SSM) is a PhD candidate at the School of Public Health, University of the Western Cape, while the co-authors hold doctoral degrees. All the authors are female and have expertise in public health, nutrition, social sciences, and quantitative, qualitative and

community participatory research. Data collection, analysis and interpretation may be influenced by our public health or nutrition work experience or both.

Data analysis

Audio recordings of the FGDs were transcribed verbatim in English by independent translators fluent in English and Afrikaans or IsiXhosa. Transcripts were reviewed for accuracy against the notes taken by the note taker by the first author (SSM) and imported into Atlas.ti 9 software for data coding and analysis. Data were analysed using directed content analysis[29]. The initial codebook was based on the SEM and HBM, including literature on barriers and facilitators for healthy eating used to develop the FGD guide. The initial codebook was piloted by two researchers (SSM and JH) before being finalised. A hybrid approach by combining the deductive and inductive approaches to coding was performed. Upon completion of coding, the researcher (SSM) merged and deleted codes as necessary. Additionally, the researcher categorised quotes based on predetermined themes. Themes were described using codes and their relevant quotations. Data analysis codes, categories, and themes were re-examined and refined by SSM, JH, and MF to improve credibility.

The food procurement questionnaire data were analysed using the statistical software package IBM SPSS for Windows version 27 (Armonk, New York, NY, USA). Categorical variables are presented as counts and percentages.

RESULTS

Food purchasing practices of the FGD participants.

In total, 45 women (53.3% Black, 46.7% Mixed-ancestry) with an average age of 49.7 ± 7.8 years (range 31-62) participated in the FGDs and completed the short food procurement questionnaire. The results of this food procurement questionnaire are presented in Table 1.

Most participants (93.3%) reported that they decided on the type of food to buy for the household. The main factors that influenced their food choices were availability (64.4%), health (57.8%), income (48.9%) and food prices (42.2%). Most participants were responsible for preparing the food (95.6%), with 77.8% purchasing food from a supermarket and 53.3% buying FV from a street vendor. Just over half of the participants (55.6%) either walked or used a taxi to get to and from food stores. Reasons for choosing primary food sources were mostly based on price (80.0%) and closeness to the home (60.0%).

Focus group discussions.

Fourteen FGDs were conducted with 45 participants from 12 communities. The average number of participants per FGD was three (ranging from two to six). The six themes and corresponding subthemes identified across the three domains are described in Table 2.

Theme 1. Nutrition knowledge

The sub-themes and relevant quotes on participants' nutrition knowledge are summarised in Table 3.

Foods perceived as healthy and unhealthy.

Participants were given a pack of food cards and asked to choose two healthy and two unhealthy foods and give reasons why. Generally, participants were able to distinguish between healthy and unhealthy foods. Most participants perceived healthy food as FV, brown bread, fish, eggs, maize meal porridge, fruit juice, dairy, beans, and breakfast cereals and cheese. Participants perceived foods such as sweets, chocolates, carbonated drinks, white bread, sausage rolls, pies, samosas, fried chicken, red meat, eggs (egg yolk), cold meats, chips, margarine, squashes and fruit juice concentrates and carbonated drinks as unhealthy foods.

Sources of nutrition information

Most participants mentioned receiving nutrition information from nurses or doctors at health facilities, such as clinics or hospitals, though they do not always have the means to follow the nutrition advice given. The media, such as television, radio, and social media, was also mentioned as a significant source of information. A few participants said that they learned about nutrition from their parents. Only one focus group participant reported receiving nutrition information from a dietician.

Theme 2. Perceptions of dietary diversity and its impact on health

The sub-themes and relevant quotes on participants' perceptions of dietary diversity and its impact on health are summarised in Table 4.

Defining dietary diversity

Most participants had a good understanding of what it meant to eat a variety of foods. However, some participants interpreted variety as consuming healthy and unhealthy foods. The participants were shown a picture with four rows of different food items (Supplementary File 4). In the picture, row A represented only starchy foods, row B unhealthy foods, row C diverse, healthy foods, and row D represented a combination of healthy and unhealthy foods. Although

most participants recognised that row C represented a variety of foods, a few thought that row D represented variety. In another exercise, participants were asked to describe two plates of food (Supplementary File 5). Most participants could distinguish between a plate with variety versus one without variety.

Possibility of consuming a diverse diet daily

Most participants expressed that they did not consume a variety of foods daily. They said that variety was possible for only some days of the week or month. Most participants mentioned having a variety of foods only on Sundays. Across all FGDs, most participants did not think it was possible to have a variety of foods every day because of financial constraints. Participants believed it was only possible to eat a variety daily at the beginning of the month after a household member received a salary, wages, or a social grant.

Perceived benefits of dietary diversity

The perceived health benefits of consuming a diverse diet mentioned by most participants included NCD prevention, improved physical appearance (healthy weight, radiant skin), increased energy levels, and long life.

Perceived consequences of a lack of dietary diversity

Malnutrition, micronutrient deficiencies and depression were the perceived consequences of a diet lacking variety mentioned by some participants.

Eating habits and quality of life

Most participants believed that their present eating habits negatively affected their health and quality of life. However, some did not believe that their diet affected their health, while others who had changed their diet because of illness thought it improved their quality of life.

Theme 3. Individual factors

The critical individual factors influencing the consumption of diverse diets and healthy food choices include household income and taste preferences. Other factors that influence food choice mentioned by a few participants include satiety, food availability, food shelf life, convenience, seasonality/weather, and time.

> *I consider how long it lasts like vegetables cannot stay fresh for long*. (Area O, participant 1)

> *What will influence it is obviously the day. If it's warm, we will eat lighter food. If it's cold, we will have stews, and you need variety*. (Area G, participant 5)

We cook what's in the house and what suits our pockets, and we cook things that won't take time to cook. (Area H, participant 1)

Health conditions

A few participants stated that health conditions affect their food choices. The health conditions have encouraged them to make healthier food choices.

In 2006, I discovered I suffer from angina, and ever since that time, I cut out fatty foods, full-cream milk, red meat, and all those things I know can increase my blood pressure. (Area G, participant 2)

Health was the last thing on my mind when I decide what to eat, before being diagnosed, I did not think about eating healthy food. I have stopped drinking fizzy drinks because it made me sick. (Area H, participant 2)

I try to avoid salt and fats because I have high blood pressure. (Area R, participant 5)

Grocery decision making

All participants were responsible for decisions on what foods were purchased, cooked, and consumed in their households.

I do the shopping. I do everything. (Area D, participant 1)

I buy the things that we are used to at home because if I buy something unusual, it'll just sit there, no one will eat it, I'll just be wasting my money. (Area L, participant 4)

I do the cooking at home because the kids are still young. *(*Area O, participant 2)

Many participants mentioned writing shopping lists and budgeting for food.

I have my list for the month… I have a booklet that I use to budget. (Area G, participant 3)

You need to budget and buy things that will carry you throughout the month. (Area H, participant 2)

All participants in the FGDs mentioned comparing food prices and usually purchasing cheaper foods or those on sale.

We check prices, and we go for cheaper options that might not be nutritious. (Area H, participant 1)

We do compare because there are usually pamphlets – Boxer, Shoprite, and Pick 'n Pay, then you look for a place with low prices. (Area P, participant 2)

Mothers always compare prices – like Boxer's/Shoprite specials. (Area R, participant 2)

Individual barriers, enablers, and facilitators

The sub-themes and relevant quotes on the perceived individual barriers, enablers, and facilitators for consuming a diverse diet are summarised in Tables 5–7, respectively.

The most critical individual barrier to consuming a diverse diet across all the FGDs was financial constraints. Most participants had a limited budget to spend on food. Lack of nutrition knowledge and taste preferences were also individual barriers to diverse diets (see Table 5).

The individual enabler for consuming a diverse diet was taste preferences for healthy foods such as FV (Table 6). Individual facilitators identified in the FGDs include drawing up a grocery budget, finding employment, or starting a business to generate income (Table 7).

Theme 4. Social influences

Social barriers, enablers, and facilitators

The sub-themes and relevant quotes on the social barriers, enablers, and facilitators for consuming a diverse diet are summarised in Tables 5–7, respectively.

Family taste preferences were the main social barrier to consuming a diverse diet. Having children or grandchildren was perceived as a negative influence on food choices and food purchases. According to participants, children dislike healthy foods like vegetables; therefore, parents cook food that children will consume. Husbands generally consumed whatever foods their wives prepared. Only two participants, who lived alone, stated that living alone made them have unhealthy food choices (Table 5).

Social factors that enabled healthier food choices were family taste preferences for healthy foods or not having picky eating in children, enabling households to have healthier food consumption. Having a family with children and a husband encouraged participants to cook a variety of foods for their families (Table 6).

No social facilitators for consuming a diverse diet were identified in the FGDs.

Theme 5. Physical environment influences

Physical environment barriers, enablers, and facilitators

The sub-themes and relevant quotes on the physical barriers, enablers, and facilitators for consuming a diverse diet are summarised in Tables 5–7, respectively.

High food prices were the main physical environment barrier to consuming a diverse diet. A lack of community food aid facilities, such as soup kitchens and community gardens, was a

barrier to only some black participants. Some participants mentioned having a home garden in the past or wanting to have one; however, lack of space, the presence of dogs and people destroying gardens in the community were barriers to starting and maintaining home gardens (Table 5).

Regarding enablers, participants mostly had a positive perception of their neighbourhood food environment, which had food stores such as supermarkets, convenience stores, and vendors near their homes. Neighbourhood presence of FV stalls that were perceived to have lower prices than supermarkets, access to community soup kitchens and gardens, and in-store food product sales were, respectively, perceived as enablers for diverse diets within the food environment (Table 6).

Starting home gardens and community gardens/projects or supporting existing community kitchens/gardens was identified as a potential facilitator for consuming diverse diets and improving access to food. Lowering the price of healthy foods was another possible facilitator within the physical environment (Table 7).

Theme 6. Societal influences on food choices

Societal barriers enablers and facilitators

The sub-themes and relevant quotes on the societal barriers, enablers, and facilitators for consuming a diverse diet are summarised in Tables 5–7, respectively.

The FGDs were conducted during the COVID-19 pandemic second wave. High and rising food prices during the COVID-19 pandemic and the food aid received were barriers to consuming a diverse diet and meant that participants could not purchase the food they usually consumed. Some participants expressed that the food aid was not distributed properly, and some food in parcels expired and was misused. Television advertisements negatively influenced participants to purchase unhealthy fast foods instead of using money to buy healthy foods (Table 5).

Food aid supplied by non-governmental organisations (NGOs), religious organisations, and the government enabled participants to have access to healthy food during the COVID-19 pandemic (Table 6). Supermarket television advertisements and catalogues enabled participants to buy food at lower prices.

Governmental support in the form of job opportunities and increasing money for social grants were identified as possible facilitators for consuming a diverse diet (Table 7).

DISCUSSION

This qualitative study identified socio-ecological barriers and enablers for consuming a diverse diet among low SES Black and Mixed-ancestry women. Overall, participants could differentiate between healthy and unhealthy foods and had a good understanding of eating a variety of food. The critically perceived barriers to consuming a diverse diet were financial constraints, food prices and family taste preferences. Individual taste preferences, accessibility and availability to food stores and vendors, community soup kitchens/gardens and food store specials were identified as the main enablers for consuming a diverse diet and making healthy food choices.

Although participants could differentiate between healthy and unhealthy foods, the concept of healthy food in its entirety is not understood. Study participants were aware of the benefits of having a diverse diet and the consequences of not consuming a variety of foods. However, the SA-DPP baseline study showed that most participants had a low DD[25]. SA-DPP participants also had a high unemployment rate and low household income[25]; therefore, it is not surprising that FGD participants identified financial constraints as a critical barrier to consuming a diverse diet.

Studies in the USA showed that lower-income households and less education were associated with food insecurity and poor-quality diet[19, 21]. A systematic review, including studies conducted in low- and lower-middle-income countries, found that lower SES was associated with diet-related NCDs, such as cardiovascular disease and cancer[30]. Low income was also reported to be a critical barrier to purchasing and consuming a healthy diet in qualitative studies in Kenya[31] and South Africa[32].

Food prices were identified as a barrier to consuming diverse diets in the FGDs, which is in line with the results of the SA-DPP baseline study, showing that cost/money was the main reason for not eating FV daily[25]. The present study was conducted during the COVID-19 pandemic, which resulted in critical job losses, drastically reduced household incomes, and a sharp increase in food prices[33], which limited households' purchasing power.

Based on two systematic reviews, one of which included studies conducted globally[34] and the other only US-based studies[35], food price is the most significant factor determining food consumption and purchasing in low-income countries and poorer households. Responses from the food procurement questionnaire indicate that participants' choice of a food store was based

primarily on food prices. The South African National Health and Nutrition Examination Survey showed that price is the main driver behind food choices when shopping among adults[11].

At a community level, most FGD participants reported high accessibility and availability to supermarkets, corner stores and food stalls; however, food prices limited the types of foods they could purchase. The cost of food has been reported as a barrier to healthy eating in several other studies conducted in the USA and Netherlands[36-38]. Budgeting and buying cheaper brands or foods on sale were among the strategies FGD participants used to cope with a limited budget. Similarly, a study conducted in Limpopo, South Africa, reported that to cope with rising food prices, women budget and write shopping lists with the necessities, buy in bulk or buy cheaper brands, such as generic store brands[39].

Most FGD participants were responsible for cooking food within the household and made the decisions on what foods to purchase. Participants mentioned having plenty of time to cook for their families. In contrast, a systematic review reported that time is a barrier to healthy eating[40]. One study supporting our findings stated that older women are less likely to perceive time as a barrier to healthy eating[41]. Family taste preferences were identified as a critical social barrier to consuming a diverse diet. While most participants prepared meals based on family preferences, they also recognised that these preferences were unhealthy.

Most FGD participants who lived with children or grandchildren cited difficulties with getting them to consume healthy foods such as vegetables. Studies with low-income women have reported that mothers often have knowledge of healthy diets but are challenged to implement those behaviours among their children[36-38]. Some participants stated they cooked vegetables separately because they liked them but did not serve them to their children.

Although children play some role in the foods consumed in the household, most participants had a taste preference for healthy foods such as FV. Despite this preference for healthy foods, some participants expressed that they could not afford to purchase healthy foods. A recent systematic review of qualitative studies reported that taste, price and convenience were key factors considered when making food choices rather than health[42]. Interestingly, the FGD findings differed from the results of the food procurement questionnaire because only a small percentage of participants reported considering taste in making food choices, but more than half reported considering health. Notably, only a few participants mentioned eating healthy foods or avoiding specific unhealthy foods because of health conditions. The differences in the

data may be attributable to social desirability bias, which commonly occur in self-reported surveys.

Access to various types of food stores and vendors was identified as an enabler within the physical environment for consuming a diverse diet. Access to food outlets within walking distance has been reported as a facilitator for healthy eating[31, 38]. According to the food procurement questionnaire, approximately half of the FGD participants walk to food stores, and almost 80% purchase food primarily in supermarkets. It has been estimated that more than 90% of the population in Cape Town purchases food from supermarkets[43]. A study in the UK found that factors such as health, convenience, and SES influence store and product choice[44]. Food procurement questionnaire data showed that price/money and proximity to a store were the two main reasons for participants' store choices.

Access to food aid such as community soup kitchens and community and home gardens were identified as an enabler and possible facilitator within the physical environment for consuming a diverse diet. Between September and December 2020, 9.34 million people (16%) in South Africa experienced acute food insecurity[33]. Community facilities such as soup kitchens and food parcels from NGOs and the government enabled FGD participants access to food during the COVID-19 lockdown. A study conducted in the USA found that using soup kitchens, food pantries and receiving food donations were associated with improved diet quality among people with food insecurity[45].

Steyn and Ochse (2013) suggested that food policies and food aid may help reduce barriers to consuming diverse diets in the South African population[9]. Despite the lack of space and presence of dogs being mentioned as barriers to creating home gardens, participants perceived community and home gardens as facilitators for diverse diets. According to a recent systematic review, community gardening was associated with high FV intake[46].

Most participants expressed that healthier foods were expensive and compared food prices between different stores using advertisements to select stores offering lower prices. Therefore, lower food prices and food store specials were identified as enablers and facilitators within the physical environment for consuming a diverse diet. In another systematic review, lower food prices were reported to be associated with increased FV consumption[47]. A study in the Netherlands also mentioned that decreasing the price of healthy foods may support healthy eating behaviours[38].

This study provides insight into the barriers and enablers to consuming a diverse diet in women residing in resource-poor communities. However, there are limitations. First, data collected were self-reported and therefore susceptible to social desirability bias, particularly regarding consuming a diverse diet and factors affecting food choices. Second, since qualitative content analysis relies on the researcher reading and interpreting texts, the study may be subjected to researcher bias. Third, participants did not provide feedback on the findings to improve credibility. However, notes taken by a note taker during the FGDs were examined during the analysis to improve credibility. Fourth, the average FGD had three participants because data were collected during the second wave of COVID-19 in South Africa, leading to a low response rate, although data saturation was still reached. Finally, this study was conducted in one city, Cape Town, where 90% of the population purchases food from supermarkets; therefore, the results cannot be generalised to the entire South African population. Different results may be found if the study was conducted in a peri-urban or rural settings.

Conclusion

Our study findings suggest that women from resource-poor communities face many challenges, such as financial constraints, high food costs, and social factors, such as family members, especially children, who inhibit their ability to consume a diverse diet and make healthy food choices. Nutrition education interventions need to address the lack of knowledge on what foods are healthy. Public health interventions should not only focus on nutrition education but also address financial barriers and the cost of food so that they can support the consumption of diverse diets, healthy food choices and adherence to FBDGs among people in resource-poor settings.

References

1. Afshin A, Sur PJ, Fay KA *et al.* (2019) Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* **393**, 1958-1972.
2. Claasen N, van der Hoeven M & Covic N (2016) *Food environments, Health and Nutrition in South Africa*. Cape Town: PLAAS, UWC and Centre of Excellence on Food Security. http://repository.uwc.ac.za/xmlui/handle/10566/4520 (accessed March 2019).
3. National Department of Health (NDoH), Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC) & ICF (2019) *South Africa Demographic and Health Survey 2016*. Pretoria, South Africa, and Rockville, Maryland, USA: NDoH, Stats SA, SAMRC, and ICF. https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf (accessed March 2022).
4. World Health Organization (2018) Non-communicable diseases (NCD) country profiles 2018. https://www.who.int/nmh/publications/ncd-profiles-2018/en/ (accessed September 2021).
5. Herforth A, Arimond M, Álvarez-Sánchez C *et al.* (2019) A global review of food-based dietary guidelines. *Adv Nutr* **10**, 590-605.
6. World Health Organization (2018) Fact sheet: Healthy diet. Geneva: WHO. www.who.int/news-room/fact-sheets/detail/healthy-diet (accessed March 2020).
7. Kennedy G, Razes M, Ballard T *et al.* (2011) Measurement of dietary diversity for monitoring the impact of food based approaches. https://www.fao.org/agrifood-economics/publications/detail/en/c/122494/ (accessed June 2019).
8. Vorster HH, Badham J & Venter CS (2013) 1. An introduction to the revised food-based dietary guidelines for South Africa. *S Afr J Clin Nutr* **26**, 5-12.
9. Steyn N & Ochse R (2013) "Enjoy a variety of foods": as a food-based dietary guideline for South Africa. *S Afr J Clin Nutr* **26**, Suppl. 1, S13-S17.
10. Labadarios D, Steyn NP & Nel J (2011) How diverse is the diet of adult South Africans? *Nutr J* **10**, 33.
11. Shisana O, Labadarios D, Rehle T *et al.* (2013) South African National Health and Nutrition Examination Survey (SANHANES-1). Cape Town: HSRC Press; 2013 https://hsrc.ac.za/uploads/pageNews/72/SANHANES-launch%20edition%20(online%20version).pdf (accessed June 2022).
12. Drimie S, Faber M, Vearey J *et al.* (2013) Dietary diversity of formal and informal residents in Johannesburg, South Africa. *BMC Public Health* **13**, 911.
13. Chakona G & Shackleton C (2017) Minimum dietary diversity scores for women indicate micronutrient adequacy and food insecurity status in South African towns. *Nutrients* **9**, 812.
14. Mozaffarian D, Angell SY, Lang T *et al.* (2018) Role of government policy in nutrition—barriers to and opportunities for healthier eating. *BMJ* **361**, k2426.
15. Leng G, Adan RAH, Belot M *et al.* (2017) The determinants of food choice. *Proc Nutr Soc* **76**, 316-327.
16. Laraia BA, Leak TM, Tester JM *et al.* (2017) Biobehavioral factors that shape nutrition in low-income populations: A narrative review. *Am J Prev Med* **52**, Suppl. 2, S118-S126.
17. Statistics South Africa (Stats SA) (2022) Quarterly Labour Force Survey, Quarter 3, 2022. Statistical release P0211. Pretoria: Statistics South Africa. https://www.statssa.gov.za/publications/P0211/P02113rdQuarter2022.pdf (accessed January 2023).
18. Statistics South Africa (Stats SA) (2022) National Poverty Lines 2022. Statistical Release P0310.1. Pretoria: Statistics South Africa. https://www.statssa.gov.za/publications/P03101/P031012022.pdf (accessed January 2023).

19. French SA, Tangney CC, Crane MM *et al.* (2019) Nutrition quality of food purchases varies by household income: the SHoPPER study. *BMC Public Health*. **19**, 231.
20. Pechey R & Monsivais P (2016) Socioeconomic inequalities in the healthiness of food choices: Exploring the contributions of food expenditures. *Prev Med* **88**, 203-209.
21. Darmon N & Drewnowski A (2008) Does social class predict diet quality? *Am J Clin Nutr* **87**, 1107-1117.
22. Spronk I, Kullen C, Burdon C *et al.* (2014) Relationship between nutrition knowledge and dietary intake. *Br J Nutr* **111**, 1713-1726.
23. Peer N, Steyn K, Lombard C *et al.* (2012) Rising diabetes prevalence among urban-dwelling Black South Africans. *PLoS One* **7**, e43336.
24. Erasmus RT, Soita DJ, Hassan MS *et al.* (2012) High prevalence of diabetes mellitus and metabolic syndrome in a South African coloured population: baseline data of a study in Bellville, Cape Town. *S Afr Med J* **102**, 841-844.
25. Madlala SS, Hill J, Kunneke E *et al.* (2022) Dietary Diversity and its association with nutritional status, cardiometabolic risk factors and food choices of adults at risk for Type 2 Diabetes Mellitus in Cape Town, South Africa. *Nutrients* **14**, 3191.
26. McLeroy KR, Bibeau D, Steckler A *et al.* (1988) An ecological perspective on health promotion programs. *Health Educ Q* **15**, 351-377.
27. Rosenstock IM, Strecher VJ & Becker MH (1988) Social learning theory and the health belief model. *Health Educ Q* **15**, 175-183
28. O'Brien BC, Harris IB, Beckman TJ *et al.* (2014) Standards for reporting qualitative research: a synthesis of recommendations. *Acad Med* **89**, 1245-1251.
29. Hsieh H-F & Shannon SE (2005) Three approaches to qualitative content analysis. *Qual Health Res* **15,** 1277-1288.
30. Williams J, Allen L, Wickramasinghe K *et al.* (2018) A systematic review of associations between non-communicable diseases and socioeconomic status within low- and lower-middle-income countries. *J Globl health* **8**, 020409.
31. Mokaya M, Saruni E, Kyallo F *et al.* (2022) Perceived facilitators and barriers to healthy dietary behaviour in adults with type 2 diabetes mellitus in Kenya: A qualitative study. *Public Health Nutr*. **25**, 1-24.
32. Besselink D, Brandt H, Klingberg S *et al.* (2022) Perceptions of healthy food, and perceived facilitators and barriers to buying and consuming healthy food, among female caregivers in Soweto, South Africa. *S Afr J Child Health* **16**, 172-177.
33. Integrated food security phase classification (IPC). IPC South Africa Acute food insecurity analysis September 2020 - March 2021 https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_South_Africa_AcuteFoodInsec_2020Nov2021Mar_Report.pdf (accessed July 2022).
34. Green R, Cornelsen L, Dangour AD *et al.* (2013) The effect of rising food prices on food consumption: systematic review with meta-regression. *BMJ* **346**, f3703.
35. Andreyeva T, Long MW & Brownell KD (2010) The impact of food prices on consumption: a systematic review of research on the price elasticity of demand for food. *Am J Public Health* **100**, 216-222.
36. Baruth M, Sharpe PA, Parra-Medina D *et al.* (2014) Perceived barriers to exercise and healthy eating among women from disadvantaged neighborhoods: results from a focus groups assessment. *Women Health* **54**, 336-353.
37. Palmer SM, Knoblauch ST, Winham DM *et al.* (2020) Putting knowledge into practice: Low-income women talk about food choice decisions. *Int J Environ Res Public Health* **17**, 5092.

38. Van der Velde LA, Schuilenburg LA, Thrivikraman JK *et al.* (2019) Needs and perceptions regarding healthy eating among people at risk of food insecurity: a qualitative analysis. *Int J Equity Health* **18**, 184.
39. Mkhawani K, Motadi SA, Mabapa NS *et al.* (2016) Effects of rising food prices on household food security on femaleheaded households in Runnymede Village, Mopani District, South Africa. *S Afr J Clin Nutr* **29**, 69-74.
40. Lara J, Yong V & Mathers JC (2016) Perceived barriers to healthy eating: a systematic review. *Proc Nutr Soc* **75**, E152.
41. Williams L, Ball K & Crawford D. (2010) Why do some socioeconomically disadvantaged women eat better than others? An investigation of the personal, social and environmental correlates of fruit and vegetable consumption. *Appetite*. **55**, 441-446.
42. Pinto VRA, Campos RFdA, Rocha F *et al.* (2021) Perceived healthiness of foods: A systematic review of qualitative studies. *Future Foods* **4**, 100056.
43. Battersby J & Peyton S (2014) The geography of supermarkets in Cape Town: Supermarket expansion and food access. *Urban Forum* **25**, 153-164.
44. Pechey R & Monsivais P (2015) Supermarket choice, shopping behavior, socioeconomic status, and food purchases. *Am J Prev Med* **49**, 868-877.
45. Mousa TY & Freeland-Graves JH (2019) Food security of food recipients of a food pantry and soup kitchen. *Public Health Nutr* **22**, 1451-1460.
46. Hume C, Grieger JA, Kalamkarian A *et al.* (2022) Community gardens and their effects on diet, health, psychosocial and community outcomes: a systematic review. *BMC Public Health.* **22**, 1247.
47. Afshin A, Peñalvo JL, Del Gobbo L *et al.* (2017) The prospective impact of food pricing on improving dietary consumption: A systematic review and meta-analysis. *PLoS One* **12**, e0172277.

Table 1 Focus group discussion participants food procurement practices (*n* 45)

Variables	*n*	%
Who decides what type of food to buy		
Herself	42	93.3
Partner/ spouse	6	13.3
Children	13	28.9
Other members of family/household	7	15.6
Brother-in-law	1	2.2
Factors influencing food choice		
Taste	12	26.7
Availability	29	64.4
Convenience and time	8	17.8
Family and/or friends	9	20.0
Household income	22	48.9
Food prices	19	42.2
Culture and/or religion	6	13.3
Health	26	57.8
Nutrition knowledge	11	24.4
Person responsible for preparing the food		
Herself	43	95.6
Partner/ spouse	6	13.3
Children	17	37.8
Other members of family/household	6	13.3
Primary food source		
Supermarket	35	77.8
Grocery store	18	40.4
Convenience store/spaza shop	14	31.1
Mobile food vendor	5	11.1
Sources for fruits and vegetables		
Supermarket	18	40.0
Fruit and vegetable market	22	48.9
Convenience store/spaza shop	4	8.9
Street vendor	24	53.3
Local farmers & home garden	2	4.4
Mode of transportation to and from food stores		
Walk	25	55.6
Bus	3	6.7
Train	2	4.4
Taxi	25	55.6
Private car	11	24.4
Walk & transport	15	33.3
Reasons for choosing primary food source		
Price/Value for money	36	80.0
Close to participant's home	27	60.0
Quality of food	10	22.2
Variety of food items	19	42.2
Can buy on credit	4	8.9
Good customer service	1	2.2

Table 2 Main themes and corresponding subthemes

Domains	Themes	Sub-themes
Perception of healthy and unhealthy food	1. Nutrition knowledge	1. Foods perceived as healthy and unhealthy
		2. Source of nutrition information
Understanding of dietary diversity and perceptions on impact of dietary diversity on health	2. Perceptions of dietary diversity and its impact on health	1. Defining dietary diversity
		2. Possibility of consuming a diverse diet daily
		3. Perceived benefits of dietary diversity
		4. Perceived consequences of a lack of dietary diversity
		5. Eating habits and quality of life
Barriers, enablers*, and facilitators¶ for consuming a diverse diet and food choice	3. Individual factors	1. Health conditions
		2. Grocery decision making
		3. Financial status
		4. Taste preferences
		5. Nutrition knowledge
	4. Social influences	1. Family structure
		2. Family taste preferences
	5. Physical environment influences	1. Proximity to food outlets
		2. Perceived consumer food environment
		3. Community food assistance
	6. Societal influences on food choices	1. COVID-19 Lockdowns
		2. Media influences

*Enablers are factors that assist in acquiring healthy food choices.

¶ Facilitators are potential solutions /strategies to overcoming barriers for food choices.

Table 3 Nutrition knowledge: themes and quotes from the focus group discussions.

Themes	Supporting Quotations
Perceived healthy and unhealthy food	**Food perceived as healthy**. • ***"****My healthy food is like broccoli, cauliflower. I'll eat this raw even. And my other healthy food is porridge in the morning. Porridge is healthy because of all the vitamins and iron that is in there that your body need for the day"* (Area N, participant 2) • *"Brown bread I love very much. It's very good for the digestive system. It helps with open stools. Tinned fish, the Lucky Star is very good. Its brain food and it's also good for the heart."* (Area G, participant 1) • *"Green veggies, they are from the soil and cheese is healthy because of proteins. So green veggies and cheese are healthy"* (Area L, participant 2) • *"Vegetables – like you eat pumpkins and eat different colours – one day this and on another day something else. They make us to feel healthy and body parts become strong when we eat these things. Eggs and fish have protein, and the proteins help the body to remain strong – then you won't be troubled by sicknesses so much"* (Area F, participant 2) **Foods perceived as unhealthy**. • *"Fried chips are very unhealthy as it has a lot of oil, … Then sweets, it's a definite no-no for me, even though I eat a chocolate, it's too much for the blood and bad for the teeth"* (Area G, participant 1) • *"The red meat is very dangerous for your heart; it gives you cholesterol and too much of a good thing is bad. Cold drink, it can be good and bad, but I think that is bad because all the sugar in here and I don't drink sugar.* (Area N, participant 2) • *"… pies and sausage rolls, fast foods actually. That is not good for the body, especially the immune system"* (Area Q, participant 1) • *"Fizzy drinks are not good for your body; even junk food like sweets and chocolates they can cause bile problems. Red meat makes you sick and chocolates are not good for children and adults"* (Area H, participant 1)
Source of nutrition information	• "*At the day hospitals there is a sister that will come around while you wait that will brief you on healthy eating especially when it comes to TB* (Area J, participant 2) • *"Sometimes we are told at the clinic, but we understand that we do not have money. You just agree but it is hard to buy these things*" (Area P, participant 2) • "*…yes, the tv and even if we go to the hospital then they have people there who speak and explain things about health"* (Area Q, participant 4) • *"I did not know you can make lentils instead of meat. The dietitian taught us there is healthier rice than what we currently eat, so we can live healthily we know how."* (Area G, participant 3)

Table 4 Perceptions of dietary diversity and its impact on health: themes and quotes from the focus group discussions

Themes	Supporting Quotations
Definition of dietary diversity	• *"…protein, vitamins that's what I think is a variety of food. You need like fibre for your digestive system and you will have like guavas cause there is a lot of vit C in that you need and poultry is also protein or something and you need a little bit of starch. And the milk is obviously for calcium and for your bones. All of the things, the iron and stuff, all that's in the fruits and the veggies we have and the meat. You must have your water."* (Area D, participant 1) • *"it's not good because you can't eat a mix of food together. It means it's sweet, its sour, it's bitter, its fatty, that's a variety"* (Area G, participant 1) • "*It means we must eat different types of food, and not only eat one type every day"* (Area H, participant 1) • *"it's not eating the same food every day" (*Area J, participant 1) • *"Something of everything cause the different vitamins"* (Area K, participant 3) • "*Variety of foods mean to eat this chicken and vegetables. Some of the food we eat is not healthy food. Some of it is healthy but we mix it with unhealthy food."* (Area L, participant 1) • "*What comes to mind is that I'm eating right, because I shouldn't be eating just one thing. I should be eating different types of food- the food that builds the body so that when I get sick the doctor doesn't tell me that there is something lacking in my body*" (Area L, participant 5) • *"I think a person who eats like that is the one who is eating nutritious food because I just eat starch – because when you just eat pap and potatoes that is all starch. Rice and potatoes are all starch. There must be spinach and broccoli that'll add something else."* (Area P, participant 2) • *"Variety means, everything like snacks, and variety is wrong foods." (*Area Q, participant 3) • *"It is eating everything that is available to you, healthy and unhealthy"* (Area R, participant 5)
Defining dietary diversity using pictures*	• *"C, there are veggies, there's milk, it's not always a must to have but there is nutrition in there"* (Area J, participant 3) • *"C Here you have your vegetables and your fruit in here and you got your starch, and you got your milk also. So, it's your 5 ingredients for the day."* (Area N, participant 2) • *"I say it is C. It is rice, chicken, beans and spinach and it is healthy"* (Area O, participant 1) • *"It is C. I say it is a variety of food because there is spinach, beans, starch, chicken, vegetables, fruits, and there is also milk, all these things are needed by the body. Everything is balancing in C."* (Area P, participant 2) • *"… for me it is C as it is a variety of everything. Vegetables and everything else. Milk is there, fruit is there, chicken is there. There is a variety of everything"* (Area Q, participant 4) • *"I would say C and D"* (Area G, participant 5) • *"I choose C and D because we are talking about variety here."* (Area L, participant 2) • *"D because it's got of everything; sweet and healthy and unhealthy, everything"* (Area K, participant 3) • *"It's D. because all kinds of food are represented here"* (Area O, participant 3) • *"I will say D. Some of it will build your body"* (Area Q, participant 2)
Defining dietary diversity using plates of food¶	**Description of plate A**: • *"A is very colourful, it looks like healthy"* (Area K, participant 2)

Themes	Supporting Quotations
	• *"This one is interesting – there's little starch, macaroni, greens, meat. It's interesting because it has a variety because it is not just one colour in here"* (Area P, participant 2) • *"The one has got a bigger variety than the other and the one has the protein and the starch and greens*" (Area N, participant 1) • *"I will say A, because it has a variety and we have to choose 3 or more groups"* (Area Q, participant 1) **Description of plate B** • *"B is not healthy even though we eat it because of circumstances"* (Area F, participant 2) • *"B has starch, and it can make you full."* (Area H, participant 1) • *"It has starch, and it doesn't look healthy, it doesn't have variety – it's starch and meat (Oh no it's cabbage)"* (Area R, participant 1)
Possibility of consuming a diverse diet daily	• *"Because you don't have means yes, the heart wants to eat like that but then you don't have means and then you take whatever so that people can sleep with something in their tummies."* (Area F, participant 1) • *"No not always, but once a month I buy the combo from Food lovers"* (Area G, participant 2) • *"I only cook plate A when I have visitors"* (Area H, participant 1) • *"I don't think you will eat a variety. Perhaps on a Sunday you will eat a variety."* (Area J, participant 2) • *"The plate look like that only on a Sunday"* (Area K, participant 1) • *"Twice or trice there is veggies. Depends, the last week in the month there will be no money, just a dry salty crack"* (Area K, participant 2) • *"During the month my plate is B, I would have liked it to be A, but I can't afford to eat like that because of the situation at home it is always B, but I wish I was eating A."* (Area L, participant 9) • *"Maybe at the beginning of the month we can try but by the second week you just cook what is available"* (Area P, participant 1) • *"That will be possible if you have someone in the house that works but with poverty, that won't be possible, because I think you will only have 1 or 2 of the healthy groups on your plate, or sometimes you won't even be having it on your plate. We must just eat whatever there is for the day"* (Area N, participant 2)
Perceived benefits of dietary diversity	• *"My skin would be better, my hair, there would not be a need for me to take cholesterol and metformin and all of those tablets"* (Area D, participant 1) • *"If we ate the right food, we would not have certain illnesses. Nowadays people are killed by illnesses like sugar diabetes, sometimes they are born with it. In the olden days people would reach 100 years but these days it is difficult to stay healthy*" (Area H, participant 2) • *"I'd say it'd be beneficial to us in a healthy way obviously – more energy to do what you need to do"* (Area L, participant 2) • *"It would be better because some illnesses are caused by what we eat. I am not saying that people will not be sick anymore, but it'll definitely be better."* (Area P, participant 2)

Themes	Supporting Quotations
Perceived consequences of a lack of dietary diversity	• *"Obviously you will start to have malnutrition you will have a big tummy, but the muscles will deteriorate cause the body needs all of plate A which plate B definitely don't have*." (Area D, participant 1) • *"It give you depression, a mental state"* (Area D, participant 2) • *"I didn't know that in life if there are certain things that you don't eat then when you go to hospital, they'll tell you that there're some vitamins that are lacking in your body"* (Area L, participant 5) • *"We are going to gain weight and then you are going to get tired cause what's in there? You burn that starch and then you are exhausted most of the time because now you are gaining weight. You can't do what you normally would do*." (Area N, participant 1)
Eating habits and quality of life	• *"It affects me in a bad way, because Kentucky is expensive, pizza is expensive so then I don't perhaps buy those tomatoes and potatoes. Most of the time I buy those, but I don't have to. I feel bad 'cause I could have got more out with that money buying vegetables."* (Area D, participant 2) • *"I don't eat the right food and you feel tired. I eat and sit down because I am unemployed. Sometimes my blood pressure increase."* (Area F, participant 1) • *"My cholesterol is slightly elevated, it's 5.6. It should be 5.0. When I eat chips, I don't feel well, I quickly feel when I eat wrong, but I love water. So, what you put in determine your body."* (Area G, participant 3) • *"We are always sick, your body aches and you are not active anymore"* (Area P, participant 2) • *"It actually makes you sick you know and mentally you tell yourself I know I'm doing wrong and you know you should not eat that, but still you do it"* (Area Q, participant 1)

*****C – picture represented diverse healthy foods, D - picture represented a combination of healthy and unhealthy foods.
¶ Plate A – represented a plate of food with variety (more food groups), Plate B represented a plate of food without variety (two food groups).

Table 5 Participants perceptions of the barriers for consuming a diverse diet and healthy food choice.

Themes	Barrier	Supporting Quotations
Individual factors	Financial constraints	• *"You can't go into the shop and just purchase enough because the money is not going to be enough."* (Area D, participant 1) • "*But we do not have options, people do not work. You can just crave for something that you do not have – but you must eat as you must take some tablets and then you eat morning mealie meal porridge*" (Area F, participant 3) • *"Not everyone is privileged to pick and choose what we want to eat. We must go according to what we earn. When you go into the shop you must see what you can afford. It's difficult to manage a balanced diet especially now because everything is expensive. You can't buy the things that's important for you and your family"* (Area G, participant 1) • *"I can't eat it every day, my pocket cannot afford it."* (Area H, participant 2) • *"We have everything available but it's all about the money"* (Area J, participant 3) • *"Things have become more difficult because I have been cooking rice mixed with potatoes (sqa-rice) or samp. It is painful to only afford to survive on starch every day. For the whole week you just eat starch"* (Area O, participant 1) • *"We buy what we can afford and then you forget about your health. Most of the time we eat things that are not nutritious"* (Area P, participant 2) • "*We know about nutritious food, but we can't because of circumstances. We know what we should eat but we end up eating what we shouldn't be eating" (*Area R, participant 2)
	Lack of knowledge	• "*We don't have enough information not 100%, I know that starch is not good for your body, but why is it not good for your body?'* (Area H, participant 1) • *"I did not know lentils are healthy"* (Area G, participant 1) • "*We definitely need more knowledge that we can give out. Our people eat very unhealthy. Our people are not informed. We have large community centres that are standing empty. Nothing is happening there"* (Area G, participant 2) • "*It's our situation, knowledge about nutrition, our background – like how we grew up affects how we cook for our kids. Like if you grew up frying on Sundays, even using reused oil and eating potato salad."* (Area O, participant 2)
	Individual taste preferences	• "*It's not about the money, it's about the choice. That's a choice that I make. The choice of buying the banana of R 2.50 and getting 2 packets of Niknaks, I would rather go with the 2 packets of Niknaks than the banana*" (Area D, participant 1) • "*I just like eating pap all the time. If I don't eat pap, I don't really feel that I'm full*" (Area L, participant 3) • "*I just eat what tastes nice to me."* (Area O, participant 1) • *"I'm not a veggie lover, I suppose I do the opposite"* (Area Q, participant 4) • *"Don't include me there, I just eat. I won't deprive myself"* (Area R, participant 2)

Themes	Barrier	Supporting Quotations
Social influences	Family structure	**Living with husband and/or children/grandchildren** • *"Yes, you can tell the children, but they don't listen. They eat what they want to eat. If you have children, you don't have a choice but with adults in the house you can reason with them and suggest different foods"* (Area J, participant 3) • "*I think when everyone left home, I will be able to make a variety*." (Area Q, participant 4) • "*I have to consider a lot at times because there are food that I'm not eating. My husband eats everything and then again, the children are very picky*" (Area Q, participant 1) • *"Like you can't just cook spaghetti for a man. You are then forced to cook umngqusho - then you won't be able to cook different colours. You have to cook umngqusho and meat. They influence too much."* (Area R, participant 5) • *"If I was not staying with people I would lose weight, because I don't eat fatty food, I use oil because I try to accommodate other people. We cater for people that live with us"* (Area H, participant 1) **Living Alone** • *"I live in the high life. Because I'm alone I can make anything I want. What I sometimes make is sweet potato with a bit of custard, that will be my supper. I know it's unhealthy. I will make cooked food 2 times a week*." (Area G, participant 1)
	Family taste preferences	• "*I love cabbage food but I can't make it and my husband can't eat the greens, my children do not eat cabbage. So I must perhaps make myself a small pot."* (Area G, participant 4) • *"When they are still at school the eat what they get and now they go out into the world you must know, they come with all those grand ideas, things you can't even pronounce. They know from all this YouTube and whatever they call it"* (Area K, participant 1) • "*Even if I make fish, I know it's not what they like. He just wants his rice and his stew. If I now implement this for a week, I will definitely make him unhappy"* (Area K, participant 2) • *"Most days I make veggie food, the children get cross with me, saying to me "this again" and I just say, "yes man"* (Area Q, participant 3)" • *"If my children can eat pasta every day, they will"* (Area Q, participant 4) • *"The husbands will eat anything, but not the children"* (Area N, participant 2) • *"I might cook chicken livers then they'll ask for meat. Yes to see that it is not being eaten even though it's healthy"* (Area R, participant 1) • *"Like some of them like veggies some do not like veggies. Others will tell you to buy pasta. Some kids will choose certain vegetables- like cabbage, spinach, carrots, butternut, potatoes -and they'll say that they do not want other vegetables"* (Area F, participant 3)

Themes	Barrier	Supporting Quotations
Physical food environment influences	Food outlet location	• "*Yes, there are no supermarkets"* (Area G, participant 1) • *"But in the community the large supermarkets are further away"* (Area G, participant 2) • *"I need to take a taxi and go to the supermarket, so it's better to settle for what I get in the neighbourhood because of time and spending less"* (Area L, participant 3) • *"I don't get everything because in the township you just get the small things. You can get cabbage or spinach but sometimes you might be craving broccoli and you can't get it in the township. So, I have to take a taxi to get things like squash. When I do my monthly shopping, I prefer to take a taxi in order to get everything I need and it's affordable. I just buy few things locally."* (Area R, participant 4)
	High retail food prices	• *"For me its like stuff became more expensive especially vegetables. It used to be easy to buy, but now it becomes quite pricy, and the value of the money has become…what you get in…"* (Area D, participant 1) • *"In the supermarkets they are very high, we use the Spaza shops in the middle of the month because the prices are very high if you want to buy bread and milk"* (Area F, participant 2) • *"The healthy foods are more expensive for example the spaza shops have white bread for R 9.00, but that bread is unhealthy. So, the people that could only afford that have to buy that. The unhealthy foods are the cheap foods and the other way around. People go for the cheap foods as they have to eat."* (Area G, participant 1) • *"So, we just buy what we really need, but food prices are climbing all the time. I started using brown sugar 2 years ago and it was cheaper but now suddenly the 2kg brown sugar is R 49 where it was R 32 before at Shoprite. Every time you go to the shop things you normally buy get more expensive"* (Area J, participant 1)
	Perception of convenience stores	• *"Now and then I will buy potatoes there when I run out of potatoes, and I need a potato or an onion you will buy there. But other than that, I don't buy there because they are more expensive."* (Area D, participant 1) • *"We are not always sure of the quality at these "house shops". Not sure if they sell fresh meat or where it came from. You have to watch the date when it's fresh meat. As a parent you will be sceptic to buy there. Tins will be safe but not fresh produce"* (Area G, participant 3) • *"I leave the township and go to town because the prices are double the prices at the mall. They are there but they are expensive, but I'll take transport and go to Spar because there is a difference"* (Area O, participant 3)
	Quality of food sold in stalls	• *"No not so good" (Area G, participant 4)* • *"Yes, it's at the stalls, everybody goes to the stalls and we just check the condition cause some sells it and it's not that good"* (Area K, participant 2)
	Community food aid	• *"There are no soup kitchens where I live"* (Area P, participant 1) • "*Yes, there are projects, but they eat the money"* (Area O, participant 3)

Themes	Barrier	Supporting Quotations
	Home garden	• *"But then in a community-based area like Bokmakierie where people have that mentality that they can just destroy everything that's also not good because I tried to start a garden at Bokmakierie school. I went to go plant aloe vera and stuff like that because it's not necessary to look after those plants. They pull the stuff out of the ground. So that patch of land is still there. For argument's sake, I want to go plant spinach in the sun it grows well, the mindset of the people there are not well." (Area D, participant 1)* • *"Where I used to live my love I had a small plot- I used to grow crops like carrots. I did not struggle too much and then we had to move to where we are right now. And now it is not possible anymore. If you had a garden, you would then have fresh vegetables"* (Area F, participant 2) • *"We have built flats in our yards, not gardens, in order to get rent money, there were gardens during our parents' time when we were young, now we don't have gardens" (Area H, participant 2)* • *"If I had a garden, I would plant some veggies because I have a little bit of land to make a little garden. If I could use old bath containers, but I don't have a fenced yard. Dogs would get inside and mess it all up. These dogs do not stay at their own place – they use my yard for shade – their own home is fenced but they do not stay there.*" (Area O, participant 1) • *"No, I do not have a plan, because even if I could think of growing my own crops – we live in the squatter camp in a very crowded place, it's impossible to make a garden."* (Area P, participant 2)
Societal influences on food choices	COVID-19_food prices	• *"If you used to eating oats, then you would eat mielie meal because mielie meal was available, the oats wasn't there. No, it was there, but we couldn't buy oats, but you would get a kilo of maize meal"* (Area D, participant 1) • *"Food became more expensive, especially during December. With Corona you could not go out and there was not everything you usually bought"* (Area G, participant 2) • *"Since the beginning of Corona most people have lost their jobs, so that little cent that you have you go and buy at the Somalian's shop because you cannot afford"* (Area L, participant 8) • *"The prices have risen. But salaries have remained the same"* (Area O, participant 1) • *"…because of high prices – like I can't buy a vegetable combo which used to cost R130 and now it is R220 at Pick n Pay and Boxer. Yes, the grocery cannot last until the end of the month, the kids want food all the time."* (Area P, participant 2) • *"The food is still there but you have to limit yourself because of high prices"* (Area P, participant 1) • "*I cannot buy certain things because they are expensive, prices have gone up."* (Area R, participant 1)
	COVID-19_food aid	• *"When it was the lockdown there was nothing. No donations, no parcels, everything was sent to other Bokmakiere, Qtown, but not to Alicedale"* (Area D, participant 2) • "*Even with those food parcels I had an issue with what was available inside them. That food that was given to people was about to expire and a lot of companies saw it as an opportunity of getting rid of the stock."* (Area L, participant 9)

Themes	Barrier	Supporting Quotations
		• *"It's food that is brought but they divide that food amongst themselves – like you'll be given pilchard and they'll take the meat for themselves"* (Area O, participant 3)
	Media influence	• *"If there is a fast food special and they advertise it even if it's KFC we want it and that's the way KFC make money. Even if I go to work towards the end of the month, I'm gonna buy KFC because of the specials e.g. every Tuesday it's a special and it's generating money and KFC has a lot of influence in our lives."* (Area L, participant 9) • *"The only thing that they advertise on the TV is junk food. They don't advertise healthy food. So there's a lack of information. They must advertise more on TV and stop this junk food and then our people won't be obese."* (Area N, participant 2) • *"Adverts do influence us, they make you not to stick to your budget. You end up buying things that you did not plan to buy"* (Area R, participant 2)

Table 6 Participants perceptions of the enablers for consuming a diverse diet and healthy food choice.

Theme	Enabler	Supporting Quotations
Individual factors	Individual Taste preferences	• *"I love fruit and vegetables a lot, my broccoli, my butternut, my squash and chicken and pork. I eat red meat now and then. I balance myself because I have picked up weight around my waist*." (Area G, participant 3) • *"I never buy junk food. So, if you like it, but it's not me"* (Area K, participant 1) • *"But in my house, I like my vegetables and I have a daughter, if I don't have then I can go to her and she will say "no mommy, here" so it's not so bad for me"* (Area N, participant 1). • *"I don't just eat everything. I like eating nutritious stuff"* (Area P, participant 1) • *"I prefer veggie food as I was brought up like that, I love my vegetables. Does not matter what vegetables it is, I love it!"* (Area Q, participant 3) • *"I like fruits but if I don't have them, I eat whatever is available – not sweet stuff"* (Area R, participant 1)
Social influences	Family Taste Preferences	• *"My husband is not a meat person; he loves his vegetables and will leave the meat. They eat everything I make them. I don't have picky children"* (Area G, participant 1) • *"No, my family likes everything"* (Area Q, participant 2) • *"So, my children love veggies during the week*" (Area G, participant 5)
	Family structure	• *"My children will ask if I can't make something else, but it's important to use my own perspective to make a change. They know I'm at home, so they look forward to the meal" (Area G, participant 1)* • *"The husband if fine, whatever you make they will go with it. The husbands go with the flow*" (Area N, participant 2) • *"I like to make everyday something different, because the children will say "hey mommy, every time the same food?" It's just to please them"* (Area N, participant 3) • *"No, they eat what I cook, but if there were no people at home staying with me, I might just be eating bread 'till Sunday"* (Area O, participant 2)
Physical environment influences	Food outlet location	• *"Basically, I just prefer to go to Shoprite because our Shoprite is there and usually, they give the stuff that you need."* (Area D, participant 2) • *"The shop is not that far- maybe 10 minutes"* (Area F, participant 2) • *"It's very convenient as it's nearby and most foods are there, so I don't have to get a taxi to go somewhere else and I can buy my weekly groceries there. We also have "house shops"."* (Area G, participant 2) • *"Everything is close by, there also Somalians, and the mall is also not far, there is Shoprite and Spar"* (Area H, participant 1) • *"Yes, Shoprite is just opposite me and Pick 'n Pay is just down the road"* (Area J, participant 2) • *"Everything is available near to us"* (Area K, participant 2) • *"Yes, you are able to get different things"* (Area O, participant 1)

Theme	Enabler	Supporting Quotations
		• "*There are also vegetable stands, Shoprite is also close, but it is only money*" (Area P, participant 2) • "Yes, everything is available" (Area Q, participant 4)
	Retail food environment_stalls	• "*For me to tell the truth, there are someone who are selling fruit and vegetables in our community. I go there to buy stuff till month end."* (Area D, participant 1) • *"Yes, with the fruit and with the veg. They are cheaper than Shoprite. Shoprite is a bit pricy on that."* (Area D, participant 2) • *"Yes, our communities have an influence because there are vegetables at the stands and at the Somalian shops you can get fresh vegetables – like you can mix your veggies – they are helpful but not so much" (*Area F, participant 1) • "*It's walking distance"* (Area K, participant 1) • "*Yes, much cheaper*" (Area K, participant 3) • *"There is lot of cars coming around selling"* (Area N, participant 2)
	Food store specials	• "*You are happy that there are specials because now you can combine or mix this and that. They really help us"* (Area F, participant 3) • "*Fruit you can't always buy but if they have a sale like 2 packets for R 50, then I buy it"* (Area G, participant 2) • *"Sometimes at Pick 'n Pay you can buy as they say 'yesterdays', so it expire tomorrow. yes, it's cheaper, so instead of paying R 30 for broccoli, it's now half price for R 15"* (Area J, participant 2) • "*They have a market in Gatesville where the vegetables on a Saturday goes for cheap. If people have the money, they can afford to go buy."* (Area N, participant 2)
	Community food aid	• *"Yes, we have quite a few food / soup kitchens that distribute food in our area, but I'm a member of neighbourhood watch so on a Saturday they bring bread with polony and butter. I will make the sandwiches and place them in bags in distribute them to the children in the community. And whatever comes my way to give, I'll give."* (Area D, participant 1) • *"Yes, there is community kitchens not all the schools have vegetable gardens. In the community we started a small one now, it's only at its beginning. We asked for donations for seeds"* (Area G, participant 1) • *"I have a garden now and that is what I am doing now, I can get stuff there and make salad – tomatoes, lettuce and some cucumber then put in the fridge instead of buying fat cakes and chips"* (Area L, participant 3) • *"Yes, there is a community soup kitchen close to the library. It seems like they do grow vegetables but sometimes they don't come right. It's just for old people who reside there."* (Area R, participant 1)
Societal influences on food choices	COVID-19 food aid	• *"So, on a Sunday before lunch there will be 4 to 5 vans driving. The one van will just have greens, the other one will have chicken akni or meat and they will come to your door and they will hand out according to the number of people… last year there was people coming around with hampers and it contained basically what you would buy from the shops like tastic rice, baked beans, fish, jungle oats, powdered milk, tea bags and coffee. It was 2 carrier bags."* (Area J, participant 2)

Theme	Enabler	Supporting Quotations
		• "*…we were mostly helped by NGO's; I was grateful to get those food parcels, but I was not satisfied about what was given to me. That's why we are here today"* (Area L, participant 8)
	Media- food store specials	• *"We always look in the paper and see, oh there is a special. Alright, run'* (Area D, participant 1) • *"Like on TV you'll see that vegetables are cheap then you buy at Pick 'n Pay*." (Area F, participant 2) • "*They make us eat correctly because we are able to go for specials."* (Area R, participant 4)

Table 7 Participants perceptions of the possible facilitators for consuming a diverse diet and healthy food choice.

Theme	Facilitator	Supporting Quotations
Individual factors	Budgeting for groceries	• "*What I can suggest is to work out a budget before going to the shop. That the most important thing because people tend to not stick to their shopping list and the one thing I have noticed with myself now is that I don't put extra money in my bag. I put in what I need, so if the bread is going to be R 20, I'm not going to put in R 30 because R10 is going to something that is not needed."* (Area D, participant 1) • *"Everything is so expensive, one need to budget and do your homework before going to the shops*." (Area G, participant 3) • *"Something else that I have noticed is that it is better when you go for groceries is to write down things and make sure that you are full not hungry because when you are hungry you can end up buying all the unnecessary stuff, and you do that because you are hungry."*(Area L, participant 6) • *That is why I say we need to buy in bulks depending on how many we are at home and bulks are cheaper than buying things one by one* (Area L, participant 3)
	Income generation	• "*If there is better income it will be possible to eat a greater variety and be more healthy. Everything cost money and there is a lot of expenses like rates, water, policies"* (Area G, participant1) • *"We need to start our own businesses. Renting flats is also a business Another business is to sell chicken feet and paraffin."* (Area H, participant 1) • *"More money. Someone must just pay us more money*" (Area L, participant 3) • *"I wish there could be job opportunities because we are not lazy. We don't want to be depending on government*" (Area R, participant 3)
Physical environment influences	Community projects & home gardens	• *"I want to say is sustainable gardening will be a good thing."* (Area D, participant 1) • *"They can implement these kind of schemes like the gardens. If every household can get a starter pack to start your own garden of vegetables or fruit and then bring it to a central point where we can buy these from the community. This is much more positive than just standing in line for a handout. Not everyone is using the money for healthy reasons"* (Area G, participant 1) • *"Soup kitchens, where people could get food like it's happening in Nyanga East. People who are just sitting in the townships could be involved in projects like that"* (Area P, participant 1) • *"If our communities could have places where we could grow crops, where people could have chickens and eggs – we could get some nutrients."* (Area P, participant 2) • *"We don't have space to grow crops, but people have ideas like they use crates or old bath containers then they put fertilizer but I'm not that creative."* (Area R, participant 3)

Theme	Facilitator	Supporting Quotations
	Lower food prices	• *"If the stuff could be cheaper. If the vegetables was less pricy, because everybody can't afford to pay R 10 for 5 or 6 carrots. So, when stuff is in full season, like now you would get watermelon, mangoes, litchi's. It's that season. Now you get it cheaper at the fruit stall. So that goes for the veggies also."* (Area D, participant 1) • *"If the prices are lower. Perhaps we need to change what we buy to be buying more healthily"* (Area G, participant 2) • *"They don't need have to have specials only form the 25th of the month. They can have specials throughout the month. There are people that go to Shoprite every day. Perhaps they can offer 4 tins of food with a packet of rice for free. Many people will buy that. The vegetable stalls are doing that. If you buy a pack of onions and potatoes, then you get a butternut for free."* (Area G, participant 5) • *"The shops need to make food affordable (food must be on sale) and the stock must be available"* (Area H, participant 2) • *"If prices are not going up you can afford to buy the variety, like what happened during lockdown. If prices can just go down so we can buy what we need. We want to eat healthy every day, which we must, but we can't afford it."* (Area J, participant 3)
Societal influences on food choices	Government support	• "*Many people look bad due to drugs, but if they can be given work opportunities, they will see they can earn and don't need to go into gangsterism. If the government can create opportunities for them"* (Area G, participant 4) • *"Grant must be increased, R400 is nothing if you buy milk and then there is no money for nappies. In this R450 you can only buy milk. And the old people's pension grant must increase because the kids are dumped with them."* (Area O, participant 2)

CHAPTER 7: MANUSCRIPT FOUR

Chapter 7 was published as a peer-reviewed research article: Madlala SS, Hill J, Kunneke E, Faber M. Nutrient density and cost of commonly consumed foods: A South African perspective. *Journal of Nutritional Science.* 202;12(10):1-13. https://doi:10.1017/jns.2022.119

7.1 Summary

The cost, nutrient density, energy density, and nutrient density relative to the cost of 116 food items commonly consumed in South Africa are described in this paper. This paper reveals food groups and foods within food groups with the best and least nutritional value per cost.

7.2 Contribution to the thesis

This paper contributes to the fourth objective of the thesis: To determine the nutrient density of foods relative to cost in South Africa, with the aim to identify foods within food groups with the best nutritional value per cost. The results of this study were used to draft an information pamphlet to assist and illustrate to resource-poor community members how to identify nutrient-dense and energy-dense foods with the best nutritional value for cost (Appendix 15). These results can be used to inform consumers how to utilise the SA-FBDGs.

7.3 Contribution of the candidate

The candidate designed the study in collaboration with the supervisor and co-supervisor. The candidate compiled the food checklist (Appendix 16) and conducted the search for food prices. With assistance from the supervisor, the candidate recorded the nutrient composition of food items and performed the edible portion nutrient density, energy density and NPR calculations. The candidate performed the statistical analysis and wrote the draft manuscript. The candidate oversaw the submission process and was responsible for revising the journal's peer-review comments. The reviewer comments and author responses are available in Appendix 17. The candidate presented the paper at the SAMRC's 16th Early Career Scientist Convention on 25–26 October 2022. Media coverage of the published manuscript is included in Appendix 18.

JNS
JOURNAL OF NUTRITIONAL SCIENCE

RESEARCH ARTICLE

Nutrient density and cost of commonly consumed foods: a South African perspective

Samukelisiwe S. Madlala[1,2]*, Jillian Hill[1], Ernesta Kunneke[3] and Mieke Faber[1,3]

[1]*Non-Communicable Diseases Research Unit, South African Medical Research Council, Cape Town, South Africa*
[2]*School of Public Health, Faculty of Community and Health Sciences, University of the Western Cape, Cape Town, South Africa*
[3]*Department of Dietetics and Nutrition, University of the Western Cape, Cape Town, South Africa*

(Received 22 September 2022 – Final revision received 13 December 2022 – Accepted 19 December 2022)

Journal of Nutritional Science (2023), vol. 12, e10, page 1 of 13 doi:10.1017/jns.2022.119

Abstract

Food-based dietary guidelines promote consumption of a variety of nutritious foods for optimal health and prevention of chronic disease. However, adherence to these guidelines is challenging because of high food costs. The present study aimed to determine the nutrient density of foods relative to cost in South Africa, with the aim to identify foods within food groups with the best nutritional value per cost. A checklist of 116 food items was developed to record the type, unit, brand and cost of foods. Food prices were obtained from the websites of three national supermarkets and the average cost per 100 g edible portion was used to calculate cost per 100 kcal (418 kJ) for each food item. Nutrient content of the food items was obtained from the South African Food Composition Tables. Nutrient density was calculated using the Nutrient Rich Food (NRF9.3) Index. Nutrient density relative to cost was calculated as NRF9.3/price per 100 kcal. Vegetables and fruits had the highest NRF9.3 score and cost per 100 kcal. Overall, pulses had the highest nutritional value per cost. Fortified maizemeal porridge and bread had the best nutritional value per cost within the starchy food group. Foods with the least nutritional value per cost were fats, oils, foods high in fat and sugar, and foods and drinks high in sugar. Analysis of nutrient density and cost of foods can be used to develop tools to guide low-income consumers to make healthier food choices by identifying foods with the best nutritional value per cost.

Key words: **Affordability: Food price: NutrientRich Food Index: NRF9.3: South Africa**

Introduction

Unhealthy diets, food choices and behaviours shaped by food environments and food systems are key contributing factors to the rise in overweight and obesity and non-communicable diseases (NCDs), which are a major public health problem worldwide[1]. The World Health Organisation (WHO) estimated that in 2016 more than 1·9 billion (39 %) adults aged 18 years and older were overweight and ≥650 million (13 %) were obese[2]. Overweight and obesity are important risk factors for NCDs and are caused by physical inactivity combined with excessive consumption of energy-dense foods high in fat and sugars[2]. High intakes of unhealthy foods such as refined grains, processed meats, ultra-processed crisps, sugar-sweetened beverages (SSB), foods high in saturated and trans fats, sweets and desserts are related to several diet-related NCDs including diabetes, cardiovascular disease, obesity and dental caries[3,4,5]. Globally, dietary risk is among the leading risk factors for mortality among adults[6], and consuming a healthy diet is crucial for the reduction of overweight and obesity and diet-related NCDs[7]. In many low- and middle-income countries, diets are known to lack micronutrients especially among vulnerable groups, this could lead to the development of deficiencies in iron, zinc, folate, vitamin A, calcium and vitamin B12[8,9].

South Africa, an upper middle-income country, is characterised by high rates of overweight and obesity[10], with an unemployment rate of 34·5 %[11] and 49·2 % of the adult population living below the upper-bound poverty line[12]. Diets in South Africa lack diversity[13] and consumption of

* **Corresponding author:** Samukelisiwe S. Madlala, email samukelisiwe.madlala@mrc.ac.za

fruits and vegetables is low[14]. The South African food-based dietary guidelines (SA-FBDGs) encourage the consumption of diverse healthy food groups and emphasise the limiting of fats, sugar and salt in the diet[15]. However, these guidelines are difficult to follow for many South Africans due to several reasons including high food prices and inflation[16]. A recent report stated that COVID-19, economic decline and unemployment, and high food prices are among the key drivers for food insecurity in South Africa[17]. From March 2021 and March 2022, the cost of the average household food basket purchased by low-income women increased by 10·3 %[18]. The core food basket consists mainly of starches (maize meal, rice, cake flour, bread), white sugar, vegetable oil, sugar beans and chicken, tea and condiments and is not nutritionally balanced[18].

The cost of food has been cited as a major determinant of dietary quality and food choices globally[19,20]. Healthier foods and diets are reported to be more expensive, making it difficult for people with low-income to eat a healthy nutritionally balanced diet[19,20,21]. In Sub-Saharan Africa, nutritious diets are the least affordable and more costly compared with other regions around the world[21]. Low-income groups often rely on cheaper energy-dense foods high in saturated fats, trans fats and added sugar[21], which put them at greater risk of becoming overweight/obese and developing diet-related NCDs, and therefore food prices are a major contributor to inadequate diets and malnutrition[22].

Identifying nutrient-dense foods with the best nutritional value per cost can potentially assist consumers to make healthier food choices. Nutrient profiling models, e.g. Nutrient Rich Food Index (NRF9.3), can be used to classify or rank foods according to their nutritional value and to identify healthier foods[23]. The NRF9.3 is also a useful tool to determine the relationship between the nutrient density of foods and their cost[19,24], and thereby identify affordable nutrient rich foods[25,26].

Approximately, 50·9 % deaths in South Africa are attributable to NCDs[27] with diabetes accounting for 7 % of NCD-related mortality[28]. Due to this high prevalence, interventions such as the South African Diabetes Prevention Programme (SA-DPP) that aims to prevent the progression of diabetes and pre-diabetes in resource-poor communities in the Cape Town metropolis[29] are being implemented. As part of the SA-DPP, a curriculum to promote healthier eating habits has been developed based on the SA-FBDGs. Cost of food may however hinder dietary change[16] and educational tools to guide communities to make healthier food choices within their financial constraints are needed. Within this context, the present study aimed to determine the nutrient density of foods relative to cost in South Africa, with the aim to identify foods within food groups with the best nutritional value per cost.

Methods

Food checklist and nutrient composition

A food checklist was created based on the SA-FBDGs. Foods were grouped into the following seven major food groups: (1) starchy foods, (2) pulses (beans, peas, lentils and soya), (3) dairy, (4) fish, chicken, meat and eggs, (5) vegetables and fruits, (6) fats, oils and foods high in fat and (7) sugar and foods and drinks high in sugar. Dietary data from a validation study of the SA-DPP study (unpublished data) was used to finalise the checklist; therefore, the list contained commonly consumed foods in resource-poor communities in Cape Town, South Africa. The checklist contained raw food, prepared food and fortified products. The food type, brand name, unit and weight, and unit price per rands (ZAR) for each item was recorded on the checklist. The common or medium package size was recorded. For vegetables and fruits, weight per kg was recorded. The South African Food Composition Tables[30] were used to obtain energy and nutrient content values per 100 g edible portion. For nutrient values not available in the South African Food Composition Tables, nutrient values were obtained from food manufacturing websites. Foods not considered were non-dairy creamer, diet beverages, tea, coffee, water, energy drinks, as these are mostly low calorie with little nutritional value[26]. The final analysis was based on a total of 116 foods representing the healthy and unhealthy groups based on the SA-FBDGs.

Food price

Studies show that 90 % of people in Cape Town purchase food from supermarkets[31,32]. Therefore, retail food prices for the food items were obtained online from the national websites of three national supermarkets namely, Pick n Pay, Checkers and Shoprite. In-store visits were done for products that were not available online. Prices were collected between September 2020 and February 2021 to account for seasonal availability of certain fruits and vegetables. Food prices were collected for Shoprite first, which generally is cheaper than the other two supermarkets. For packaged food, the price for the brand with the lowest cost was collected. For the other two supermarkets, the price for the same brand used for Shoprite was collected. Only regular prices were recorded, not sale/promotional pricing. Food prices were recorded in ZAR ($0·06). For each food item, the average of the prices collected from the supermarkets was used to calculate the cost (ZAR) per 100 g edible portion using yield factor and retention factors to adjust for preparation and waste[33], which was then used to calculate cost per 100 kcal. Energy density was calculated per 100 g edible portion and per 100 kcal.

Nutrient density

Nutrient density is defined as the ratio of nutrient content to total energy. Calculations based on 100 kcal rather than 100 g, nutrient density is better reflected[24]. The nutrient density for each of the food items was calculated using the Nutrient Rich Foods Index NRF9.3 model[34]. The NRF9.3 was based on the subtraction of two subscores: Nutrients to encourage (NRn) subscore minus nutrients to limit (LIM) subscore. The NRn subscore is the sum of the percentages of daily values (DVs) of protein, fibre, vitamin A, vitamin B6, vitamin D, folate, calcium, zinc and iron. The LIM subscore is the sum of the percentages of the maximum recommended values

(MRVs) of saturated fat, added sugar and sodium[8,34]. The reference DV and MRV were based on the FAO Codex nutrient reference values[35] and are summarised in Table 1. Percentages of DV were capped at 100 % to avoid the index score to be disproportionately effected by one nutrient present in very large amounts[8]. The US Food and Drug Administration guidelines were used to determine nutrients selected for the model[9]. Nutrients of public health concern among South African adults were included in the model. The nutrients reported to be low in the diet of South African adults are vitamin A, vitamin D, folate, iron, zinc[36], calcium and vitamin B6[37]. Nutrients to limit were selected following the guidance of previous studies[8,34].

The NRF9.3 Index score was calculated per 100 kcal and per 100 g for each food item. The nutrient-to-price ratio (NPR) was used as an indicator for foods with the best nutritional value per cost and was calculated by dividing the NRF9.3 score to cost (ZAR) per 100 g and cost (ZAR) per 100 kcal of food. Foods were ranked according to the NRF9.3 score per 100 kcal, and NPR.

Data analysis

Data were captured into Microsoft Excel data files. All analyses were performed using IBM SPSS for Windows version 28 (Armonk, New York, USA). The Shapiro–Wilk test was performed to test the data for normality. Continuous data were expressed as median and interquartile range (IQR). Median (IQR) values of the NRF9.3 (per 100 kcal and per 100 g), energy density (kcal/100 g), food prices (ZAR/100 g and ZAR/100 kcal) and NPR for each food item and food group were computed. Analysis of variance (ANOVA) test was used to compare energy density, nutrient density and NPR across food groups. The Tukey *post hoc* test was used to locate differences between food groups. Bubble/Scatter plots were used to show the relationship between nutrient density and energy density, cost per 100 kcal and NPR. Spearman correlation analysis was performed to assess the relationship between the NRF9.3 score and the cost per 100 kcal of foods. Significance was set at P-value < 0·05.

Table 1. Reference daily values and maximum recommended values for nutrients

Nutrients	Standard
Protein (g)	50
Fibre (g)	25
Vitamin A (μg RE)	800
Vitamin B6 (mg)	1·3
Vitamin D (μg)	5
Folate (μg)	400
Calcium (mg)	1000
Zinc (mg)	14
Iron (mg)	22
Maximum recommended values	
Saturated fat (g)	22
Added sugar (g)	50
Sodium (mg)	2000

g, grams; μg, micrograms; RE, retinol equivalents; mg, milligrams.
Reference values from the FAO Codex nutrient reference values[35].

Results

Table 2 shows the median energy density, nutrient density (based on the NRF9.3 score), cost and NPR (per 100 g and per 100 kcal) for 116 food items grouped into 7 food groups. *Post hoc* analysis showed that there were significant differences between food groups. Energy density was lowest for the vegetables and fruits group (52·4 kcal/100 g), and highest for fats, oils and foods high in fat group (573·4 kcal/100 g). Nutrient density was highest for the vegetables and fruits group, followed by pulses, and was lowest for the sugar and foods and drinks high in sugar group. Cost per 100 g was highest for the fish, chicken, meat and eggs group (ZAR 10·9/100 g) and lowest for the pulses and starchy foods groups (ZAR 1·6/100 g). Cost per 100 kcal was highest for the vegetables and fruits group (ZAR 7·7/100 kcal), followed by the fish, chicken, meat and eggs group (ZAR 4·8/100 kcal) and the dairy group (ZAR 3·3/100 kcal).

Fig. 1 shows the relation between median nutrient density and energy density of food groups. The fats, oils and foods high in fat group had the highest energy density but a low nutrient density score. The vegetables and fruits group had the highest nutrient density score but the lowest energy density.

Fig. 2 shows the relation between median energy density in relation to cost per 100 kcal for food groups. The fats, oils and foods high in fat group, sugar and foods and drinks high in sugar group as well as starchy foods had the lowest cost less per 100 kcal and are therefore the cheapest sources of energy. The vegetables and fruits group had a high nutrient density and cost more per 100 kcal in comparison to other food groups. The pulses group had a lower cost per 100 kcal but high nutrient density. The ranking of individual foods according to the energy-to-cost ratio is indicated in Supplementary Table S1. Healthier foods such as vegetables and fruits, lean meat, fish and chicken were the most expensive sources of energy.

Fig. 3 shows the relation between median nutrient density scores and NPR (per 100 kcal) of food groups. Food groups with the highest median NPR (per 100 kcal) were pulses and starchy foods, while the sugar and foods and drinks high in sugar group had the lowest median NPR (per 100 kcal).

Table 3 shows the ranking of foods within food groups according to NPR (per 100 kcal). In Table 3, two subgroups are given for the starchy food group (fortified and unfortified starch foods) and three subgroups for the vegetables and fruits group (vitamin A-rich vegetables and fruits, other vegetables and other fruits). Fortified starches, particularly maize meal and to a lesser extent bread, had higher NPR values than unfortified starches. Pulses with the highest NPR values were lentils, sugar beans and split peas. Dairy products had lower NPRs compared with the fish, chicken, meat and eggs group. Chicken giblets, eggs, pilchards and low-fat fish had the best nutrient density relative to cost. Dairy products with the highest NPR values were sour milk, low fat milk, full cream milk and double cream yoghurt. Vitamin A-rich vegetables and fruits had higher NRF9.3 scores compared with other fruits and vegetables. Vegetables with the highest NPR were

https://doi.org/10.1017/jns.2022.119 Published online by Cambridge University Press

Table 2. Median energy density, nutrient density (NRF9.3), food prices (per 100 g and per 100 kcal) and nutrient-to-price ratio of food groups

	N	Energy density (kcal/100 g) Median (IQR)	Nutrient density (NRF9.3/100 kcal) Median (IQR)	Price per 100 g Median (IQR)	Price per 100 kcal Median (IQR)	NPR NRF9.3/ZAR 100 g Median (IQR)	NPR NRF9.3/ZAR 100 kcal Median (IQR)
All items	116	142·7 (62·8–373·1)	30·9 (12·5–68·0)	3·9 (2·0–7·9)	2·6 (1·4–5·5)	8·2 (3·1–24·2)	8·3 (3·1–24·8)
Food groups							
Starchy foods[a]	20	136·5 (83·2–340·4)^{e,f}	35·2 (26·6–47·9)^{e,g}	1·6 (0·6–3·3)^{d,f}	0·8 (0·5–1·6)^{e}	41·3 (24·7–85·3)^{c,d,e,f,g}	43·5 (24·7–95·4)^{c,d,e,f,g}
Pulses[b]	5	120·7 (103·9–134·2)^{f}	77·7 (55·7–115·3)^{f,g}	1·6 (1·4–3·2)^{d}	1·2 (1·1–3·1)^{e}	67·1 (24·2–77·8)^{f,g}	67·1 (24·2–77·8)^{g}
Dairy[c]	10	76·9 (62·1–339·2)^{f}	32·3 (26·3–41·9)^{e,g}	3·0 (1·3–14·2)	3·3 (2·1–4·2)^{e}	11·9 (6·4–16·1)^{a}	11·9 (6·4–16·1)^{a,g}
Fish, chicken, meat and eggs[d]	20	221·8 (150·6–304·9)^{e,f}	41·8 (16·3–92·6)^{f,g}	10·9 (6·1–16·9)^{a,b,e,g}	4·8 (3·1–6·9)^{a,b}	7·9 (2·5–9·7)^{a}	7·9 (2·5–9·7)^{a}
Vegetables and fruits[e]	30	52·4 (27·4–64·1)^{a,f,g}	82·9 (33·3–132·6)^{a,c,f,g}	3·2 (2·0–3·2)^{d}	7·7 (3·5–12·8)^{d,f,g}	8·7 (4·7–17·1)^{a,g}	8·7 (4·7–15·4)^{a,g}
Fats, oils and foods high in fat[f]	18	573·4 (410·3–714·5)^{a,b,c,d,e,g}	10·1 (−4·1–15·8)^{b,d,e}	7·8 (3·5–10·1)^{a}	1·6 (0·6–2·2)^{e}	4·5 (−2·5–8·8)^{a}	5·7 (−5·2–11·2)^{a}
Sugar & foods and drinks high in sugar[g]	13	364·1 (134·5–433·3)^{e,f}	−34·1 (−72·1–(−11·8))^{a,b,c,d,e}	4·6 (1·9–6·6)^{d}	1·5 (1·4–2·9)^{e}	−9·6 (−29·6–(−4·5))^{a,b,e}	−9·6 (−42·4–(−6·6))^{a,b,c,d,e,f}
P-value*		<0·001	<0·001	<0·001	<0·001	<0·001	<0·001

NRF, Nutrient Rich Foods; NPR, nutrient-to-price ratio; ZAR, South African Rand; IQR, interquartile range; 100 kcal = 418 kJ.
* Statistical difference between food groups, obtained by ANOVA test, significant at $P < 0·001$ level.
Each food group (the reference food group) was assigned a letter.
[a] Starchy foods.
[b] Pulses.
[c] Dairy.
[d] Fish, chicken, meat and eggs.
[e] Vegetables and fruits.
[f] Fats, oils and foods high in fat.
[g] Sugar and foods and drinks high in sugar. Median superscript letters indicate food groups that differ significantly from the reference food group; ANOVA Tukey *post hoc* test, significant at $P < 0·05$ level.

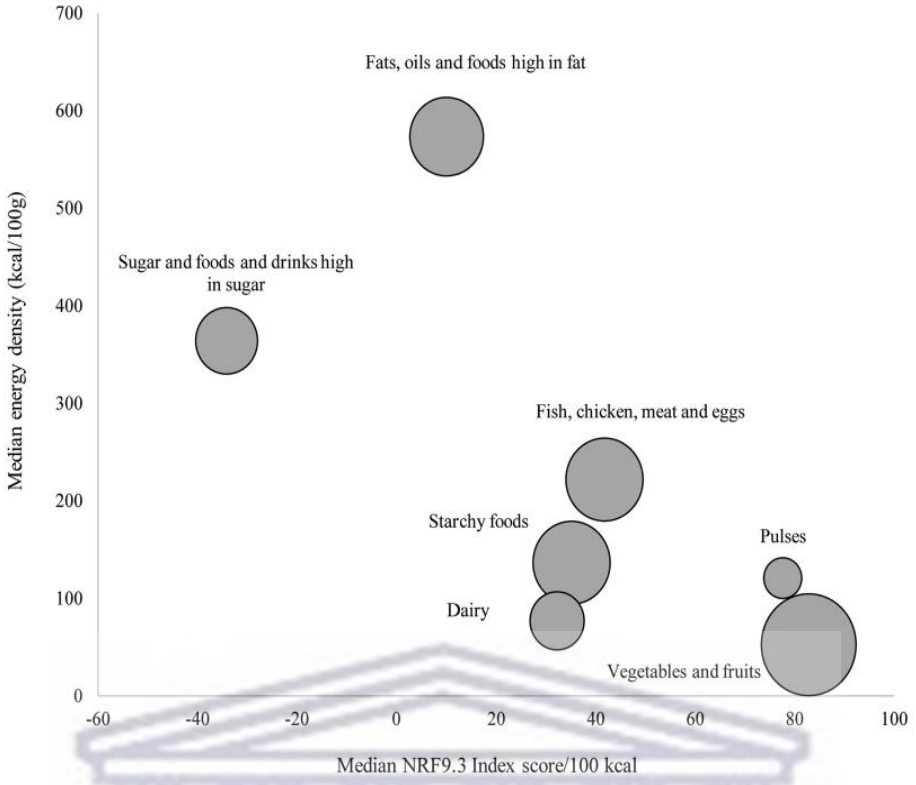


Fig. 1. Median Nutrient Rrich Foods (NRF9.3) scores in relation to energy density (kcal/100 g) for seven major food groups.

carrot, butternut, orange-fleshed sweet potato and mixed vegetables. Figs. 4–6 show the relation of NPR (per 100 kcal) and the nutrient density score for starchy foods, animal protein sources and vegetables and fruits, respectively.

The ranking of individual foods by NPR (per 100 kcal) and NPR (per 100 g) are indicated in Supplementary Tables S2 and S3. The top 50 foods ranked included a mixture of food items, but it was dominated by starchy foods. Overall, energy-dense

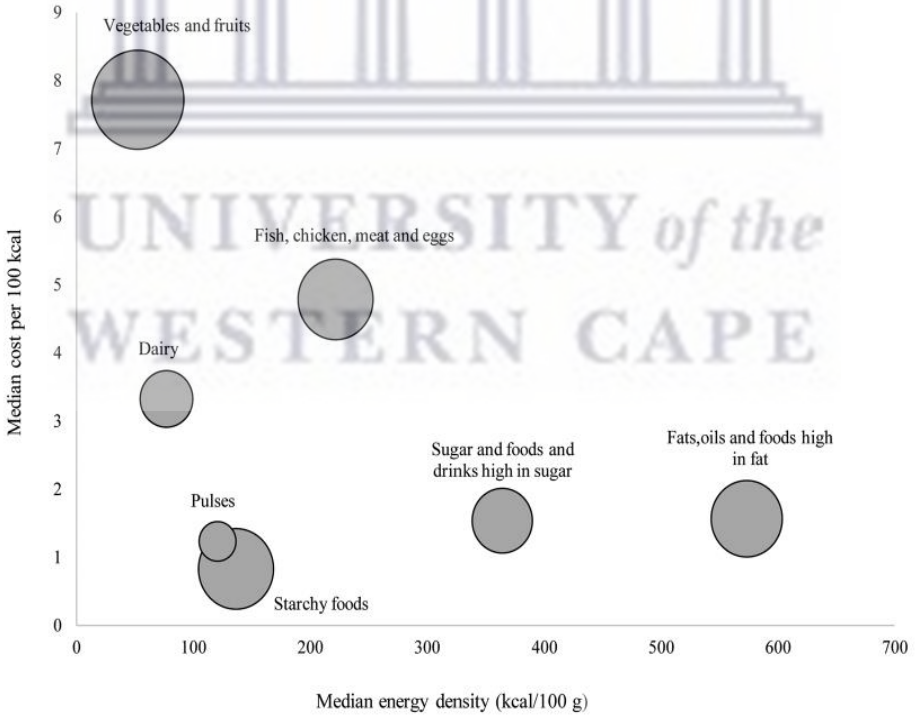


Fig. 2. Median energy density (kcal/100 g) in relation to cost per 100 kcal by seven major food group.

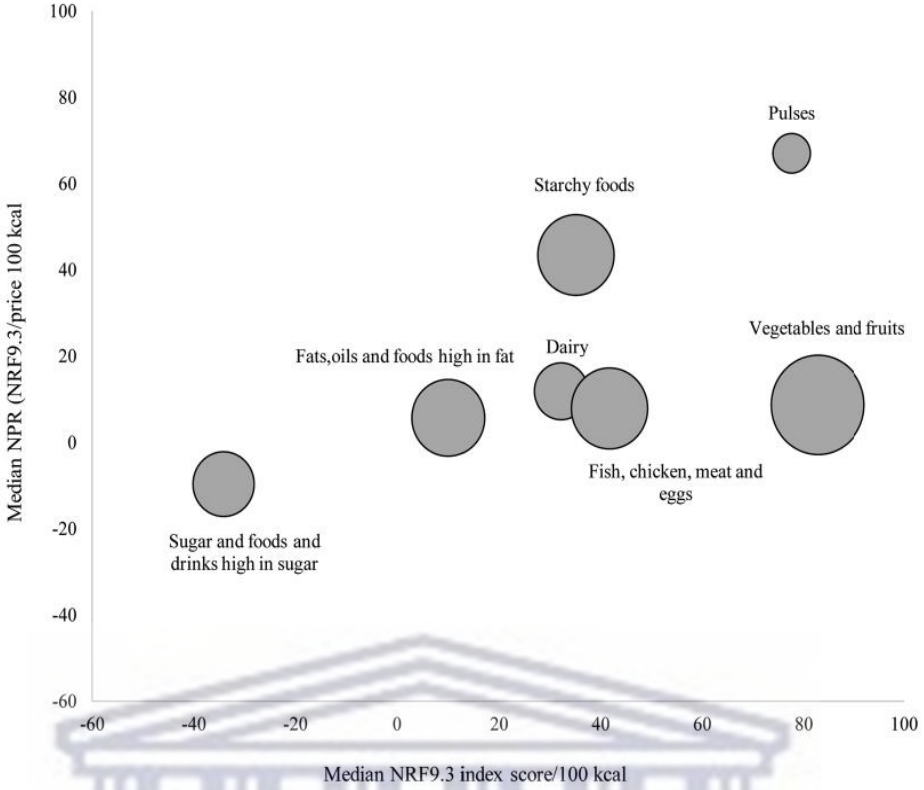


Fig. 3. Median Nutrient Rich Foods (NRF9.3) scores shown in relation to the nutrient-to-price ratio (NPR) (NRF9.3/price 100 kcal) by seven major food groups.

foods had higher cost per 100 g than per 100 kcal (Supplementary Table S2). Spearman correlation analysis showed that the nutrient density score is positively related to the cost per 100 kcal of food item ($r = 0{\cdot}434$, $P = <0{\cdot}01$), indicating that when nutrient density increases so does the energy cost of food.

Discussion

The findings of the present study suggest that energy density, nutrient density, cost and nutrient density relative to cost varies across and within food groups. Based on the NRF9.3 scores, the vegetable and fruit group had the highest nutrient density, followed by pulses, fish, chicken, meat and eggs group, starchy foods and the dairy food group. Overall, vegetables and fruits also had the highest cost per 100 kcal in comparison with the other food groups, and are therefore the most nutrient-dense but also the most expensive per 100 kcal. Nutritional value per cost was highest in the pulses food group. Fats, oils and foods high in fat, and sugar and foods and drinks high in sugar had the highest energy density and lowest nutritional value per cost and were therefore the most affordable sources of energy however they were not nutrient rich.

The starchy food group had the second best nutritional value per cost in comparison with other food groups. This is in contrast to a Brazilian study which showed that starchy foods (grains and cereals) had the lowest nutritional value per cost[38]. In South Africa, mandatory fortification of two staple foods, maize meal and bread flour, was introduced in 2003 to improve nutrient intakes and address micronutrient deficiencies in the population[39]. These fortified staple foods, which are widely consumed in South Africa, had the best nutritional value per cost within the starchy food group[40]. Starchy foods overall had the lowest energy cost, which is in line with literature stating that starches and grains are the cheapest source of energy[38,41]. The SA-FBDGs recommend that starchy foods be included in most meals[15], but excessive consumption of these high energy refined starches may lead to overweight and obesity[42,43].

The fish, chicken, meat and eggs group had a relatively high nutrient density score, but had the fourth highest nutritional value per cost with dairy foods having the third highest. Chicken giblets, eggs, canned pilchards and milk (including low and full fat milk), respectively had the highest nutritional value per cost of animal protein sources. Similarly, a French study found that organ meat had the highest nutritional value per cost in the meat group, and eggs also had a high nutritional value per cost[25]. According to another French study, organ meats, beef, eggs, milk, canned fish with bones, lamb/mutton, and cheese had the highest micronutrient density of all animal protein sources, while deli meats had the lowest nutrient density score in the meat group[44]. Our results show that processed meat such as polony, viennas and sausages are cheaper animal-source foods, but their nutrient density is also very low. Processed meat in South Africa is less expensive in comparison with red meat and chicken and may be more preferred by people with lower income[45]. There is limited data on the consumption of processed

Table 3. Ranking of selected South African foods within each food group according to the nutrient-to-price ratio per 100 kcal.

Food groups	Food item	NPR (NRF9.3/ZAR 100 kcal)	Nutrient density (NRF9.3/ 100 kcal)	Price per 100 kcal
Fortified starchy foods	Stiff porridge (maize meal, fortified)	242	44	0·18
	Soft porridge (maize meal, fortified)	242	44	0·18
	Brown bread (fortified)	129	108	0·83
	White bread (fortified)	98	79	0·81
	All bran flakes, breakfast cereal	55	105	1·92
	Corn flakes, plain, breakfast cereal	49	71	1·43
	Morvite original instant porridge, prepared[¶]	25	49	2·01
	Weet-Bix, breakfast cereal	19	33	1·70
Unfortified starchy foods	Samp, cooked (white)*	102	26	0·26
	Samp and beans, 1:1, cooked	87	41	0·47
	Brown rice, cooked	49	27	0·55
	White rice, cooked	47	22	0·47
	Pasta, Macaroni/Spaghetti, cooked	40	31	0·77
	Potato, boiled without skin	34	38	1·11
	Oats, rolled, cooked	34	28	0·83
	Popcorn, plain	25	16	0·65
	Pasta, whole wheat Macaroni/Spaghetti, cooked	25	34	1·38
	Noodles, egg, cooked	17	36	2·11
	White-fleshed sweet potato, boiled	6	27	4·15
	Roti, made with sun oil	5	6	1·21
Pulses	Lentils, whole, cooked	85	104	1·23
	Sugar beans, cooked	71	78	1·09
	Lentils, split	67	73	1·09
	Soya mince, cooked	32	126	3·95
	Baked beans, canned in tomato sauce	17	38	2·31
Dairy	Maas/Sour milk	17	34	2·02
	Milk, low fat/2 % fat, fresh	16	41	2·55
	Milk, full fat/whole, fresh	16	34	2·08
	Yoghurt, plain, double cream	15	44	3·05
	Milk, full fat/whole, UHT	14	30	2·16
	Yoghurt, plain, low fat	10	49	5·00
	Cheese, Cheddar	7	29	4·15
	Cheese, Gouda (Edam, Swiss)	7	31	4·51
	Yoghurt, fruit, low fat, sweetened	5	17	3·61
	Cheese, processed, full fat	3	10	4·17
Fish, chicken, meat and eggs	Chicken giblets, cooked	58	193	3·30
	Egg, chicken, boiled/poached	43	131	3·02
	Pilchards in tomato sauce, canned	27	162	6·10
	Fish, low fat, grilled	15	167	11·33
	Chicken, meat and skin, frozen, roasted	10	35	3·62
	Fish, medium fat, grilled/steamed	10	57	5·91
	Pork, loin, grilled (chop)	9	48	5·55
	Beef, chuck, cooked – moist	8	56	6·65
	Chicken, feet, raw	8	18	2·18
	Chicken, white meat, fresh, cooked	8	49	6·02
	Beef, topside/lean mince, cooked	8	60	7·87
	Patty, beef, frozen, grilled	7	30	4·02
	Tuna, canned in water	5	103	20·97
	Beef, brisket/regular mince, cooked	4	17	3·91
	Mutton, shoulder, braised	3	22	7·08
	Polony/Bologna, beef and pork	2	3	1·34
	Mutton, loin, grilled (chop)	2	16	8·12
	Bacon, cured, pan-fried/grilled	0·4	1	3·53
	Vienna sausage, beef and pork, canned[§]	−3	−8	2·46
	Sausage, beef and pork/boerewors, grilled	−4	−10	2·65
Vitamin A-rich fruits and vegetables	Carrot, boiled (flesh and skin)	53	169	3·21
	Butternut, squash, boiled	49	117	2·41
	Orange-fleshed sweet potato, baked	46	150	3·25
	Spinach (Swiss Chard), boiled	15	231	15·58
	Pumpkin, boiled	15	173	11·85
	Mango, raw (peeled)	6	45	8·14
	Peach, raw	4	29	6·99

Continued

Table 3. Continued

Food groups	Food item	NPR (NRF9.3/ZAR 100 kcal)	Nutrient density (NRF9.3/ 100 kcal)	Price per 100 kcal
Other vegetables	Mixed vegetables, frozen, boiled	32	135	4·22
	Onion, boiled	25	57	2·28
	Peas, frozen, boiled	18	86	4·91
	Beetroot, boiled with skin	14	51	3·66
	Tomato, raw	12	115	9·54
	Cabbage, boiled	12	86	7·47
	Green beans, frozen, boiled	9	92	10·03
	Broccoli, boiled	9	135	15·80
	Gem squash, boiled	8	80	9·75
	Pepper, sweet, green, boiled	7	132	20·14
	Cauliflower, boiled	6	92	15·47
	Lettuce, raw	5	134	27·52
	Cucumber, English, raw	2	89	40·16
Other fruits	Orange, raw (peeled)	17	57	3·34
	Banana, raw (peeled)	13	47	3·52
	Apple, golden delicious, raw	9	25	2·85
	Pear, raw	8	24	2·89
	Naartjie/Tangerine, raw (peeled)	8	44	5·51
	Avocado, raw (peeled)	5	13	2·58
	Plum, raw	4	26	6·82
	Mango and orange juice	3	34	10·59
	Nectarine, raw	3	25	7·96
	Grape, average, raw	2	26	9·90
	Pineapple, raw (peeled)	0·7	32	48·98
Fats and oils	Margarine, brick/hard	39	15	0·37
	Margarine, polyunsaturated, soft	38	15	0·40
	Salad dressing, French	−3	−5	1·51
	Canola oil	−11	−4	0·35
	Butter	−12	−20	1·63
	Salad dressing, mayonnaise	−16	−11	0·70
	Sunflower oil	−18	−5	0·30
Foods high in fat	Vetkoek, home-made‡	14	25	1·73
	Snack, savoury, potato crisps/chips	12	29	2·41
	Pie, chicken, commercial, baked	11	23	2·10
	Peanut butter (unsalted/unsweetened)	8	12	1·48
	Peanuts, roasted, salted	8	17	2·19
	Peanut butter, smooth style	7	8	1·16
	Avocado, raw (peeled)	5	13	2·58
	Potato chips/French fries	6	12	1·92
	Snack, savoury, average, e.g. Niknaks, Fritos‡	1	1	1·46
	Samoosa, with mutton filling	−1	−3	2·67
Sugar and foods and drinks high in sugar	Dairy-fruit juice mix	7	18	2·65
	Muffin, plain	5	8	1·50
	Doughnut, plain	−1	−2	2·25
	Cold drink, squash, diluted	−6	−45	7·58
	Sweets, fruit gum	−7	−34	4·79
	Cookies, commercial, plain	−8	−11	1·40
	Sweets, chocolate, milk	−8	−25	3·05
	Ice cream, regular (10 % fat)	−10	−13	1·34
	Cookies, commercial, with filling	−13	−18	1·40
	Jam/Marmalade	−22	−40	1·81
	Sweets, hard boiled and soft jelly type	−31	−48	1·54
	Cold drink, carbonated	−54	−98	1·83
	Sugar, brown	−189	−97	0·51
	Sugar, white, granulated	−213	−100	0·47

NPR, nutrient-to-price; NRF, Nutrient Rrich Foods; ZAR, South African Rand, 100 kcal = 418 kJ.
¶ Morvite – instant sorghum porridge.
* Samp – dried corn kernels.
§ Vienna sausage – Hot dog/Frankfurter (thin parboiled sausage traditionally made of pork and beef).
‡ Vetkoek – Fried dough bread.
ǂ Niknaks, Fritos – Corn-based snack.

meat, however FAOSTAT balance sheets between 1999 and 2009 show that processed meat consumption increased by 45·8 %[46]. Processed meat is classified as carcinogenic and consumption of processed meat is associated with colorectal cancer[47]. The eighth SA-FBDG states that fish, chicken, lean meat and eggs can be eaten daily. It is important for

Fig. 4. Relation of the nutrient-to-price ratio (NPR) and the nutrient density (NRF9.3) score for starchy foods.

consumers to continue to be educated about the benefits of eating lean meats and be encouraged to consume these foods in moderation, particularly as the consumption of meat and processed meat increases in South Africa[45].

Pulses had the best nutritional value per cost across all food groups. These foods are good source of carbohydrates, protein, fibre and several micronutrients including iron, magnesium and potassium and are therefore known to be nutrient rich[48]. Pulses may be beneficial in preventing and managing NCDs as they can potentially reduce the risk of obesity[49] and certain cancers[50]. Since pulses have a much lower cost per 100 kcal in comparison with animal protein sources and have a higher nutrient density relative to cost, they would be a good protein substitute and would be a more affordable choice for low-income consumers. Although using pulses as a meat substitute is encouraged in the SA-FBDGs[51], the recommended intake is lower than the Eat Lancet recommendations[52]. It has been suggested that promotion of legumes and soya be included in the National Food and Nutrition Security communication plan, as this may stimulate production and consumption of these foods[52].

Overall, the vegetables and fruits group had the highest nutrient density but also the highest energy cost. Within the vegetables and fruits group, vitamin A-rich fruits and vegetables had the highest NRF9.3 scores, which is similar to findings of a study that was done in New Zealand[53]. In contrast to studies in Brazil[38] and New Zealand[53], which reported high nutrient-to-cost ratios, the vegetables and fruits group had a low NPR in our study. Generally, vegetables and fruits are reported to be expensive[21], and cost has been cited globally as a major barrier to acquiring vegetables and fruits[54]. Although vegetables and fruits are VAT zero-rated in South Africa[55], cost prevents consumption of these foods among low-income households[56]. The South African population consumes less than half of the WHO recommended daily intake of 400 g for the prevention of cardiovascular diseases and some types of cancers[11]. Low-income consumers are concerned about getting the most kilojoules per unit cost[52], and it may therefore be difficult to advise them to eat more vegetables and fruits[57]. Home gardening and community gardens have been shown to improve the availability and access to a variety of vegetables and improve dietary diversity and overall dietary intake among children and adults in urban and rural communities in South Africa[58,59]. Households should thus be encouraged to grow at least some vegetables and/or fruits. Furthermore, vegetables and fruits had the lowest energy density and therefore supply a significant amount of nutrients for fewer calories[60]. Considering the high rates of overweight and obesity in South Africa[10], consumption of high-water content vegetables and fruits should be encouraged to aid in reducing calorie intake and therefore curb overweight and obesity.

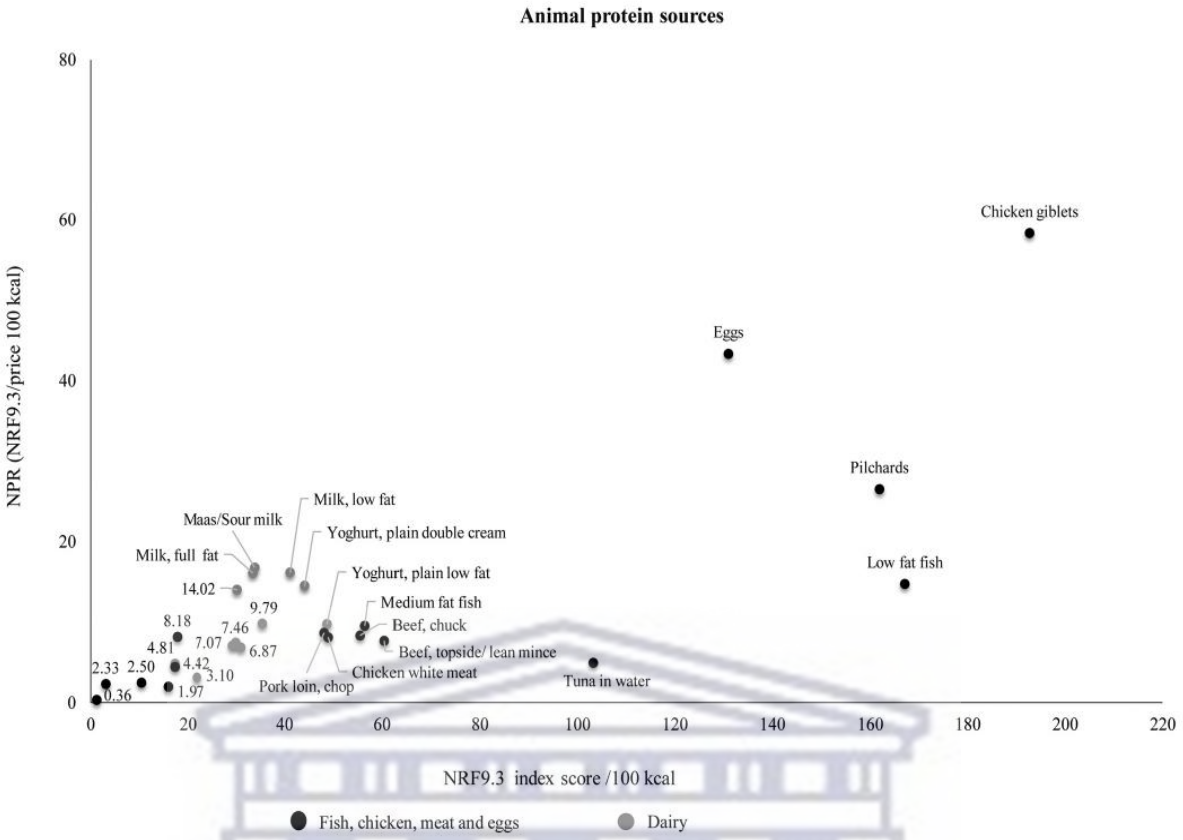


Fig. 5. Relation of the nutrient-to-price ratio (NPR) and the nutrient density (NRF9.3) score for animal protein sources.

Numerous studies have shown that energy density and energy cost are inversely related, suggesting that higher food price is associated with lower energy density[61,62]. The fats, oils and foods high in fat group, and the sugar and foods and drinks high in sugar group had the highest energy density, lowest nutrient density, lowest energy cost and lowest nutrient density relative to cost. These findings are supported by literature that states that fats and sweets are the cheapest sources of energy[24,38,44,63]. Sugar consumption in South Africa exceeds the WHO recommendations of total energy intake (<10 %)[64]. In an attempt to reduce sugar and calorie intake, and purchasing of SSBs, a levy tax on SSBs was introduced in 2016 in South Africa[65]. However, these high sugar drinks are still relatively low cost. The SA-FBDGs emphasise that fats and oils, sugar and foods and drinks high in sugar should be used sparingly[15,66], as overconsumption of nutrient poor foods is associated with weight gain and subsequent negative health outcomes such as diabetes[52].

Food price and diet cost are known to limit access to healthy diets among low-income consumers[44]. People tend to consume foods that they can afford to purchase[67], and food cost therefore contributes to lower-income groups' inability to adhere to dietary guidelines[68]. Low-cost energy-dense foods are more accessible for low-income households, which contributes to overweight and obesity in low-income settings[69]. Also, besides from being cheaper, unhealthy foods are often convenient and highly palatable compared with healthier foods which often require preparation skills and are less palatable[42]. Increasing the price of nutrient poor foods through taxation has been shown to reduce the purchasing of such foods[70]. Other barriers to purchasing healthier foods besides cost include accessibility, food distribution and retail, food storage, food preservation and safety, cooking skills or preparation time[57].

A healthy diet is often unaffordable for the majority of the South African population[71]. Low-income households in Limpopo province in South Africa were reported to use various strategies to combat rising food prices; these included eating indigenous or traditional foods and growing vegetables at home[72]. Agricultural interventions can improve not only livelihoods, but household food security as well[73]. These interventions could benefit mostly low-income consumers who cannot afford to buy fresh vegetables and fruits. It has been argued that changes in the food and agricultural sector are needed to improve the South African food system[74], that changes to agricultural policies and store policies can improve access to quality and affordable diets[75], and that the implementation of food assistance programmes may be a viable short-term strategy that can lower the cost of nutritionally balanced diets[25].

A strength of the present study is that the average price was calculated for each food item to account for food price variation across three stores. However, the study was based on 116 food items and did not include all foods available in

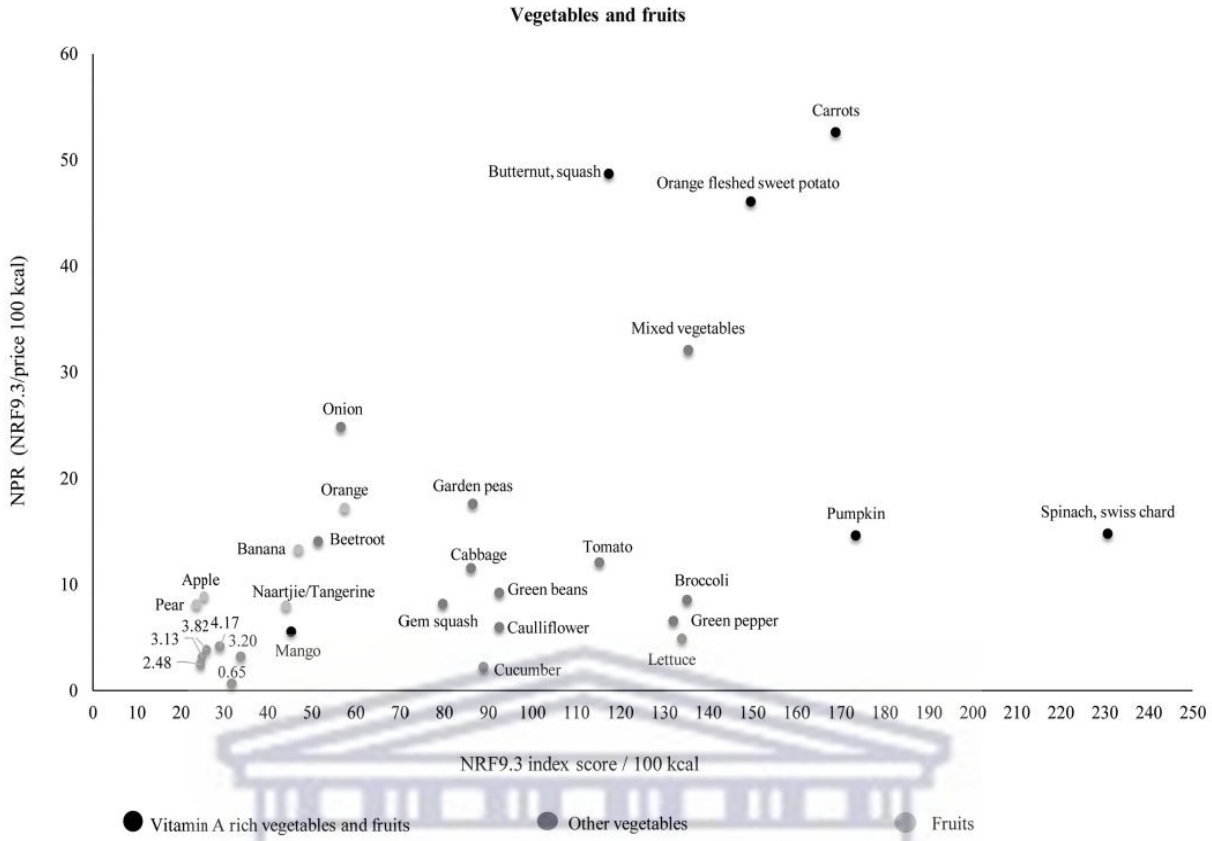


Fig. 6. Relation of the nutrient-to-price ratio (NPR) and the nutrient density (NRF9.3) score for vegetables and fruits.

national supermarkets. All foods selected in the study are however available nationally. The food checklist was based on foods commonly consumed by low-income households in Cape Town and is therefore not representative of all foods eaten in South Africa. Also, the collected food prices were limited to three supermarkets mostly used by low-income households in the Western Cape province; these supermarkets do however represent the main food chains in South Africa. The cost of food items was not recorded for all brands available, but the lowest priced supermarket (Shoprite) was used to determine the lowest priced brands for which information was then collected in all three supermarkets. The NRF Index calculations were limited to selected nine macronutrients, vitamins and minerals, if different nutrients are used, the results may vary. Food prices collected were limited to Western Cape province. Food prices may however differ by province/geographical location and seasonality.

Conclusion

Through nutrient profiling, the study identified foods within food groups with the best nutritional value per cost. Food groups with the best nutritional value per cost were pulses, starchy foods, dairy, vegetables and fruits, and fish, chicken, meat and eggs, respectively. Pulses such as sugar beans and lentils had the best nutritional value per cost and would be a more affordable substitute for meat and chicken for low-income consumers. The FBDGs recommend eating vegetables and fruits daily, yet these foods, although nutrient dense, were also the most expensive sources of energy. In an environment of rising food prices, South African households can increase vegetable and fruit consumption through home and community gardens. Compared with other studies done on the nutrient density of foods, our study included fortified staple foods which were found to have the highest nutritional value per cost within the starchy foods group. Fortification of staple foods can provide nutritional benefits at low costs, particularly for low-income consumers who rely on these foods during times of financial difficulties. The food groups with the least nutritional value per cost were fats, oils and foods high in fat and sugar and foods and drinks high in sugar; these foods were also the cheapest sources of energy and therefore should be consumed sparingly as stated in the FBDGs. This research can be used in public health interventions to prevent micronutrient deficiencies and reduce the burden of disease among people with lesser financial means. The identification of foods with the best nutritional value per cost can be used to develop public health educational tools to guide consumers in making healthier food choices and encouraging adherence to FBDGs in resource-poor settings.

Supplementary material

The supplementary material for this article can be found at https://doi.org/10.1017/jns.2022.119.

Acknowledgements

S. S. M., J. H., E. K. and M. F. conceptualised the study. S. S. M., J. H. and M. F. contributed to the study design. S. S. M. was responsible for data collection, data analysis, statistical analysis and wrote the draft manuscript. M. F. supervised and contributed to the data collection and data analysis and contributed to drafting the manuscript. All authors reviewed and approved the final manuscript.

The work reported herein was made possible through funding by the South African Medical Research Council through its Division of Research Capacity Development under the Internship Scholarship Programme from funding received from the South African National Treasury. The content hereof is the sole responsibility of the authors and does not necessarily represent the official views of the SAMRC or the funders.

The authors declare no conflict of interest.

The study did not involve human subjects therefore ethical approval was not required. The present study is part of a PhD study, which was approved by the University of the Western Cape Biomedical Research Ethics Committee (approval no. BM20/1/1).

References

1. Branca F, Lartey A, Oenema S, *et al.* (2019) Transforming the food system to fight non-communicable diseases. *Br Med J* **364**, l296.
2. World Health Organization (2021) Obesity and overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (accessed June 2022).
3. Forouhi NG, Krauss RM, Taubes G, *et al.* (2018) Dietary fat and cardiometabolic health: evidence, controversies, and consensus for guidance. *Br Med J* **361**, k2139.
4. Malik VS, Li Y, Tobias DK, *et al.* (2016) Dietary protein intake and risk of type 2 diabetes in US men and women. *Am J Epidemiol* **183**, 715–728.
5. Hruby A, Manson JE, Qi L, *et al.* (2016) Determinants and consequences of obesity. *Am J Public Health* **106**, 1656–1662.
6. Murray CJL, Aravkin AY, Zheng P, *et al.* (2020) Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet* **396**, 1223–1249.
7. Mozaffarian D (2016) Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. *Circulation* **133**, 187–225.
8. Drewnowski A, Amanquah D & Gavin-Smith B (2021) How to develop nutrient profiling models intended for global use: a manual. *Adv Nutr* **12**, 609–620.
9. Drewnowski A (2017) Uses of nutrient profiling to address public health needs: from regulation to reformulation. *Proc Nutr Soc* **76**, 220–229.
10. National Department of Health (NDoH) Statistics South Africa (Stats SA), South African Medical Research Council (SAMRC), and ICF (2019) *South Africa Demographic and Health Survey 2016*. Pretoria, South Africa, and Rockville, Maryland, USA: NDoH, Stats SA, SAMRC, and ICF. https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf (accessed March 2022).
11. Statistics South Africa (2022) South Africa's youth continues to bear the burden of unemployment. https://www.statssa.gov.za/?p=15407#:~:text=According%20to%20the%20Quarterly%20Labour,stands%20at%2034%2C5%25 (accessed July 2022).
12. Statistics South Africa (2018) Men, Women and Children: Findings of the Living Conditions Survey 2014/15. Pretoria: Statistics South Africa. https://www.statssa.gov.za/publications/Report-03-10-02%20/Report-03-10-02%202015.pdf (accessed July 2022).
13. Labadarios D, Steyn NP & Nel J (2011) How diverse is the diet of adult South Africans? *Nutr J* **10**, 33.
14. Shisana O, Labadarios D, Rehle T, *et al.* (2013) *South African National Health and Nutrition Examination Survey (SANHANES-1)*. Cape Town: HSRC Press. http://www.hsrc.ac.za/uploads/pageNews/72/SANHANES-launch%20edition%20(online%20version).pdf (accessed June 2022).
15. Vorster HH, Badham J & Venter CS (2013) An introduction to the revised food-based dietary guidelines for South Africa. *S Afr J Clin Nutr* **26**, 5–12.
16. Schonfeldt H, Hall N & Bester M (2013) Relevance of food-based dietary guidelines to food and nutrition security: a South African perspective. *Nutr Bull* **38**, 226–235.
17. Integrated Food Security Phase Classification (IPC) (2021) IPC South Africa Acute Food Insecurity Analysis September 2020 – March 2021. https://www.ipcinfo.org/fileadmin/user_upload/ipcinfo/docs/IPC_South_Africa_AcuteFoodInsec_2020Nov2021Mar_Report.pdf (accessed July 2022).
18. Pietermaritzburg Economic Justice & Dignity Group (PMBEJD). Household Affordability Index. https://pmbejd.org.za/wp-content/uploads/2022/03/March-2022-Household-Affordability-Index-PMBEJD_30032022.pdf (accessed July 2022).
19. Darmon N & Drewnowski A (2015) Contribution of food prices and diet cost to socioeconomic disparities in diet quality and health: a systematic review and analysis. *Nutr Rev* **73**, 643–660.
20. Rao M, Afshin A, Singh G, *et al.* (2013) Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open* **3**, e004277.
21. Laraia BA, Leak TM, Tester JM, *et al.* (2017) Biobehavioral factors that shape nutrition in low-income populations: a narrative review. *Am J Prev Med* **52**, S118–S126.
22. Lee A, Mhurchu CN, Sacks G, *et al.* (2013) Monitoring the price and affordability of foods and diets globally. *Obes Rev* **14**, 82–95.
23. World Health Organization (2011) *Nutrient Profiling: Report of a WHO/IASO Technical Meeting*. London, UK: WHO. https://apps.who.int/nutrition/publications/profiling/WHO_IASO_report2010.pdf?ua=1 (accessed June 2022).
24. Drewnowski A (2009) Defining nutrient density: development and validation of the Nutrient Rich Foods Index. *J Am Coll Nutr* **28**, 421S–426S.
25. Maillot M, Ferguson EL, Drewnowski A, *et al.* (2008) Nutrient profiling can help identify foods of good nutritional quality for their price: a validation study with linear programming. *J Nutr* **138**, 1107–1113.
26. Drewnowski A (2010) The Nutrient Rich Foods Index helps to identify healthy, affordable foods. *Am J Clin Nutr* **91**, 1095S–1101S.
27. National Department of Health (NDoH) (2022) *The National Strategic Plan for the Prevention and Control of Non-Communicable Diseases, 2022–2027*. Pretoria: NDOH.
28. World Health Organisation (2018) Non-Communicable Diseases (NCD) Country Profiles. https://www.who.int/nmh/publications/ncd-profiles-2018/en/ (accessed March 2022).
29. Hill J, Peer N, Jonathan D, *et al.* (2020) Findings from community-based screenings for type 2 diabetes mellitus in at risk communities in Cape Town, South Africa: a pilot study. *Int J Environ Res Public Health* **17**, 2876.
30. SAFOODS (2017) SAMRC *Food Composition Tables for South Africa*, 5th ed. Cape Town: South African Medical Research Council.
31. Haysom G, Crush J & Caesar M (2017). The Urban Food System of Cape Town, South Africa Cape Town: Hungry Cities Partnership. https://hungrycities.net/wp-content/uploads/2017/08/HCPReport3.pdf (accessed June 2022).
32. Battersby J (2011) Urban food insecurity in Cape Town, South Africa: an alternative approach to food access. *Dev South Afr* **28**, 545–561.
33. Bognár A (2002) Tables on Weight Yield of Food and Retention Factors of Food Constituents for the Calculation of Nutrient Composition of Cooked Foods (Dishes). https://www.fao.org/uploads/media/bognar_bfe-r-02-03.pdf (accessed November 2021).

34. Fulgoni VL 3rd, Keast DR & Drewnowski A (2009) Development and validation of the nutrient-rich foods index: a tool to measure nutritional quality of foods. *J Nutr* **139**, 1549–1554.
35. Lewis J (2019) *Codex Nutrient Reference Values*. Rome: FAO and WHO. https://www.fao.org/3/ca6969en/CA6969EN.pdf (accessed May 2022).
36. Academy of Science of South Africa (2013) Improved Nutritional Assessment of Micronutrients. https://www.assaf.org.za/wp-content/uploads/2014/06/ASSAf-Micronutrients-WEB.pdf (accessed April 2022).
37. Steyn NP, Wolmarans P, Nel JH, *et al.* (2008) National fortification of staple foods can make a significant contribution to micronutrient intake of South African adults. *Public Health Nutr* **11**, 307–313.
38. Siqueira KB, Borges CA, Binoti ML, *et al.* (2021) Nutrient density and affordability of foods in Brazil by food group and degree of processing. *Public Health Nutr* **24**, 4564–4571.
39. Government Notices (2008) Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act no. 54 of 1972) Amendment of Regulations Relating to the Fortification of Certain Foodstuffs. https://www.gov.za/sites/default/files/gcis_document/201409/315841206.pdf (accessed July 2022).
40. Duvenage S & Schönfeldt H (2007) Impact of South African fortification legislation on product formulation for low-income households. *J Food Compos Anal* **20**, 688–695.
41. Mendoza A, Pérez AE, Aggarwal A, *et al.* (2017) Energy density of foods and diets in Mexico and their monetary cost by socioeconomic strata: analyses of ENSANUT data 2012. *J Epidemiol Community Health* **71**, 713–721.
42. Ledikwe JH, Rolls BJ, Smiciklas-Wright H, *et al.* (2007) Reductions in dietary energy density are associated with weight loss in overweight and obese participants in the PREMIER trial. *Am J Clin Nutr* **85**, 1212–1221.
43. Ello-Martin JA, Roe LS, Ledikwe JH, *et al.* (2007) Dietary energy density in the treatment of obesity: a year-long trial comparing 2 weight-loss diets. *Am J Clin Nutr* **85**, 1465–1477.
44. Maillot M, Darmon N, Darmon M, *et al.* (2007) Nutrient-dense food groups have high energy costs: An econometric approach to nutrient profiling. *J Nutr* **137**, 1815–1820.
45. Kassier SM (2016) Colon cancer and the consumption of red and processed meat: an association that is medium, rare or well done? *S Afr J Clin Nutr* **29**, 145–149.
46. Ronquest-Ross L-C, Vink N & Sigge GO*et al.*(2015) Food consumption changes in South Africa since 1994. *S Afr J Sci* **111**, 12.
47. International Agency for Research on Cancer (IARC) (2015). *Press Release No. 240: IARC Monographs Evaluate Consumption of red Meat and Processed Meat*. Lyon: IARC. https://www.iarc.who.int/wp-content/uploads/2018/07/pr240_E.pdf (accessed September 2022).
48. Mitchell DC, Marinangeli CPF, Pigat S, *et al.* (2021) Pulse intake improves nutrient density among US adult consumers. *Nutrients* **13**, 2668.
49. Papanikolaou Y & Fulgoni VL III (2008) Bean consumption is associated with greater nutrient intake, reduced systolic blood pressure, lower body weight, and a smaller waist circumference in adults: results from the National Health and Nutrition Examination Survey 1999–2002. *J Am Coll Nutr* **27**, 569–576.
50. World Cancer Research Fund International (2022) Eat Wholegrains, Vegetables, Fruit and Beans. https://www.wcrf.org/diet-activity-and-cancer/cancer-prevention-recommendations/eat-wholegrains-vegetables-fruit-and-beans/ (accessed September 2022).
51. Venter CS, Vorster HH, Ochse R, *et al.* (2013) "Eat dry beans, split peas, lentils and soya regularly": a food-based dietary guideline. *S Afr J Clin Nutr* **26**, 36–45.
52. Browne CA (2021) Food-based dietary guidelines for South Africans: an under-utilised tool for improving nutritional well-being. *S Afr J Clin Nutr* **34**, Si–Sii.
53. Starck CS, Blumfield M, Keighley T, *et al.* (2021) Nutrient dense, low-cost foods can improve the affordability and quality of the New Zealand diet – a substitution modeling study. *Int J Environ Res Public Health* **18**, 7950.
54. Miller V, Mente A, Dehghan M, *et al.* (2017) Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): a prospective cohort study. *Lancet* **390**, 2037–2049.
55. Mbunyuza L (2008) Zero Rated and Exempt Supplies. National Department of Treasury. https://static.pmg.org.za/docs/Zero-rated%20and%20exempt%20supplies.pdf (accessed March 2022).
56. Okop KJ, Ndayi K, Tsolekile L, *et al.* (2019) Low intake of commonly available fruits and vegetables in socio-economically disadvantaged communities of South Africa: influence of affordability and sugary drinks intake. *BMC Public Health* **19**, 940.
57. Drewnowski A (2018) Nutrient density: addressing the challenge of obesity. *Br J Nutr* **120**, S8–S14.
58. Faber M, Witten C & Drimie S (2011) Community-based agricultural interventions in the context of food and nutrition security in South Africa. *S Afr J Clin Nutr* **24**, 21–30.
59. Modibedi TP, Masekoameng MR & Maake MMS (2021) The contribution of urban community gardens to food availability in Emfuleni Local Municipality, Gauteng Province. *Urban Ecosystems* **24**, 301–309.
60. Darmon N, Darmon M, Maillot M, *et al.* (2005) A nutrient density standard for vegetables and fruits: nutrients per calorie and nutrients per unit cost. *J Am Diet Assoc* **105**, 1881–1887.
61. Drewnowski A & Darmon N (2005) Food choices and diet costs: an economic analysis. *J Nutr* **135**, 900–904.
62. Drewnowski A (2004) Obesity and the food environment: dietary energy density and diet costs. *Am J Prev Med* **27**, 154–162.
63. Beal T & Ortenzi F (2022) Priority micronutrient density in foods. *Front Nutr* **9**, 806566.
64. Steyn NP & Temple NJ (2012) Evidence to support a food-based dietary guideline on sugar consumption in South Africa. *BMC Public Health* **12**, 502.
65. National Department of Health (2020) National Strategic Plan for the Prevention and Control of Non-Communicable Diseases 2020–2025. https://www.sancda.org.za/wp-content/uploads/2020/05/17-May-2020-South-Africa-NCD-STRATEGIC-PLAN_For-Circulation.pdf (accessed March 2022).
66. Temple N & Steyn N (2013) Sugar and health: a food-based dietary guideline for South Africa. *S Afr J Clin Nutr* **26**, S100–S114.
67. Beheshti R, Igusa T & Jones-Smith J (2016) Simulated models suggest that price per calorie is the dominant price metric that low-income individuals use for food decision making. *J Nutr* **146**, 2304–2311.
68. Aggarwal A, Monsivais P & Drewnowski A (2012) Nutrient intakes linked to better health outcomes are associated with higher diet costs in the US. *PLoS One* **7**, e37533.
69. Monsivais P & Drewnowski A (2007) The rising cost of low-energy-density foods. *J Am Diet Assoc* **107**, 2071–2076.
70. Niebylski ML, Redburn KA, Duhaney T, *et al.* (2015) Healthy food subsidies and unhealthy food taxation: a systematic review of the evidence. *Nutrition* **31**, 787–795.
71. Temple NJ & Steyn NP (2011) The cost of a healthy diet: a South African perspective. *Nutrition* **27**, 505–508.
72. Mkhawani K, Motadi SA & Mabapa NS (2016) Effects of rising food prices on household food security on femaleheaded households in Runnymede village, Mopani district, South Africa. *S Afr J Clin Nutr* **29**, 69–74.
73. Gassner A, Harris D, Mausch K, *et al.* (2019) Poverty eradication and food security through agriculture in Africa: rethinking objectives and entry points. *Outlook Agric* **48**, 309–315.
74. Naicker A, Makanjana O, Palmer K, *et al.* (2021) The impact of the COVID-19 pandemic on food consumption habits, food purchasing behaviours, and food security status among South Africans. *Afr J Inter-Multidiscip Stud* **3**, 131–143.
75. Faber M & Drimie S (2016) Rising food prices and household food security. *S Afr J Clin Nutr* **29**, 53–54.

CHAPTER 8: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

8.1. Introduction

This chapter begins with the background and rationale for the study, along with the overall aim of the PhD study. Then the main findings of the research are summarised and discussed, followed by the strengths and limitations of the study. Finally, the chapter concludes with recommendations for policy and public health nutrition practice and future research.

8.2 Background and rationale for the study

South Africa is affected by multiple challenges, including a high prevalence of NCDs (WHO, 2022), high unemployment rates and low incomes (Stats SA, 2023), and high and rising food prices (PMBEJD, 2023). Regarding nutritional status, South Africa has a triple burden of malnutrition, which includes childhood under- and over-nutrition, micronutrient deficiencies (Hall et al., 2019), and overweight and obesity among adults (NDoH et al., 2019). The nutrition transition in South Africa, which is characterised by increased consumption of animal proteins and energy-dense processed foods (Claasen et al., 2016, Shisana et al., 2013), is associated with a high prevalence of overweight and obesity and diet-related NCDs such as T2DM (Nnyepi et al., 2015, Shisana et al., 2013). This nutrition transition is shaped by the local retail food environment. Access to healthy foods within the local retail food environment is critical for healthy food choices and diets with a variety of foods (FAO, 2016).

Dietary diversity is critical for micronutrient adequacy (Herforth et al., 2019) and may also prevent NCDs (McCullough et al., 2002). Although DD is an essential part of a healthy diet, evidence suggests that higher DD is associated with greater consumption of unhealthy energy-dense foods and overweight or obesity among adults (de Oliveira Otto et al., 2018). In a South African context, limited data exist on the association among DD, food choices and cardiometabolic risk factors for NCDs.

South African adults consume a diet low in variety, as seen in national studies (Shisana et al., 2013, Labadarios et al., 2011). However, little is known about the barriers and enablers of consuming a diverse diet, particularly among lower SES groups. For low-income households, food prices and food affordability may restrict access to diverse, nutrient-dense diets. Nutrient profiling models, such as the NRF9.3 index in combination with food prices, can assist in identifying nutritious and affordable foods (Drewnowski, 2010).

By examining nutrient density and the cost of food, it may be possible to develop public health educational tools to assist South Africans in adhering to the FBDGs. Within this context, this

PhD study aimed to determine the association of DD with nutritional status and food choices of adults at risk of T2DM and explore the barriers and enablers for consuming a diverse diet in resource-poor communities around Cape Town, and to determine the nutrient density of foods relative to cost to identify foods with the best nutritional value per cost.

The thesis was completed using,

- A systematic scoping review of the evidence on adult food choices in association with the local retail food environment and food access in resource-poor communities (Chapter 4);
- A cross-sectional study to determine the relationship of DD with nutritional status, cardiometabolic risk factors and food choices of adults at risk of T2DM in resource-poor communities around Cape Town (Chapter 5);
- A qualitative study exploring the barriers and enablers for consuming a diverse diet in resource-poor communities in Cape Town, South Africa (Chapter 6);
- A study on nutrient density and cost of foods to identify foods within food groups with the best nutritional value per cost (Chapter 7).

8.3 Main findings and conclusions

8.3.1 Dietary diversity was not associated with nutritional status.

Results of the cross-sectional study showed that adults at risk of T2DM residing in resource-poor communities in Cape Town consumed a diet with low variety. Furthermore, women who participated in the FGDs stated that a variety of foods were only consumed once a week, mainly on Sundays or occasionally during the month after receiving some form of income. The present PhD study findings are consistent with several others that show South Africans consume a diet lacking in diversity (Saha et al., 2019, de Bruin & Gresse, 2018, Chakona & Shackleton, 2017, Shisana et al., 2013, Drimie et al., 2013, Oldewage-Theron & Kruger, 2011, Labadarios et al., 2011).

Dietary diversity was not associated with either nutritional status based on BMI and WHR or cardiometabolic risk factors (FPG, OGTT, TC, HDL-C and LDL-C) except for TG. In contrast, systematic reviews have reported DD as positively (Qorbani et al., 2022) and inversely associated with nutritional status (Salehi-Abargouei et al., 2016). Studies in Iran showed that higher DD was associated with lower FPG, HDL-C, TG and WC in individuals with prediabetes (Gholizadeh et al., 2018) and normal blood glucose levels in individuals with metabolic syndrome (Farhangi & Jahangiry, 2018). In the present study, the only cardiovascular

risk factor associated with low DD was elevated TGs. Only one study conducted in Iran (Farhangi & Jahangiry, 2018) and one in Thailand (Chalermsri et al., 2022) showed that low DD was associated with high TG.

Contrasting results from our study with others may be attributable to using different methods to define and measure DD and the eligibility criteria for recruiting participants. In the cross-sectional study, all participants were at risk for diabetes, and most were either overweight or obese and had a low DD, which may have contributed to the lack of associations found among DD, nutritional status, and most cardiometabolic risk factors. The MDD-W indicator used to measure the DD of participants also considers only healthy foods.

8.3.2 Dietary diversity was associated with the intake of healthy and unhealthy foods.

The most consumed healthy food groups by participants in the cross-sectional study were grains/roots/tubers and meat/poultry/fish. These findings are consistent with a recent desktop review reporting that South African adults mostly consumed foods from the starchy food group (Walsh & Van den Berg, 2022). Similar to the finding in this study, national surveys also indicate that starchy foods, followed by meat, poultry and fish, were the two most consumed food groups (Shisana et al., 2013, Labadarios et al., 2011). Dark-green leafy vegetables, nuts and seeds, and pulses were the least consumed food groups.

A higher percentage of participants with adequate DD consumed healthy food groups as well as unhealthy food groups. Based on the frequency intake of selected healthy and unhealthy foods, adequate DD was associated with unhealthy food choices, which included fats and oils, foods covered in pastry or crumbs, cookies, sweets, and salty foods. Higher DD was also correlated with the intake of sugary foods. Other studies have also shown that adequate DD is associated with consuming healthy and unhealthy foods (de Oliveira Otto et al., 2015, Zhang et al., 2017).

Results of the FGDs showed that some participants interpreted eating a variety of food or the term DD to mean the inclusion of unhealthy food choices. As a result of these findings, nutrition educators should clearly define what DD or eating a variety of foods means when promoting SA-FBDGs to curb the consumption of unhealthy foods that lead to overweight and obesity and subsequently to NCDs.

Results of the nutrient profiling showed that foods high in fat and foods and drinks high in sugar were the cheapest sources of energy, which is similar to the findings of other studies (Beal & Ortenzi, 2022, Siqueira et al., 2021, Drewnowski, 2009). Highly processed energy-

dense foods high in sugar and fats are easily accessible and inexpensive in South Africa (Claasen et al., 2016) and, therefore, may be more frequently consumed by the urban impoverished (Peyton et al., 2015, Alkon et al., 2013).

Local retail food environments with inadequate access to healthy foods may contribute to unhealthy food choices and diets lacking variety. According to the FGD participants, most grocery shopping was done at supermarkets, but many street vendors and convenience stores (spaza or tuck shops) also existed in their communities. Street vendors and convenience stores in South Africa have been found to sell predominantly unhealthy processed packaged foods (Hill et al., 2018, Igumbor et al., 2012). According to Battersby and Peyton (2014), supermarket expansion into Cape Town's low-income communities may contribute to the nutritional transition. Supermarkets in low-income communities in Cape Town generally stock fewer healthy foods; therefore, residents have limited access to healthy foods compared to residents in higher-income communities (Battersby & Peyton, 2014).

The presence of unhealthy food stores in resource-poor communities is not unique to South Africa, as the scoping review findings indicate that low neighbourhood SES is associated with healthy and unhealthy food environments. The findings of the PhD study suggest that there is a need for interventions to create healthier food environments in resource-poor communities in South Africa to curb the consumption of unhealthy food choices and improve DD.

8.3.3 Low fruit and vegetable consumption among adults at risk of diabetes

Findings from the cross-sectional study show that only 5.2% of study participants consumed dark-green leafy vegetables, and 34.8% had other vitamin A-rich FV the previous day. The SANHANES-1 data show that dark-green leafy vegetables and vitamin A-rich FV are among the least consumed food groups in South African households (Shisana et al., 2013). Food frequency data of the cross-sectional study showed that overall, only 23.5% of participants consumed fresh fruit, and 40.1% consumed vegetables daily.

According to the SA-FBDGs, individuals are advised to “eat plenty of vegetables and fruit every day” (Naude, 2013). However, FV remain the least consumed food group in South Africa (Walsh & Van den Berg, 2022). The per capita intake of FV intake in South Africa has been estimated at 200 g per day (Shisana et al., 2013), which is half the WHO recommendation of at least 400 g per day for the prevention of diabetes, CVDs, and certain types of cancers (WHO, 2018).

Cost is the main barrier preventing the consumption of FV, as indicated by the findings from the cross-sectional study and FGD participants. Nutrient profiling also showed that FV were the most expensive sources of energy. In countries such as Brazil (Siqueira et al., 2021) and New Zealand (Starck et al., 2021), the FV group had the best nutritional value per cost. In the present PhD study, although FV were the most nutrient-dense, this group had a lower nutritional value per cost.

The recent drought in South Africa has led to a rapid increase in prices for FV more than other foods (FAO et al., 2022a). The drought may be the reason for the higher prices of FV in the present study compared to prices in other countries. Among urban residents, low FV consumption may be because of a lack of subsistence farming and reliance on markets to procure these foods. Many urban dwellers also lack access to land and water to produce their own food for subsistence (Jonah & May, 2020). The FGD participants mentioned a lack of space to plant FV as a barrier to consuming a diverse diet. However, starting home and community gardens were considered a solution to increase the consumption of FV and diverse diets by these participants.

8.3.4 Low household income, food prices and family taste preferences are barriers to consuming a diverse diet.

Financial constraints, high food prices and family taste preferences were the critical barriers to not consuming a diverse diet and making healthy food choices among women who participated in the FGDs. The socio-demographic data of the cross-sectional study revealed that participants had high unemployment, low household incomes, and lower formal education levels.

In the literature, lower education level and household income have been associated with the consumption of low-cost starchy foods (Schonfeldt et al., 2013), unhealthy diets, and low consumption of FV (Rippin et al., 2020, Msambichaka et al., 2018). Increased household incomes, poverty alleviation and job creation have been proposed as solutions to enable greater access to diverse and nutrient-rich foods (FAO et al., 2022b, Mayén et al., 2014). The FGD participants also suggested budgeting and income generation activities such as seeking employment and starting businesses as interventions to address financial constraints and improve food access.

Economic access to food depends on food prices and the income of households. Most of the South African population depends on cash to purchase food, especially in urban areas (Jonah & May, 2020). The high cost of foods and especially the high price of FV were mentioned as

barriers to consuming a diverse diet in the FGDs. High food cost was found to be the main barrier to accessing healthy food in resource-poor communities in the scoping review. The cost was also cited as the primary barrier to daily FV consumption in the cross-sectional study of this PhD study.

During the COVID-19 pandemic, there was a noticeable increase in food prices globally (FAO et al., 2022a). This rise in food prices negatively impacted household purchasing power and consequently affected diet quality and comprised food security in many households in South Africa (Jonah & May, 2020). For some FGD participants, job losses caused by the COVID-19 lockdown, coupled with rising food prices, further limited access to a variety of foods.

Family plays a significant role in influencing dietary intake within the social environment (Larson & Story, 2009). The FGD participants cited family taste preferences as a critical social barrier to consuming a diverse diet and making healthy food choices. FGD participants living with their children indicated they influence what foods are purchased and consumed in their households. Other qualitative studies with low-income women also reported a negative influence of children on household food choices (Palmer et al., 2020, Baruth et al., 2014). Children, unlike parents and grandparents, prefer highly palatable unhealthy foods. Good taste or palatability is a crucial determinant for the consumption of healthy, nutrient-dense foods such as FV, as suggested by studies (Chen & Antonelli, 2020, Liem & Russell, 2019).

8.3.5 Individual taste preferences, access to food stores, food store specials and community soup kitchens/gardens are enablers to consuming a diverse diet.

Sensory factors such as taste play a significant role in eating behaviours and food choices (Chen & Antonelli, 2020). Hough and Sosa (2015) have argued that food-insecure individuals eat whatever food is available, and these foods tend to be energy dense, contributing to obesity. Access to food is generally determined by food preferences (Jonah & May, 2020).

FGD participants preferred healthy food choices such as FV; however, these choices were dependent on availability and purchasing power. Food preferences shape the foods supplied within the food environments and vice versa. Age, ethnicity, and education may also influence taste preferences (Chen & Antonelli, 2020). In the present research, FGD participants were slightly older and had overall good nutrition knowledge. Literature suggests that preference for healthier food options increases with age (Szakos et al., 2022, Vella et al., 2013).

Most FGD participants reported that the retail food environment in their communities was physically accessible, and in-store healthy food choices were available; however, lack of money prevented them from applying these choices. More than half of the FGD participants either walked or used a taxi to get to and from food stores. Between 1994 and 2012, the number of supermarkets in Cape Town increased from 89 to 235 (Battersby, 2017). This expansion of supermarkets and malls was predominantly in lower-income communities in Cape Town (Battersby, 2017). This development may explain why FGD participants perceived food stores as easily accessible since they did not have to go outside their communities to get basic groceries.

Improving physical access to retailers in neighbourhoods may increase diet quality and the overall health of residents. In the literature, interventions to improve food systems and retail food environments include expanding supermarkets into food deserts and increasing the number of food markets and fresh produce street vendors (van Liere & Curtis, 2018). Results of the scoping review showed that physical access to healthy food store types, such as supermarkets, large grocery stores and farmers markets, and particularly, vendors selling FV, as decisive facilitators for healthy food access in resource-poor communities.

Lower food prices were suggested as a significant facilitator for consuming diverse diets by FGD participants. Retail food prices and promotions influence consumer choices and willingness to purchase specific food products (Castro et al., 2018). In low SES neighbourhoods, lower prices may not necessarily give rise to food items being affordable because of insufficient incomes (Crawford et al., 2017). Nevertheless, lowering food prices may decrease barriers to accessing healthier foods and consuming a diverse diet.

Food store promotions helped FGD participants to buy foods needed in their households within their limited budget and, therefore, may enable the consumption of diverse diets. The scoping review showed that lower in-store food prices, especially for foods such as FV, were decisive facilitators for healthy food access in resource-poor communities. The presence of community soup kitchens/gardens or having a home garden enabled FGD participants access to healthy food, albeit not daily. Similarly, in the scoping review, food assistance programmes, including food pantries, food banks, and soup kitchens run by the government and NGOs, were also found to facilitate healthy food access in resource-poor communities.

8.3.6 Food sources with the best nutritional value per cost

Foods within food groups with the best nutritional value per cost were identified in the nutrient density and cost of foods study. Overall, the pulses food group had the highest nutritional value per cost. The SA-FBDGs encourage consumers to "eat dry beans, split peas, lentils and soya regularly" (Venter et al., 2013). However, in the cross-sectional study, pulses were one of the food groups least consumed by adult participants. The General Household Survey 2013-2018 also showed that pulses were the least consumed food items in South Africa overall (Sambu & Swart, 2022). Substituting meat and chicken for pulses, such as sugar beans and lentils, may be beneficial for low-income consumers as these foods are more affordable sources of protein. FGD participants mentioned that they were unaware that lentils could replace meat. These findings highlight the need for nutrition education on healthy and affordable food substitutes.

Starchy foods had the second-best nutritional value per cost, especially maize meal, and bread, which are fortified per legislation. Results from the cross-sectional study indicate that starchy foods were consumed across all DDS quintiles. Temple and colleagues (2011) argued that starchy foods, which have a low energy cost, may also be the most inexpensive for the impoverished to meet their energy needs. According to the Bureau for Food and Agricultural Policy (BFAP), low-income South African consumers spend 32% of their food budget on bread and cereals (BFAP, 2020). The consumption of starchy foods in South Africa is also said to exceed the recommended daily intake of carbohydrates, contributing to excess energy intake that may contribute to obesity and overweight among the population. (Walsh & Van den Berg, 2022, Makwela, 2016).

Dairy products with the highest nutritional value per cost were sour milk, low-fat milk, full-cream milk, and double-cream yoghurt. In the SA-FBDGs, individuals are encouraged to "have milk, maas or yoghurt every day" (Vorster et al., 2013). However, only almost half of the participants in the cross-sectional study consumed dairy products the previous day. A recent desktop review found that consumption of milk and milk products was significantly low among South African adults (Walsh & Van den Berg, 2022).

Despite being relatively expensive, nutrient-rich sources of protein, meat, chicken, and fish, were the second most consumed food group by cross-sectional study participants. According to the BFAP, low-income South African consumers spend 21% of their food budget on meat (BFAP, 2020). The SANHANES-1 data show that organ meat and eggs are among the least-consumed food groups in South African households (Shisana et al., 2013). However, based on

nutrient profiling, low-income consumers could choose animal proteins such as chicken giblets, eggs, pilchards, and low-fat fish, as these were foods within the fish, chicken, meat, and eggs food group that had the best nutrient density relative to cost. Results of the nutrient profiling showed that processed meats such as sausages (boerewors), Vienna sausages, bacon, and polony had the lowest nutritional value per cost.

The vegetables and fruits food groups, and more specifically, the vitamin A-rich FV food group, had the highest nutrient density along with the highest energy cost across all food groups. Studies conducted in South Africa (Temple et al., 2011, Temple & Steyn, 2009) and globally (Bai et al., 2021, Drewnowski & Rehm, 2013, Aggarwal et al., 2012) confirm our findings that nutrient-dense foods such as FV cost more than energy-dense foods. Nevertheless, within the vegetables and fruits food group, carrots, butternut, orange-fleshed sweet potatoes, and mixed vegetables were identified as vegetables with the best nutritional value per cost. Since FV have low energy density and high water content, when consumed adequately, they can curb excessive weight gain (Guyenet, 2019, Nour et al., 2018) and are therefore vital in addressing the overweight and obesity epidemic in South Africa.

The fats, oils, and foods high in the fat group had the highest energy density and the second lowest nutritional value per cost. From 1994 to 2012, the consumption of fats and oils and savoury snacks increased in South Africa (Ronquest-Ross et al., 2015). However, these foods should be eaten sparingly, as outlined in the SA-FBDG (Smuts & Wolmarans, 2013). Excessive consumption of dietary fat, particularly saturated and trans fats, has been associated with an increased risk of obesity, coronary heart disease and certain types of cancer (WHO, 2021, Forouhi et al., 2018). In 2011, the NDoH introduced regulations to limit trans fats to below 2% in all foods in South Africa (NDoH, 2011).

Sugar and foods and drinks high in the sugar group had the lowest nutritional value per cost. In South Africa, people in urban areas and younger age groups consume the most sugary foods and snacks (Sambu & Swart, 2022). High sugary food intake has been associated with poor diets, overweight and obesity, and NCDs such as T2DM, hypertension, CVDs, and cancer (Huang et al., 2023). Sugar-sweetened beverages remain widely consumed in South Africa, as demonstrated by the SADHS 2016 data, which showed that 36% of South Africans consume SSBs daily (NDoH et al., 2019). The cross-sectional study of this research also showed that SSBs were the most consumed unhealthy food group (85.7%) the previous day. The South African government introduced a levy tax on SSBs in 2016 in an attempt to reduce sugar and energy intake, as well as the purchase of SSBs (NDoH, 2020).

8.4 Strengths and limitations of the study

8.4.1 Strengths

The studies in this PhD had many strengths related to the data methods and study results, which are detailed in the manuscripts. Briefly, the strengths of this PhD study included the following,

- The scoping review provided an overview of the evidence on adult food choices in association with the local retail food environment and determined barriers to and facilitators of healthy food access in resource-poor communities.
- Concerning the cross-sectional study, a relatively large sample size was used to test associations between DD with nutritional status, cardiometabolic risk factors and food choices of adults at risk of T2DM in resource-poor communities.
- In contrast to surveys, focus groups allowed for a more open and personalised dialogue. The qualitative study also provides insight into the barriers to and enablers of consuming a diverse diet in women living in resource-poor communities. Qualitative study results may be beneficial for future interventions and behaviour change programmes.
- This study identified South African foods within food groups with the best nutritional value per cost using the NRF9.3 index.

8.4.2 Limitations

The limitations for each study objective are detailed in the respective manuscripts. The main limitations of the PhD research included,

- Data analysis for the PhD study was limited to the urban population residing in the resource-poor communities of Cape Town, South Africa. Therefore, the results might be different should the same analyses be conducted in other settings in South Africa.
- In the cross-sectional study, the MDD-W was used to assess the DD of adult males and females, as there are no standardized measures to assess the DD of males. The DD was based on an unquantified 24-hour recall, subject to recall error and social desirability. Dietary data were based on self-report and may be subject to error and recall bias. As this cross-sectional study examined associations, a causal relationship cannot be established.
- Qualitative data is self-reported and may be susceptible to social desirability bias. Content analysis used in the qualitative study depends on the researcher's reading and interpretation of texts; therefore, the study may be susceptible to researcher bias.

- Concerning the nutrient density and cost of foods study, the cost, nutrient density, and NPRs were determined for only 116 food items. The prices of foods were calculated using the average price for supermarkets in the Western Cape Province. However, food prices may vary depending on the province in South Africa where prices are collected and seasonality.

8.5 Overall Conclusion

The findings of this research indicated a high prevalence of low DD among adults at risk of diabetes in resource-poor communities. Considering these findings, a public health initiative to increase DD and healthy food choices is needed in South Africa. Dietary diversity was not associated with either nutritional status based on BMI and WHR or cardiometabolic risk factors, except for the association of low DD with elevated TGs. Adequate DD was associated with healthy and unhealthy food choices, which further emphasises the limitation of the usefulness of DD indicators in NCD research. Financial constraints, high food prices and family taste preferences were the critical barriers to consuming a diverse diet and making healthy food choices. Through nutrient profiling, foods within food groups that are both nutrient-rich and affordable were identified in the research. Knowledge of what foods have the best nutritional value per cost may enable low-income consumers to make healthier food choices and consume diverse diets.

8.6 Recommendations

8.6.1 Recommendation for public health policy and practice

- Considering food costs as a critical barrier to eating healthily, the findings highlight the economic challenges to adopting healthier eating habits. Government and policy interventions are needed to transform food systems and environments to make healthier food choices more affordable.
- Diverse diets and healthy food choices could be made more affordable through government intervention, such as taxing unhealthy foods or providing subsidies to disadvantaged groups. South Africa already has a health promotion levy tax on SSBs (NDoH, 2020); however, other processed foods with high salt, sugar and fat content could be taxed to discourage consumption. In South Africa, selected foods are exempt from value-added tax (VAT). According to the Pietermaritzburg Economic Justice & Dignity Group, fewer food groups can be found on the plate because of the high VAT on basic foods (PMBEJD, 2023). Therefore, it is recommended that more basic food items be VAT free. Recently, there have been growing calls for VAT to be removed from most chicken

products (frozen portions, chicken feet, gizzards and livers) as they are the main meat source for households in South Africa (Staff reporter, 2023). Government subsidies on staple food basket items for South African households may also help consumers afford more variety in their diets.

- The findings of the qualitative study highlight the need to increase household income among lower-income groups in South Africa, as income and SES are important determinants of food choice. Policy actions aimed at increasing household income levels (especially among the lowest income groups and vulnerable groups) are needed to help improve financial access to diverse diets. Addressing the unemployment crisis in South Africa is therefore of utmost importance. The expanded public works programme of the Department of Public Works and Infrastructure (DPWI) should be strengthened to continue alleviating poverty and improve incomes for the unemployed by providing temporary work and skills training (DPWI, 2022).
- Consumer nutrition education on FBDGs, especially to lower income groups, should provide practical advice on how to make healthy food choices that are affordable within a limited budget and should emphasise the importance of DD. Nutrition education should highlight nutrient-dense foods with the best nutritional value per cost and discourage the consumption of high-energy, nutrient-poor foods such as SSBs, sweet foods, and high-fat and salted foods. Dietary advice could also be given according to foods with the lowest to middle-energy density cost (Temple & Steyn, 2009). It is recommended that dietitians and nutritionists be trained in nutrient profiling and its application.
- Public mass media campaigns and advocacy using mass media and social media could be used to educate the public on diverse diets and healthy food choices. Marketing of healthy foods in stores and through mass media may encourage consumers to purchase foods that provide greater nutritional value for money and therefore increase the demand for healthy foods.
- Nutrition education and skills programmes addressing individuals' knowledge, attitudes and behaviours should include meal planning, food shopping, preparation, and budgeting.
- The qualitative study findings highlight the need to identify strategies that can be used in home and community settings to improve the taste of FV and increase healthy food consumption in children. Schools could be involved in educating children on the importance of consuming a healthy diet, which may lead to forming good eating habits that may prevent malnutrition and NCD development at an early age.

- Fruit and vegetable gardens can improve DD and increase consumption of these foods in lower-income groups and resource-poor communities. Therefore, nutrition education could also include lessons on how to grow crops in limited spaces, such as using containers (buckets, tubs, pots, tyres) to grow food and how to save water and collect rainwater for gardening. The food security, land reform and restitution programmes of the National Department of Agriculture, Land Reform and Rural Development should focus on restoring abandoned gardens/community projects and support urban agriculture in urban areas, including community food gardens and household gardens.
- The National Department of Social Development needs to expand, strengthen, and monitor its food banks, food parcels, food vouchers, social relief of distress programmes and soup kitchens/drop-in centre programmes to improve access to food for the impoverished. Results from this research suggest that food assistance programmes enable and facilitate access to healthy food choices and are utilised in times of financial difficulty.
- Nutrient profiling information can potentially be used in food labelling schemes and marketing regulations to help consumers identify healthier foods and restrict the consumption of unhealthy foods.

8.6.2 Recommendation for future research

- The use of the MDD-W indicator may be limited in NCD research as it does not reflect the overall quality of the diet but rather nutrient adequacy. Future research should investigate other indicators that better reflect DD, including healthy and unhealthy food groups, such as the Global Diet Quality Score, which has recently been validated for nutrient adequacy and diet-related NCD outcomes (Bromage et al., 2021).
- It is recommended that researchers investigate which interventions, including nutrition education, home and community gardens or food taxation/subsidies, have the highest impact on addressing barriers to consuming a diverse diet in resource-poor areas in different settings for tailored interventions. This recommendation can be achieved by conducting a comparative study to assess the change in diets before and after implementing an intervention.
- Develop and pilot test a nutrition education tool based on nutrient density principles to help people with limited budgets to identify healthy foods with good nutritional value per cost and assess their validity and relevance. Future research could also test the impact or

usefulness of dietary guidance using such a tool by conducting a randomised controlled trial.

- Studies analysing the price differences between different types of retail outlets may be suitable for developing food budgeting nutrition education materials for consumers. Therefore, future research on the nutrient density of food should analyse food price data from convenience stores, butcheries, greengrocers, markets, and wholesalers. Information on which foods have the best nutritional value per cost, including where to purchase these foods at a lower price, may be given during consumer nutrition education.
- Research examining the potential adherence to FBDGs and their association with NCDs in South Africa is recommended. This recommendation can be achieved by conducting longitudinal studies.

8.7 References

Aggarwal, A., Monsivais, P. & Drewnowski, A. (2012). Nutrient intakes linked to better health outcomes are associated with higher diet costs in the US. *PLoS One,* 7, e37533.

Alkon, A., Block, D., Moore, K., et al. (2013). Foodways of the urban poor. *Geoforum,* 48, 126-135.

Bai, Y., Alemu, R., Block, S. A., et al. (2021). Cost and affordability of nutritious diets at retail prices: Evidence from 177 countries. *Food Policy,* 99, 101983.

Baruth, M., Sharpe, P. A., Parra-Medina, D., et al. (2014). Perceived barriers to exercise and healthy eating among women from disadvantaged neighborhoods: results from a focus groups assessment. *Women Health,* 54, 336-353.

Battersby, J. (2017). Food system transformation in the absence of food system planning: The case of supermarket and shopping mall retail expansion in Cape Town, South Africa. *Built Environ,* 43, 417-430.

Battersby, J. & Peyton, S. (2014). The geography of supermarkets in Cape Town: Supermarket Expansion and Food Access. *Urban Forum,* 25,153-164.

Beal, T. & Ortenzi, F. (2022). Priority Micronutrient Density in Foods. *Front Nutr,* 9, 806566.

BFAP. (2020). *How South Africans spend their budgets* [Online]. Available https://www.grainsa.co.za/upload/files/2020.03.23%20BFAP%20COVID%2019%20Brief%202%20-%20How%20South%20Africans%20spend%20their%20food%20budgets.pdf [11 April 2023].

Bromage, S., Batis, C., Bhupathiraju, S. N., et al. (2021). Development and validation of a novel food-based Global Diet Quality Score (GDQS). *J Nutr,* 151, 75S-92S.

Castro, I. A., Majmundar, A., Williams, C. B., et al. (2018). Customer purchase intentions and choice in food retail environments: A scoping review. *Int J Environ Res Public Health,* 15, 2493.

Chakona, G. & Shackleton, C. (2017). Minimum dietary diversity scores for women indicate micronutrient adequacy and food insecurity status in South African Towns. *Nutrients,* 9, 812.

Chalermsri, C., Ziaei, S., Ekström, E.-C., et al. (2022). Dietary diversity associated with risk of cardiovascular diseases among community-dwelling older people: A national health examination survey from Thailand. *Front Nutr,* 9, 1002066.

Chen, P.-J. & Antonelli, M. (2020). Conceptual models of food choice: influential factors related to foods, individual differences, and society. *Foods,* 9, 1898.

Claasen, N., Van Der Hoeven, M. & Covic, N. (2016). Food environments, health and nutrition in South Africa. Cape Town: PLAAS, UWC and Centre of Excellence on Food Security. [Online]. Available http://repository.uwc.ac.za/xmlui/handle/10566/4520 [23 March 2019].

Crawford, B., Byun, R., Mitchell, E., et al. (2017). Socioeconomic differences in the cost, availability and quality of healthy food in Sydney. *Aust N Z J Public Health,* 41, 567-571.

De Bruin, E. & Gresse, A. (2018). Dietary diversity amongst adults who buy at shopping malls in the Nelson Mandela bay area. *J Consum Sci, Special Edition Food and nutrition challenges in Southern Africa,* 3, 11-21.

De Oliveira Otto, M. C., Anderson, C. a. M., Dearborn, J. L., et al. (2018). Dietary diversity: Implications for obesity prevention in adult populations: A science advisory from the American Heart Association. *Circulation,* 138, e160-e168.

De Oliveira Otto, M. C., Padhye, N. S., Bertoni, A. G., et al. (2015). Everything in moderation - Dietary diversity and quality, central obesity and risk of diabetes. *PLoS One,* 10, e0141341.

DPWI. (2022). *Public Works and Infrastructure on work opportunities created by Expanded Public Works Programme* [Online]. Available https://www.gov.za/speeches/public-works-and-infrastructure-work-opportunities-created-expanded-public-works-programme [8 March 2023].

Drewnowski, A. (2009). Defining nutrient density: Development and validation of the Nutrient Rich Foods Index. *J Am Coll Nutr,* 28, 421S-426S.

Drewnowski, A. (2010). The Nutrient Rich Foods Index helps to identify healthy, affordable foods. *Am J Clin Nutr,* 91, 1095s-1101s.

Drewnowski, A. & Rehm, C. D. (2013). Vegetable cost metrics show that potatoes and beans provide most nutrients per penny. *PLoS One,* 8, e63277.

Drimie, S., Faber, M., Vearey, J., et al. (2013). Dietary diversity of formal and informal residents in Johannesburg, South Africa. *BMC Public Health,* 13, 911.

FAO. (2016). Influencing food environments for healthy diets. Rome: FAO. Available https://www.fao.org/3/i6484e/i6484e.pdf [20 February 2019].

FAO, European Union, CIRAD, et al. (2022a). Food systems profile – South Africa. Catalysing the sustainable and inclusive transformation of food systems.Rome, Brussels, Montpellier, France and Bellville, South Africa: FAO, European Union, CIRAD and DSI-NRF Centre of Excellence in Food Security (CoE-FS). Available: https://www.fao.org/documents/card/en/c/cc0071en [30 January 2023].

FAO, IFAD, UNICEF, et al. (2022b). The state of food security and nutrition in the world 2022. Repurposing food and agricultural policies to make healthy diets more affordable. Rome: FAO. Available https://www.fao.org/3/cc0639en/cc0639en.pdf [2 February 2023].

Farhangi, M. A. & Jahangiry, L. (2018). Dietary diversity score is associated with cardiovascular risk factors and serum adiponectin concentrations in patients with metabolic syndrome. *BMC Cardiovasc Disord,* 18, 68.

Forouhi, N. G., Krauss, R. M., Taubes, G., et al. (2018). Dietary fat and cardiometabolic health: evidence, controversies, and consensus for guidance. *BMJ,* 361, k2139.

Gholizadeh, F., Moludi, J., Lotfi Yagin, N., et al. (2018). The relation of dietary diversity score and food insecurity to metabolic syndrome features and glucose level among pre-diabetes subjects. *Prim Care Diabetes,* 12, 338-344.

Guyenet, S. J. (2019). Impact of whole, fresh fruit consumption on energy intake and adiposity: A systematic review. *Front Nutr,* 6, 66.

Hall, K., Sambu, W., Almeleh, C., et al. (2019). *The South African early childhood review 2019.* Cape Town: Children's Institute, University of Cape Town and Ilifa Labantwana.[Online]. Available https://ilifalabantwana.co.za/sa-early-childhood-review-2019/ [15 February 2023].

Herforth, A., Arimond, M., Álvarez-Sánchez, C., et al. (2019). A global review of food-based dietary guidelines. *Adv Nutr,* 10, 590-605.

Hill, J., Mchiza, Z., Puoane, T., et al. (2019). Food sold by street-food vendors in Cape Town and surrounding areas: a focus on food and nutrition knowledge as well as practices related to food preparation of street-food vendors. *J Hunger Environ Nutr,* 14, 401-415.

Hough, G. & Sosa, M. (2015). Food choice in low income populations – A review. *Food Qual Prefer,* 40, 334-342.

Huang, Y., Chen, Z., Chen, B., et al. (2023). Dietary sugar consumption and health: umbrella review. *BMJ,* 381, e071609.

Igumbor, E. U., Sanders, D., Puoane, T. R., et al. (2012). "Big Food," the consumer food environment, health, and the policy response in South Africa. *PLoS Med,* 9, e1001253.

Igumbor, E. U., Sanders, D., Puoane, T. R., et al. (2012). "Big Food," the consumer food environment, health, and the policy response in South Africa. *PLoS Med,* 9, e1001253.

Jonah, C. M. P. & May, J. D. (2020). The nexus between urbanization and food insecurity in South Africa: does the type of dwelling matter? *Int J Urban Sustain Dev,* 12, 1-13.

Labadarios, D., Steyn, N. & Nel, J. (2011). How diverse is the diet of adult South African? *Nutr J,* 10, 33.

Larson, N. & Story, M. (2009). A review of environmental influences on food choices. *Ann Behav Med,* 38, S56-73.

Liem, D. G. & Russell, C. G. (2019). The Influence of taste liking on the consumption of nutrient rich and nutrient poor foods. *Front Nutr,* 6, 174.

Makwela, M. (2016). *South Africans consuming too much starch*. Available: https://foodsecurity.ac.za/news/south-africans-consuming-too-much-starch/[24 May 2023].

Mayén, A. L., Stringhini, S., Ford, N. D., et al. (2016). Socioeconomic predictors of dietary patterns among Guatemalan adults. *Int J Public Health,* 61, 1069-1077.

McCullough, M. L., Feskanich, D., Stampfer, M. J., et al. (2002). Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. *Am J Clin Nutr,* 76, 1261-1271.

Msambichaka, B., Eze, I. C., Abdul, R., et al. (2018). Insufficient fruit and vegetable intake in a low- and middle-income setting: A population-based survey in semi-urban Tanzania. *Nutrients,* 10, 222.

Naude, C. E. (2013). "Eat plenty of vegetables and fruit every day": A food-based dietary guideline for South Africa. *S Afr J Clin Nutr,* 26, S46-S56.

NDoH. (2011). Government Notices : Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972). *Regulations relating to trans-fat in foodstuffs.* Available https://www.gov.za/sites/default/files/gcis_document/201409/34029reg9427gon127.pdf [16 May 2023]

NDoH. (2020). *National strategic plan for the prevention and control of Non-communicable diseases 2020-2025*. Available https://www.sancda.org.za/wp-content/uploads/2020/05/17-May-2020-South-Africa-NCD-STRATEGIC-PLAN_For-Circulation.pdf [8 March 2022].

NDoH, Stats SA, SAMRC, et al. (2019). *South Africa Demographic and Health Survey 2016.* Pretoria, South Africa, and Rockville, Maryland, USA: NDoH, Stats SA, SAMRC, and ICF. Available https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf [29 March 2022].

Nnyepi, M. S., Gwisai, N., Lekgoa, M., et al. (2015). Evidence of nutrition transition in Southern Africa. *Proc Nutr Soc,* 74, 478-486.

Nour, M., Lutze, S. A., Grech, A., et al. (2018). The relationship between vegetable intake and weight outcomes: A systematic review of cohort studies. *Nutrients,* 10,1626.

Oldewage-Theron, W. & Kruger, R. (2011). Dietary diversity and adequacy of women caregivers in a peri-urban informal settlement in South Africa. *Nutrition,* 27, 420-427.

Palmer, S. M., Knoblauch, S. T., Winham, D. M., et al. (2020). Putting knowledge into practice: low-income women talk about food choice decisions. *Int J Environ Res Public Health,* 17, 5092.

Peyton, S., Moseley, W. & Battersby, J. (2015). Implications of supermarket expansion on urban food security in Cape Town, South Africa. *Afr Geogr Rev,* 34, 36-54.

PMBJED. (2023). *Household Affordability Index February 2023* [Online]. Available https://pmbejd.org.za/wp-content/uploads/2023/02/February-2023-Household-Affordability-Index-PMBEJD_28022023.pdf [10 March 2023].

Qorbani, M., Mahdavi-Gorabi, A., Khatibi, N., et al. (2022). Dietary diversity score and cardio-metabolic risk factors: an updated systematic review and meta-analysis. *Eat Weight Dis,* 27, 85-100.

Rippin, H. L., Hutchinson, J., Greenwood, D. C., et al. (2020). Inequalities in education and national income are associated with poorer diet: Pooled analysis of individual participant data across 12 European countries. *PLoS One,* 15, e0232447.

Ronquest-Ross, L.-C., Vink, N. & Sigge, G. (2015). Food consumption changes in South Africa since 1994. *S Afr J Sci,* 111, 12.

Saha, S., Abu, B., Oldewage-Theron, W., et al. (2019). Available food options at local shops in relation to food insecurity among older adults in Sharpeville, South Africa. *Afr J Food Agric Nutr Dev*, 19*,* 14500-14516.

Salehi-Abargouei, A., Akbari, F., Bellissimo, N., et al. (2016). Dietary diversity score and obesity: a systematic review and meta-analysis of observational studies. *Eur J Clin Nutr,* 70, 1-9.

Sambu, W. & Swart, R. (2022). Food consumption trends documented in nationally representative (and other) surveys in South Africa. *In:* National Department of Health & DSI-NRF Center of Excellence in Food Security (2022) (ed.) *Foods procured, Nutritional status and Dietary Intake of People Living in South Africa: Desktop review.* Pretoria: National Department of Health, South Africa, 40-83.

Schönfeldt, H., Hall, N. & Bester, M. (2013). Relevance of food-based dietary guidelines to food and nutrition security: A South African perspective. *Nutr Bull,* 38, 226-235.

Shisana, O., Labadarios, D., Rehle, T., et al. (2013). *South African National Health and Nutrition Examination Survey (SANHANES-1).* Cape Town: HSRC Press. [Online]. Available http://www.hsrc.ac.za/uploads/pageNews/72/SANHANES-launch%20edition%20(online%20version).pdf [19 January 2020].

Siqueira, K. B., Borges, C. A., Binoti, M. L., et al. (2021). Nutrient density and affordability of foods in Brazil by food group and degree of processing. *Public Health Nutr,* 24, 4564-4571.

Smuts, C. M. & Wolmarans, P. (2013). The importance of the quality or type of fat in the diet: a food-based dietary guideline for South Africa. *S Afr J Clin Nutr,* 26, S87-S99.

Staff Reporter. (2023). Ongoing call for VAT-free chicken intensified after global price increases. *Weekend Argus*. [Online]. Available https://www.iol.co.za/weekend-argus/news/ongoing-call-for-vat-free-chicken-intensified-after-global-price-increases-b15e5826-b11f-4f5c-b911-536ff935a396 [6 March 2023].

Starck, C. S., Blumfield, M., Keighley, T., et al. (2021). Nutrient dense, low-cost foods can improve the affordability and quality of the New Zealand Diet–A substitution modeling study. *Int J Environ Res Public Health,* 18, 7950.

Stats SA. (2023). *Incidence of long-term unemployment among women is higher than the national average.* [Online]. Available https://www.statssa.gov.za/?p=16113 [27 March 2023].

Szakos, D., Ózsvári, L. & Kasza, G. (2022). Health-related nutritional preferences of older adults: A segmentation study for functional food development. *J Funct Foods,* 92, 105065.

Temple, N. & Steyn, N. (2009. Food prices and energy density as barriers to healthy food patterns in Cape Town, South Africa. *J Hunger Environ Nutr,* 4, 203-213.

Temple, N. J., Steyn, N. P., Fourie, J., et al. (2011). Price and availability of healthy food: A study in rural South Africa. *Nutrition,* 27, 55-58.

Van Liere,M.J. & Curtis, V. (2018). How to get consumers to choose fruits, not fries. *Sight & Life,* 32, 113-118.

Vella, M. N., Stratton, L. M., Sheeshka, J., et al. (2013). Exploration of functional food consumption in older adults in relation to food matrices, bioactive ingredients, and health. *J Nutr Gerontol Geriatr,* 32, 122-144.

Venter, C. S., Vorster, H. H., Ochse, R., et al. (2013). "Eat dry beans, split peas, lentils and soya regularly": A food-based dietary guideline. *S Afr J Clin Nutr,* 26, 36-45.

Vorster, H., Wenhold, F., Wright, H., et al. (2013). "7. 'Have milk, maas or yoghurt every day': a food-based dietary guideline for South Africa". *S Afr J Clin Nutr,* 26, S57-S65.

Walsh, C. & van den Berg, L. (2022). The nutritional status of South African adults: A review of the literature published from 1997–2019 (Narrative review based on reference tables). NDoH & DSI-NRF Center of Excellence in Food Security (2022) (eds.). *Foods procured, Nutritional status and Dietary Intake of People Living in South Africa: Desktop review.* Pretoria: National Department of Health, South Africa, 216-229.

WHO. (2018). *Fact sheet: Healthy diet.* Geneva: WHO. [Online]. Available www.who.int/news-room/fact-sheets/detail/healthy-diet [9 March 2019].

WHO. (2021). *Obesity and overweight*. [Online]. Available https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight [6 June 2022].

WHO. (2022). *Noncommunicable diseases progress monitor 2022*. Geneva: WHO. [Online]. Available https://www.who.int/publications/i/item/9789240047761 [17 January 2023].

Zhang, Q., Chen, X., Liu, Z., et al. (2017). Diet diversity and nutritional status among adults in southwest China. *PLoS One,* 12, e0172406.

APPENDICES

Appendix 1: Ethical approval

Appendix 1a: South African Diabetes Prevention Programme study ethics approval

HUMAN RESEARCH ETHICS COMMITTEE

8 February 2023

Prof Andre Kengne
Director: Non-Communicable Diseases Research Unit
SAMRC Cape Town

Dear Prof Kengne

Protocol ID: EC018-7/2015
Protocol title: A randomised evaluation of the South African Diabetes Prevention Programme (SA-DPP)
Meeting date: 25 October 2022

Thank you for your progress report and application for the renewal to the Committee, dated 3 October 2022. The Committee noted the progress report and granted ethics approval for the study for another year.

Please note that the approval is valid for 1 year, i.e. from 25 October 2022 to 24 October 2023. Any changes to the research protocol must be submitted as an amendment. Any adverse events must be reported within 48 hours. Any protocol deviations have to be reported.

Wishing you well with your research.

Yours sincerely

Prof Danie du Toit
Chairperson: SAMRC Human Research Ethics Committee

Members present at the meeting: Prof D du Toit (Chairperson), Ms S Behardien, Adv J Early, Dr H Etheredge, Prof A Kengne, Prof C Lombard, Dr A Loxton, Dr E Nicol, Dr W Zembe

THE SOUTH AFRICAN MEDICAL RESEARCH COUNCIL
Francie Van Zijl Drive, Parowvallei, 7505, Cape Town | Po Box 19070, Tygerberg, 7505, South Africa
Tel: +27 (0)21 938 0687 | Fax: +27 (0)86 685 4023 | Email: adri.labuschagne@mrc.ac.za | Web: www.samrc.ac.za/ethics/ethics.htm

Appendix 1b: Permission letter to use data from the South African Diabetes Prevention Programme study.

Date: 15 October 2019

Dear: University of the Western Cape Higher Degrees Committee

This letter is to verify that (Ms. Samukelisiwe Madlala student no. 3967209), a doctoral student at University of Western Cape School of Public Health and student intern at the South African Medical Research Council (SAMRC) Non-communicable Diseases Research Unit has permission from Prof. Andre P Kengne the principal investigator of the requested data set, to utilize the data obtained for the project titled , "A randomised evaluation of the South African Diabetes Prevention Programme (SA-DPP) in the Western Cape", for the purpose of analysis in her doctoral thesis. Student will be given access to identifiers. The SA-DPP was approved by the ethics committee of the SAMRC (approval no. EC018-7/2015).

SIGNATURE:_____

Prof Andre P Kengne (SA-DPP Principal Investigator)
Director, Non-Communicable Diseases Research Unit, South African Medical Research Council
Address: PO Box 19070, Tygerberg, 7505 South Africa
Tel: +27 21 9380529; Fax: +27 21 9380460
Email: andre.kengne@mrc.ac.za

Appendix 1c: First Ethics approval from the University of the Western Cape

UNIVERSITY of the WESTERN CAPE

OFFICE OF THE DIRECTOR: RESEARCH
RESEARCH AND INNOVATION DIVISION

Private Bag X17, Bellville 7535
South Africa
T: +27 21 959 4111/2948
F: +27 21 959 3170
E: research-ethics@uwc.ac.za
www.uwc.ac.za

05 March 2020

Ms S Madlala
School of Public Health
Faculty of Community and Health Sciences

Ethics Reference Number: BM20/1/1

Project Title: Dietary diversity and its association with nutritional status of adults at risk and the nutrient density and cost of foods available in resource poor communities.

Approval Period: 14 February 2020 – 14 February 2023

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the scientific methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report by 30 November for the duration of the project.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

NHREC REGISTRATION NUMBER -130416-050

Appendix 1d: Second Ethics approval from the University of the Western Cape

UNIVERSITY of the WESTERN CAPE

50 YEARS of hope, action & knowledge

02 October 2020

Ms S Madlala, Prof M Faber, Dr J Hill and Prof E Kunneke
School of Public Health
Faculty of Community of Health Sciences

Ethics Reference Number: BM20/1/1

Project Title: Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods.

Approval Period: 18 September 2020 – 18 September 2023

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the scientific methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report annually by 30 November for the duration of the project.

Permission to conduct the study must be submitted to BMREC for record-keeping.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Director: Research Development
University of the Western Cape
Private Bag X 17
Bellville 7535
Republic of South Africa
Tel: +27 21 959 4111
Email: research-ethics@uwc.ac.za

NHREC Registration Number: BMREC-130416-050

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

Appendix 2: Participant information sheets

Appendix 2a: Participant information sheet (English)

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21 959 2809 Fax: 27 21 959 2872

E-mail: soph-comm@uwc.ac.za

INFORMATION SHEET

Project Title: Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods.

I am a student intern at the South African Medical Research Council (SAMRC), Non-communicable Diseases Research Unit (NCDRU). I am registered for a Doctorate in Public Health in the School of Public Health (SOPH), University of the Western Cape. This research will form part of my doctoral thesis.

What is this study about?

This study is part of larger ongoing study titled "The South African Diabetes Prevention Programme (SA-DPP). This study aims to decrease the risk of people in the community developing diabetes. The SA-DPP study also examines the variety of foods in diets of participants as food plays a major role in health and disease risk of individuals. More knowledge on what are the barriers and facilitators for consuming diverse diets is needed by researchers to develop interventions that assist communities in having access to affordable healthy food so residents can make better choices, consume a healthy diverse diet and improve their health. The purpose of this study is to explore and describe the barriers facilitators for consuming a diverse diet in resource -poor communities around Cape Town.

What information will we be collecting?

You will be asked to complete a short questionnaire and participate in a focus group discussion with other members of your community.

What will I be asked to do if I agree to participate?

The questionnaire asks several questions on food purchasing, who buys food at home, and the types of food you buy at food stores. The questionnaire will take approximately 5-10 minutes to complete. After completing the questionnaire, you will participate in a focus group discussion where you will be asked to give your views on what you think are the barriers and facilitators for consuming a diverse diet. The focus group discussion will take 90 minutes to complete.

Would my participation in this study be kept confidential?

Information collected will be strictly confidential your name, answers and comments will not be identifiable on the published reports. Concerning the focus group discussion, the researcher will do the following to ensure anonymity, (1) your name will not be included on the focus group discussion recordings and transcripts; instead, a (2) a code will be placed on the transcripts. To ensure your

confidentiality, the transcription from the discussion will be kept on a password-protected computer and the recording will be deleted from the recording device and the computer. If we write a report or article about this research project, your identity will be protected.

Your participation in this research is completely voluntary. You may choose not to take part at all. You can withdraw from the study at any time without any negative consequences. If you decide to participate in this research, you may stop participating at any time. By accepting to take part you will be asked to answer the questions honestly.

What are the risks of this research?

There are no risks of participating in the study. If, however during the focus group discussion you feel uncomfortable with answering any question you can chose not to say anything.

What are the benefits of this research?

This research is not designed to help you personally, but the results may help researchers understand challenges that people face for consuming a variety of foods. The results of this study will be used to design a pamphlet that will help you and members of your community to identify affordable nutrient rich foods that enable you to consume a diverse diet and therefore make healthier choices and prevent risk of diabetes.

As a token of appreciation, you will receive R50 for your time.

What if I have questions?

This research is being conducted by Samukelisiwe Madlala at the School of Public Health at the University of the Western Cape. If you have any questions about the research study itself, please contact Samukelisiwe Madlala at: P.O. Box 19070, Tygerberg. 7505, Tel; 0728717352 email: Samukelisiwe.Madlala@mrc.ac.za or 3967209@myuwc.ac.za. Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:

Prof Uta Lehmann

Head of Department: School of Public Health

University of the Western Cape

Private Bag X17

Bellville 7535

ulehmann@uwc.ac.za

Prof Anthea Rhoda

Dean: Faculty of Community and Health Sciences

University of the Western Cape

Private Bag X17

Bellville 7535

chs-deansoffice@uwc.ac.za

This research has been approved by the University of the Western Cape's Biomedical Research Ethics Committee.

Biomedical Research Ethics Committee

University of the Western Cape

Private Bag X17

Bellville

7535

Tel: 021 959 4111

e-mail: research-ethics@uwc.ac.za

Appendix 2b: Participant information sheet (Afrikaans)

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21 959 2809 Fax: 27 21 959 2872

E-mail: soph-comm@uwc.ac.za

DEELNEMER INFORMASIE VORM

Projek titel: Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods.

Ek is 'n internskap student by die Suid Afrikaanse Mediese Navorsingraad (SAMRC), Navorsingseenheid vir Nie-oordraagbare siektes **(**NCDRU). Ek is geregistreer vir 'n Doktoraat in Pubieke Gesondheid by die Skool van Publieke Gesondheid (SOPH**),** Universiteit van Wes Kaap-land. Hierdie navorsing vorm deel van my doktorale tesis.

Waaroor handel die studie?

Hierdie studie is deel van 'n groter studie getiteld: "Die Suid Afrikaanse Diabetes Voorkomingsprogram" (SA-DVP). Hierdie studie het ten doel om die risiko vir die ontwikkeling van diabetes in die gemeenskap te verminder. Die SA-DVP studie beoog om ook die verskeindenheid van voedsels te ondersoek in die diete van die respondente aangesien voedsel 'n baie groot rol speel in die gesondheid en siekte risiko van individue. Meer kennis omtrent die hindernisse en fasiliteerders in die inname van 'n diverse dieet word benodig deur navorsers om intervensies te ontwikkel wat die gemeenskap sal ondersteun om beter keuses te maak in terme van 'n meer diverse dieet en verbetering in gesondheid. Die doel van die studie is om die hindernisse en fasiliteerders in die inname van 'n diverse dieet te ondersoek in gemeenskappe met swak hulpbonne rondom Kaapstad.

Watter inligting word ingesamel?

U sal gevra word om 'n kort vraelys in te vul en 'n fokus groepbespreking met ander persone in u gemeenskap.

Wat sal ek gevra word om te doen as ek instem om deel te neem?

Die vraelys sal u vra u verskeie vrae gevra word omtrent voedselaankope – wie koop die voedsel by die huis en die tipe voedsel wat aangekoop word in die winkels. Die vraelys sal 5- 10 minute neem om te voltooi. Na afhandeling van die vraelys sal u gevra word om deel te neem aan 'n fokus groepbespreking waar u gevra sal word om u opinie te gee omtrent die hindernisse en fasiliteerders in die inname van 'n diverse dieet. Die fokus groepbespreking sal 1.5 ure neem om af te handel.

Sal my deelname aan die studie konfidensieel gehou word?

Informasie wat ingesamel word sal streng konfidensieel gehou word. U naam, antwoorde en kommentaar sal nie identifiseerbaar wees op die gepubliseerde verslae nie. Wat betref die fokus groepbespreking sal die navorser die volgende doen om annonimiteit te verseker (1) U naam sal nie ingesluit word in die vraelys, klankopnames en transkripsies nie; (2) 'n kode sal eerder gebruik word

op al die transkripsies. Om konfidensialiteit te verseker sal die transkripsie in ‘n wagwoord beskermde rekenaar gestoor word en die klankopname sal afgevee word van die klankopnemer en die rekenaar. As ons ‘n verslag of artikel skryf aangaande die navorsingprojek sal u identiteit beskerm word.

U deelname aan die navorsing is heeltemal vrywillig. U mag kies om glad nie deel te neem nie. U mag ook ontrek aan die studie op enige tydstip sonder enige negatiewe konsekwensies. Indien u besluit om deel te neem mag u op enige tydstip deelname ontrek. Deur deelname te aanvaar sal van u verwag word om die vrae eerlik te beantwoord.

Wat is die risiko verbonde aan die navorsing?

Daar is geen risiko verbonde in die deelname aan die studie nie. Indien u ongemaklik voel met die beantwoording van vrae kan u kies om so te se.

Wat is die voordele van die navorsing?

Hierdie navorsing is nie bedoel om u persoonlik te bevoordeel nie, maar die resultate mag navorsers help om die uitdagings te verstaan om ‘n verskeindenheid van voedselsoorte in te neem. Die resultate van die studie sal gebruik word om ‘n pamflet te ontwerp wat deur u self en ander mense in die gemeenskap gebruik kan word om bekostigbare, nutrientryke voedsels te identifiseer wat gebruik kan word om ‘n meer diverse dieet in te neem wat gesonder keuses insluit om die risiko vir diabetes te voorkom.

As ‘n blyk van waardering sal u R 50 ontvang vir u tyd.

Indien u enige vrae het?

Hierdie navorsing word gedoen deur Samukelisiwe Madlala die Skool van Publieke Gesondheid (SOPH**),** Universiteit van Wes-Kaapland. Indien U enige vrae het omtrent die navorsingstudie, kontak Samukelisiwe Madlala by P.O. Box 19070, Tygerberg, 7505, Tel: 0728717352, E-mail: Samukelisiwe.Madlala@mrc.ac.za of 3967209@myuwc.ac.za. Indien u enige vrae het oor die studie en u regte as as emand wat aan die studie deelgeneem het, of om enige problem te raporteer aangaan die studie, kontak asseblief

Prof Uta Lehmann

Direkteur: Skool van Publieke Gesondheid

Universiteit van Wes-Kaapland

Privaatsak X17

Bellville 7535

ulehmann@uwc.ac.za

Prof Anthea Rhoda

Dekaan van die Fakulteit Gemeenskap en Gesondheidswetenskappe

Universiteit van die Wes Kaap

Privaatsak X17

Bellville 7535

chs-deansoffice@uwc.ac.za

Hierdie navorsing is goedgekeur deur die Universiteit van Wes-Kaapland se Biomediese Navorsingsetiekkomitee.

Biomediese Navorsingsetiekkomitee

Universiteit van Wes-Kaapland

Privaatsak X17

Bellville

7535

Tel: 021 959 4111

e-pos: research-ethics@uwc.ac.za

Appendix 2c: Participant information sheet (IsiXhosa)

UNIVERSITY OF THE WESTERN CAPE

Private Bag X 17, Bellville 7535, South Africa

Tel: +27 21 959 2809 Fax: 27 21-959 2872

E-mail: soph-comm@uwc.ac.za

UXWEBHU LOLWAZI LOMTHATHI NXAXHEBA

Intloko yophando: Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods.

Ndingumfundi oncedisayo eSAMRC kwindawo yezifo ezingathethwayo. Ndibhalisele ubucwephesha kwezempilo yoluntu jikelele kwidyunivesithi yaseNtshona Koloni. Olu phando luzakwenza isiqendu ssezifundo zam.

Lungantoni uphando?

Olu phando luyinxalenye lophando olukhulu oluqhubekayo olubizwa ngokuba "South African Diabetes Prevention Programme (SA-DPP) ngamafutshane. Olu phando injongo zalo kukuhlisa imngcipheko wokufumana kwabantu ekuhlaleni iswekile. Uphando iSA-DPP luxilonga iindidi zokutya zabathathi nxaxheba njengoko ukutya kudlala indima ebalulekileyo kwezempilo nongcipheko lwezifo kumntu ngamnye. Ulwazi olubanzi lokwazi zintoni izithinteli kunye neziphembeleli zokutya indidi ezahlukeneyo zokutya luyadingeka kubaphandi ukuphuhlisa ungenelelo oluzakunceda iingingqi zikwazi ukufikelela ekutyeni okusempilweni ukuze abahlali benze ukhetho olungcono, batye ukutya okusempilweni okwahlukeneyo ukuphuhliso impilo yabo. Injongo yoluphando kukujonga yaya lucacise izithinteli neziphembeleli zokutya indidi ezahlukeneyo zokutya kwingingqi ezihluphekileyo jikelele eNtshona Koloni.

Loluphi ulwazi esizakube siluqokelela?

Uzakucelwa ukuba uthathe inxaxheba kudliwano ndlebe lobuso-ngobuso yaye uthathe inxaxheba kwingxoxo zeqembu kunye namanye amalungu asengingqini yakho.

Yintoni endizakucelwa ndiyenze ukuba ndiyavuma ukuthatha inxaxheba?

Iphepha lemibuzo liza kukubuza imibuzo malunga nokuthenga ukutya, nokuba ngubani othenga ukutya ekhayeni lakho, yaye zeziphi iindidi zokutya enizithengayo kwivenkile zokutya. Iphepha lemibuzo e iya kuthatha imizuzu emi-5 ukuya kweli-10 ukuyigqiba. Emva kokugqiba kwakho iphepha lemibuzo uza kuthatha inxaxheba kwingxoxo yeqela apho uya kucelwa ukuba unikwe izimvo zakho malunga nokuba ucinga ukuba zeziphi izinto ezizithintela ukutya ngendlela ezahlukeneyo. Ingxoxo yeqela ekugxilwe kulo iya kuthatha malunga neeyure ezili 1.5 ukuligqiba.

Ingaba ukuthatha inxaxheba kwam kolu phando kuya kugcinwa kuyimfihlo?

Ulwazi oluqokelelweyo luya kuba yimfihlo igama lakho, iimpendulo kunye nezimvo aziyi kuchazwa kwingxelo ezipapashiweyo. Ngokuphathelele kwingxoxo yeqela ekugxilwe kulo, umphandi uyakwenza oku kulandelayo, [1] igama lakho aliyi kubandakanywa kwiirekhodi zeengxoxo ezigxilwe kwiqela nasekuprintweni ; [2] kuya kubekwa ikhowudi endaweni yokukhuphela. Ukuqinisekisa imfihlelo yesazisi sakho, ukukhutshelwa kwengxoxo kuya kugcinwa kwikhompuyutha ekhuselekileyo kunye negama elishicilweleyo licinywe kwisixhobo sokurekhoda kunye nakwi khompuyutha .Ukuba sibhala ingxelo okanye inqaku malunga nale projekthi yophando, isazisi sakho siya kukhuselwa.

Ukuthabatha kwakho inxaxheba koluphando kukuzithandela. Unokukhetha ukungathathi nxaxheba. Unokurhoxa esifundweni nangaliphi na ixesha ngaphandle kweziphumo ezimbi. Ukuba uthatha isigqibo sokuthatha inxaxheba kolu phando, unokuyeka nangaliphi na ixesha ufuna. Ngokuvuma kwakho ukuthatha inxaxheba uyakucelwa ukuba uphendule imibuzo ngokunyaniseka .

Ingaba bukhona na ubungozi koluphando?

Akukho bungozi ngokuthatha inxaxheba koluphando.Ukuba nangona kunjalo ngexesha kwingxoxo zeqembu uziva ungakhululekanga ngokuphendula nawuphi na umbuzo unokukhetha ukungaphenduli .

Zithini izibonelelo zolu phando?

Oluphando alwenzelwanga ukunceda wena kodwa iziphumo zinokunceda abaphandi baqonde imiceli mngeni abajongana nayo abantu xa besitya iintlobo ezahlukeneyo zokutya .Iziphumo zoluphando ziya kusetyenziselwa ukuyilwa kwencadwana ezakunceda wena kunye namalungu oluntu lwakho ukuba nifumane ukutya okunesondlo okunukukunceda ukuba utye ukutya okwahlukeneyo kwaye ke wenze ukhetho olunempilo kwaye untintele umngcipheko wesifo seswekile.

Njengophawu lokukuxabisa kwethu uyakufumana intlawulo engange R50 ngexesha lakho.

Ndingathetha nabani ukuba ndinombuzo okanye ingxaki ngoluphando

Olu phando luqhutywa ngu-Samukelisiwe Madlala kwiSikolo seMpilo yoLuntu kwiYunivesithi yeNtshona Kapa. Ukuba unayo nayiphi na imibuzo malunga nesifundo ngokwayo, nceda tsalela uSamukelisiwe Madlala ku: P.O. Ibhokisi le-19070, iTygerberg. I-7505, umnxeba; 0728717352 i-imeyile: Samukelisiwe.Madlala@mrc.ac.za okanye 3967209@myuwc.ac.za. Ungaba unemibuzo malunga nolu phononongo kunye namalungelo akho njengomthathi-nxaxheba ophando okanye ukuba unqwenela ukunika ingxelo naziphi na iingxaki onazo. funda, nceda unxibelelane:

Prof Uta Lehmann

Head of Department: School of Public Health

University of the Western Cape

Private Bag X17

Bellville 7535

ulehmann@uwc.ac.za

Prof Anthea Rhoda

Dean: Faculty of Community and Health Sciences

University of the Western Cape

Private Bag X17

Bellville 7535

chs-deansoffice@uwc.ac.za

Oluphando lupasiswe sisigqeba sekomiti yophando IYunivesithi yaseNtshona Koloni kunye nekomiti yezemigomo Biomedical.

Biomedical Research Ethics Committee

University of the Western Cape

Private Bag X17

Bellville

7535

Tel: 021 959 4111

e-mail: research-ethics@uwc.ac.za

Appendix 3: Participant consent forms

Appendix 3a: Participant consent form (English)

UNIVERSITY OF THE WESTERN CAPE
Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21 959 2809 Fax: 27 21-959 2872
E-mail: soph-comm@uwc.ac.za

CONSENT FORM

Title of Research Project: Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods**.**

I understand that the researcher will ensure that my name will not be included on the questionnaire, recordings and notes taken during the focus group discussion instead a code will be used to identify me. I understand that the notes made from the focus group discussion will be kept on a password-protected computer and the recording will be deleted from the recording device and the computer as soon as the research is complete. I also understand that if a report is written about this research project, my identity will be protected.

Please tick only one below

☐ I agree to be **audiotaped** during my participation in this study.

☐ I do not agree to be **audiotaped** during my participation in this study.

Signed at: _____ on (date) _____

Name of participant _____ Signature of participant _____

Signed at: _____ on (date) _____

Name of investigator _____ Signature of investigator _____

Biomedical Research Ethics Committee
University of the Western Cape
Private Bag X17
Bellville
7535
Tel: 021 959 4111
E-mail: research-ethics@uwc.ac.za

Appendix 3b: Participant consent form (Afrikaans)

UNIVERSITY OF THE WESTERN CAPE
Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2809 Fax: 27 21-959 2872
E-mail: soph-comm@uwc.ac.za

DEELNEMER INFORMASIE VORM

Projek titel: Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods.

Ek verstaan dat die navorser sal verseker dat my naam nie ingesluit sal word by die vraelys, klankopnames en notas wat geneem word gedurende die fokus groepbespreking nie, maar dat 'n kode in plek daarvan gebruik sal word om my te identifiseer. Ek verstaan dat die notas wat gemaak word gedurende die fokusgroepbespreking geberg sal word op 'n wagwoord-beskermde rekenaar en dat die klankopname afgevee sal word van die klankopname masjien en die rekenaar sodra die navorsing voltooi is. Ek verstaan ook dat indien 'n verslag geskryf word oor die navorsing, my identitiet beskerm sal word.

Tik asseblief slegs een blok hieronder:

☐ Ek stem in om opgeneem te word met 'n klankopnemer gedurende my deelname aan die studie.

☐ Ek stem nie in om met 'n klankopnemerr opgeneem te word gedurende my deelname aan die studie nie.

Geteken te : _____ op (datum) _____

Deelnemer se naam _____ Deelnemer se handtekening _____

Geteken te: _____ op (datum) _____

Naam van navorser _____ Handtekening van navorser _____

Biomediese Navorsingsetiekkomitee
Universiteit van Wes-Kaapland
Privaatsak X17
Bellville
7535
Tel: 021 959 4111
e-pos: research-ethics@uwc.ac.za

Appendix 3c: Participant consent form (IsiXhosa)

UNIVERSITY OF THE WESTERN CAPE
Private Bag X 17, Bellville 7535, South Africa
Tel: +27 21-959 2809 Fax: 27 21-959 2872
E-mail: soph-comm@uwc.ac.za

IFOMU YESIVUMELWANO

Intloko yophando: Dietary diversity and its association with nutritional status of adults at risk of diabetes and the nutrient density and cost of foods.

Ndiyaqonda ukuba umphandi uya kuqinisesekisa ukuba igama lam aliyi kufakwa kwiphepha lemibuzo, kwiirekhodi kunye namanqaku athathwe ngexesha lengxoxo yeqela ekugxilwe kulo, endaweni yoko kuya kusetyenziswa ikhowudi yokundazisa. Ndiyaqonda ukuba amanqaku awenziwe kwingxoxo yeqela aza kugcinwa kwikhompuyutha ekhuselwe ngenombolo yokuvula kwaye ukurekhodwa kuya kucinywa kwisixhobo sokurekhoda kunye nekhompuyutha kwangoko nje kwakugqitywa uphando. Ndiyaqonda ukuba ingxelo ebhaliweyo malunga nale projekthi yophando, isazisi sam siyakukhuselwa.

Nceda phawula kuphela apha ngezantsi

☐ Ndiyavumelana nolu dliwanondlebe ukuba lushicilelwe.

☐ Andivumelani nolu dliwanondlebe ukuba lushicilelwe.

Isayinwe e:	_____	nge (umhla)	_____
Igama lomthathi-nxaxheba	_____	Umsayino womthathi-nxaxheba	_____
Isayinwe e:	_____	nge (umhla)	_____
Igama lomphandi	_____	Umsayino womphandi	_____

Biomedical Research Ethics Committee
University of the Western Cape
Private Bag X17
Bellville
7535
Tel: 021 959 4111
E-mail: research-ethics@uwc.ac.za

Appendix 4: Manuscript: Scoping review protocol

Open access Protocol

BMJ Open

Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review protocol

Samukelisiwe Sthokozisiwe Madlala ,[1,2] Jillian Hill,[1] Ernesta Kunneke,[3] Mieke Faber[1,3]

To cite: Madlala SS, Hill J, Kunneke E, *et al*. Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review protocol. *BMJ Open* 2021;**11**:e044904. doi:10.1136/bmjopen-2020-044904

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-044904).

Received 17 September 2020
Accepted 28 July 2021

[1]Non-Communicable Diseases Research Unit, South African Medical Research Council, Cape Town, South Africa
[2]School of Public Health, Faculty of Community and Health Sciences, University of the Western Cape, Cape Town, South Africa
[3]Department of Dietetics and Nutrition, University of the Western Cape, Cape Town, South Africa

Correspondence to
Samukelisiwe Sthokozisiwe Madlala;
samukelisiwe.madlala@mrc.ac.za

ABSTRACT

Introduction The local retail food environment influences dietary patterns and food choices, as suggested in the literature. The lack of access to healthy food within this environment may result in unhealthy food choices which may lead to obesity and the development of non-communicable diseases. Evidence suggests that resource-poor communities may have unhealthy food environments, therefore, preventing residents from making healthy food choices. A systematic scoping review will be conducted to provide an overview of the evidence on adult food choices in association with the local retail food environment and food access in resource-poor communities.

Methods and analysis This protocol for the scoping review was developed following the Preferred Reporting Items for Systematic reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines and the framework process by Arksey and O'Malley. Observational studies, published from July 2005 to January 2021, will be searched and screened. Keywords and medical subject headings (MeSH) terms will be used to search several multidisciplinary databases. Two independent reviewers will screen identified articles using the selection criteria and extract data using the PRISMA-ScR checklist. Descriptive numerical and thematic analysis will be performed to evaluate and categorise quantitative and qualitative data.

Ethics and dissemination Ethical approval will not be required for the review, as data from published studies will be used. The results of this scoping review will form part of a PhD thesis that will be submitted to the University of the Western Cape, South Africa. The review findings will also be presented at conferences and published in a peer-reviewed journal.

Open science framework registration number https://osf.io/shf93.

Strengths and limitations of this study

- ► The findings will provide insight on how the retail food environment plays a role in determining healthy food access and identify the barriers, enablers and mediators of food access which affect food choices of adults in resource-poor communities.
- ► Several multidisciplinary databases will be used in the search, as the food environment topic is extensive.
- ► In this systematic approach, findings from a body of knowledge that is heterogeneous in terms of methods and discipline will be summarised.
- ► Only studies published in English will be included.
- ► There will be no formal appraisal done which means possibility of inclusion of methodologically inferior studies. However, to reduce number of poor-quality studies included, only peer-reviewed and published studies will be included.

INTRODUCTION

Malnutrition in the form of overweight, obesity and underweight is the leading cause of disease globally.[1] Dietary-related disease risk is determined by food choices and dietary consumption.[2] Food choices are defined as foods selected and consumed based on an individual's decision which is influenced by a combination of individual, environmental and economic factors.[3] Food choices are also a result of the relationship between individual factors and the food environment.[4] Glanz *et al* distinguish two types of environments that influence access to healthy food to make healthy food choices. These environments are namely the community nutrition environment (types and location of food stores and accessibility in each community), and the consumer nutrition environment (the availability of healthy and unhealthy food choices within any establishment where food is sold or served, ie, restaurant, school or work cafeteria, price, promotion and placement of food choices).[5] The food environment is also referred to as the local food environment. The retail food environment combines the physical proximity to food store locations, the distribution of food stores and markets at a community level, and consumer access to healthy affordable foods at food stores or markets.[6] The community and the consumer

nutrition environment, the interest topics of this study, will be referred to as the local retail food environment.

The local retail food environment is an important determinant of food choices and may influence individual, family and population-level health.[7] Furthermore, it may influence dietary patterns and food choices.[7 8] The lack of access to healthy food within this environment may result in unhealthy food choices, which may lead to obesity and the development of non-communicable diseases (NCDs) such as cancers, cardiovascular diseases and type 2 diabetes mellitus.[8–10] The local retail food environment is also a determining factor for food access.[7]

Food access relates to the physical and economic access to food.[11] Access to food means that it must be physically procured by individuals and be economically accessible. Thus, people can afford to buy the food that is available in the local retail food environment, and in adequate amounts.[11] Access to food consists of several components. Examples are quantity (sufficient amounts of food), quality (nutritionally balanced food), safety (food that is devoid of harmful substances and can impact health), and culturally acceptable and preferable foods (those that support traditional or preferred diets).[12] Therefore, access to food affects food choices.

Food access in the local retail food environment is dependent on the spatial proximity of food stores, affordability, cultural appropriateness and healthiness of foods available.[13] Lack of access to healthy food such as fresh fruits and vegetables is often seen in low-income communities.[13–19] Communities with limited healthy foods available to residents are known as 'food desert' areas.[20 21] Many resource-poor communities have a large number of fast-food restaurants, liquor stores and convenience stores supplying cheap, processed nutrient-poor foods.[22] It therefore follows that people with low incomes may have poor food choices that include cheap, energy-nutrient dense and nutrient-deficient foods. Low-income individuals living in food deserts are at a greater risk of developing NCDs in comparison to individuals in high-resource communities.[17 18 20 23 24] Increasing access to affordable and healthy food in resource-poor communities is therefore important.

STUDY RATIONALE

The rise in interest in the food environment can be attributed to the demand to improve dietary, nutritional and health outcomes.[25] The food environment is an important approach for implementing interventions that support healthy diets and address malnutrition as this is where consumers make decisions on what food to buy and consume.[26] Retail food environments influence the type of food purchased and consumed.[5] The accessibility of healthy food in the retail food environment enables people to have better quality diets with fruit and vegetables, and therefore better health outcomes. There are many intervention strategies used to improve access to food in urban and rural communities; these include increasing the number of chain supermarkets in food deserts, increasing the number and supporting farmers markets, establishing community gardens, increasing the price of unhealthy food and serving healthier convenience foods.[13 21 27 28]

While there are interventions to improve access to food in urban and rural communities, many people are still struggling to purchase and consume healthy food.[13 21 27 28] Healthy food access is important for enhancing the economy and improving community health. To address the healthy food access issue in communities, it is necessary understanding the role of the local retail food environment in enabling or hindering resource-poor community residents' access to healthy food for making better food choices. Past reviews conducted on the food environment have focused on associations between school food environments and children's diet[29 30] child weight status,[31] food environment in high-income countries[32] and low-income and middle-income countries.[25] The majority of literature to date has also focused on the food environment and overweight/obesity and physical activity and not given much attention to dietary outcomes more especially food choices. To our knowledge, this will be the first review to examine the association of the local retail food environment and food access on the food choices of adults. It is important to understand the relationship between the local retail food environment and food access and adult food choices so that appropriate interventions can be created to prevent NCDs in adult population residing in resource-poor communitites. The aim of the scoping review is to gain an understanding of what is the association between adult food choices and the factors that determine healthy food access in the local retail food environment of resource-poor communities.

The objectives are to:

1. assess whether adult food choices are associated with the local retail food environment in resource-poor communities; and
2. determine the barriers and facilitators for healthy food access in resource-poor communities.

METHODS AND ANALYSIS

Protocol structure

The protocol was developed following the framework described by Arksey and O'Malley.[33] The framework includes five stages namely (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) charting the data and (5) collating, summarising and reporting the results.[33] The final protocol was registered with the Open Science Framework on 9 September 2020 (https://osf.io/shf93).

Step 1: identifying research questions

The population, concept and context (PCC) search strategy was used for the development of the research questions.[34] This search strategy will enable the

Table 1 Literature search strategy

Concept	MeSH terms/Keywords
Diet/food choice	*MeSH terms:* Diet, healthy OR Diet western OR Diet high fat *Keywords:* Food choice OR food behaviours OR adult OR food OR fruit OR vegetable OR nutrition OR processed food OR salty food OR fatty foods OR sugar-sweetened beverages OR fast food OR street food.
Local retail food environment	*Keywords:* Food environment OR nutrition environment OR Local retail food environment OR neighbourhood OR consumer nutrition environment OR community nutrition environment OR food desert OR food swamp
Resource poor	*MeSH terms:* Low income OR low-income population OR poverty. *Keywords:* Low income OR low socio-economic status OR disadvantaged OR resource poor OR poor OR deprived
Food access	*MeSH terms*: Food deserts OR Food security. *Keywords:* Food access OR food availability OR food cost OR food affordability OR food price OR food quality
Store type	*Keywords:* Food store OR supermarket OR grocery store OR convenience store OR corner store OR fast food OR restaurant OR street vendor

MeSH, medical subject headings.

identification of relevant studies to meet the aim of the scoping review.[35] For this scoping review, the population is male and female adults, the concept is food choices and the context is the local retail food environment and food access in resource-poor settings. To understand the association between food choices and the food environment and food access, the following research questions will be used to guide the search strategy.

- What is the association between adult food choices and the local retail food environment in resource-poor communities?
- Does food accessible in the local retail food environment influence healthy food choices?
- What characteristics of the local retail food environment enable food access or limit food access?

Step 2: identifying relevant studies

A search on published literature will be conducted using the following databases, PubMed/Medline, CINAHL, EBSCOhost, Green FILE, PsycARTICLES, Social Science Research Network, Scopus, Science Direct and Web of Science. Table 1 presents a summary of the search keywords or medical subject headings (MeSH) terms that will be used. The Boolean (AND, OR) method will be used to combine search terms. The original search strategy was developed in PubMed and will be adapted to the other databases. The PubMed search strategy is presented in table 2. A reference list of bibliographies of studies found will be checked for additional sources.

Step 3: study selection

Eligibility criteria will be used to ensure that the studies included in the scoping review are relevant to the research questions.

Inclusion criteria

- Observational studies (ie, cohort, cross-sectional, case-control and ecological studies) reporting on the association between adult food choices (outcome)

Table 2 Electronic search record of PubMed database

Date	Keyword searched	Database used	Number of publications retrieved
02 February 2021	((((Food choice[Title/Abstract] OR food behaviours[Title/Abstract] OR adult[Title/Abstract] OR food[Title/Abstract] OR fruit[Title/Abstract] OR vegetable[Title/Abstract] OR diet[Title/Abstract] OR nutrition[Title/Abstract] OR processed food[Title/Abstract] OR salty food[Title/Abstract] OR fatty foods[Title/Abstract] OR sugar-sweetened beverages[Title/Abstract] OR fast food[Title/Abstract] OR street food.[Title/Abstract]) AND (Food environment[Title/Abstract] OR nutrition environment[Title/Abstract] OR Local retail food environment[Title/Abstract] OR neighbourhood[Title/Abstract] OR consumer nutrition environment[Title/Abstract] OR community nutrition environment[Title/Abstract] OR food desert[Title/Abstract] OR food swamp[Title/Abstract])) AND (Low income[Title/Abstract] OR low socio-economic status[Title/Abstract] OR disadvantaged[Title/Abstract] OR resource poor[Title/Abstract] OR poor[Title/Abstract] OR poverty[Title/Abstract] OR deprived[Title/Abstract])) AND (Food access[Title/Abstract] OR food availability[Title/Abstract] OR food cost[Title/Abstract] OR food affordability[Title/Abstract] OR food price[Title/Abstract] OR food quality[Title/Abstract])) AND (Food store[Title/Abstract] OR supermarket[Title/Abstract] OR grocery store[Title/Abstract] OR convenience store[Title/Abstract] OR corner store[Title/Abstract] OR fast food[Title/Abstract] OR restaurant[Title/Abstract] OR street vendor[Title/Abstract]) Filters applied: Results by year 2005–2021	PubMed	69

and the local retail food environment and food access (exposures) in resource-poor communities.
- Empirical and theoretical studies.
- Studies including adults 18–65 years old.
- Studies on the food environment outside the home environment but within the retail food environment, which is the community and the consumer food environment.
- Studies on food access, food choices and diets of adults in resource-poor communities.
- English peer-reviewed journal articles from July 2005 to January 2021.

Exclusion criteria

- Experimental studies (randomised controlled trials), systematic reviews and meta-analysis.
- Research not reported in peer-reviewed journals, studies discussing organisational food environment (home, school and work) and information environment (television advertising).
- Studies on children, pregnant women and the elderly.
- Studies that only focus on the food environment and nutritional status.
- Studies that focus on indirect measures of diet, such as food purchasing or the number of trips to food stores.
- Papers written in another language besides English and research papers published before July 2005 will be excluded from the study.

Eligible articles will be uploaded into EndnoteX9 library, and duplicates identified and removed. Two levels will be followed when screening articles. Level one involves two reviewers screening the title and abstracts (TIABS) of searched articles to identify eligible ones. In level two, the two reviewers will read the full-text articles to determine whether they meet the eligibility criteria. Both levels of screening will be performed on the Rayyan Qatar Computing Research Institute (QCRI) systematic reviews web application.[36] A third reviewer will be consulted should there be any disagreement on full-text articles to reach a consensus. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist will be used to guide the selection process.[37] The study selection process is presented in the PRISMA flow diagram (see figure 1).[38]

Step 4: charting the data

The PCC format will be used to guide the data extraction. A data charting form, as per the framework of Arksey and O'Malley,[33] will be developed to extract data from studies included (see table 3). The data extraction form will be piloted by two reviewers on 10% of the sample of included studies.[39] This will be done to ensure that reviewers understand the data collection procedure and whether all relevant information is correctly captured. The data extraction form will be revised should the reviewers decide that relevant items are not adequately captured. Inter-rater reliability will be attained by comparing 20% of the sample of independently screened papers by the two reviewers.[39] Disagreements will be discussed by the two reviewers to reach consensus or through consulting a third reviewer.

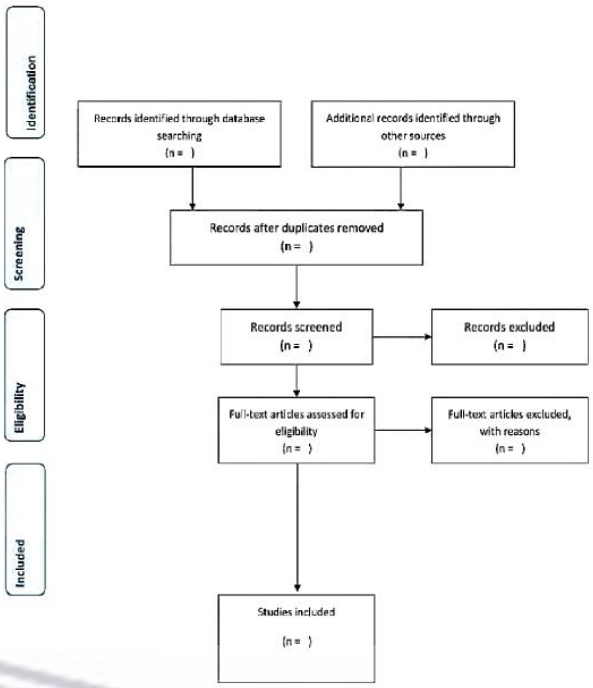


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analysis flow diagram for the scoping review process.

Reducing bias

Eligibility criteria will be used to reduce selection bias. Two reviewers will review eligible studies and this will reduce error and increase reliability of the findings of the scoping review. Methods to reduce bias are presented in table 4. A systematic approach will be followed when reviewing the research evidence to ensure the relevance and validity of results. By including different types of evidence or data sources, such as quantitative or qualitative research, expert opinion and policy documents, heterogeneity will be ensured.[35]

Step 5: collating, summarising and reporting results

The process of collating, summarising and reporting results will follow three steps as recommended by Levac *et al*.[35] In the first step, a descriptive numerical summary for quantitative studies and thematic analysis for qualitative studies will be done. The descriptive numerical summary will state the number of studies included, types of study design, year of publication, characteristics of populations and the countries where the studies were done. With regards to the qualitative analysis, descriptive themes will be developed by categorising ideas by topic/concept. In the second step, the results and outcome of the study

Table 3 Data extraction form

1. Authors		
2. Title of study		
3. Year of publication		
4. Aim/objective of the study		
5.Study setting (location/ country)		
6. Study participants (number, age, gender and ethnicity)		
7. Sampling method		
8. Study design/publication type	Cross-sectional:☐	Cohort☐
	Case-control☐	Others
9. Data collection method	Quantitative☐	Mixed method☐
	Qualitative☐	Other
10. Data analysis		
11. Reported outcomes	Study findings relevant to study objectives.	
12. Most relative findings	Findings as relates to food choices and healthy diet measured by fruit and vegetable intake, various food group intake, intake of salty and fatty foods, sugar-sweetened beverage intake, fast-food intake, diet quality, energy and micronutrient intake and healthy diet score vs unhealthy diet scores.[30]	
13. Facilitators	Describe the factors that enable healthy food choices and food access in the local retail food environment.	
14. Barriers	Describe the factors that hinder healthy food choices and food access in the local retail food environment.	

in relation to the aim of the research question will be discussed. The third step involves reporting the implications of the findings in terms of future research, practice and policy.[34]

Table 4 Types of bias and resolution

Bias	Resolution
Selection bias	► Clear definition of exposure and outcomes in the inclusion and exclusion criteria. ► Two reviewers will independently screen TIABS and full text articles and extract data to reduce bias. ► Inter-rater reliability will be assessed to reduce bias. ► The Rayyan software will be used for screening TIABS and full text articles. This software allows for 'blind screening' among reviewers, this will reduce bias.
Publishing bias	All research findings whether positive or negative will be reported in the findings.
Language bias	Only English articles were selected. Literature states that excluding non-English studies does not impact outcomes of most reviews.

Patient and public involvement

There was no patient or public involvement in the design of this protocol.

ETHICS AND DISSEMINATION

Ethical approval will not be required for the review, as data from published studies will be used for the analysis. The results of this scoping review will form part of a PhD thesis that will be submitted to the University of the Western Cape. The review findings will also be presented at conferences and published in a peer-reviewed journal.

Contributors SSM and MF conceived the idea and developed the research questions and methods for the protocol. SSM was responsible for drafting the manuscript. MF supervised the writing of the protocol. MF, JH and EK critically revised the manuscript for its methodological and scientific content. All authors approved the final version of the manuscript.

Funding The work reported herein was made possible through funding by the South African Medical Research Council through its Division of Research Capacity Development under the Internship Scholarship Programme from funding received from the South African National Treasury (grant/award number :N/A).

Disclaimer The views expressed are those of the authors and not necessarily those of the South African Medical Research Council.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

ORCID iD

Samukelisiwe Sthokozisiwe Madlala http://orcid.org/0000-0002-7715-2147

REFERENCES

1 Swinburn BA, Kraak VI, Allender S, *et al*. The global syndemic of obesity, undernutrition, and climate change: the Lancet Commission report. *Lancet* 2019;393:791–846.
2 Lytle L, Myers A. *Measures registry user guide: food environment*. Washington (DC): National Collaborative on Childhood Obesity Research, 2017. http://nccor.org/tools-mruserguides/wp content/uploads/2017/NCCOR_MR_User_Guide_Food_Environment-FINAL.pdf
3 Buttriss J, Stanner S, McKevith B, *et al*. Successful ways to modify food choice: lessons from the literature. *Nutr Bulletin* 2004;29:333–43.
4 Herforth A, Ahmed S. The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. *Food Security* 2015;7:505–20.
5 Glanz K, Sallis JF, Saelens BE, *et al*. Healthy nutrition environments: concepts and measures. *Am J Health Promot* 2005;19:330–3.
6 Centers for Disease Control and Prevention (CDC). General food environment resources, 2014. Available: http://www.cdc.gov/healthyplaces/healthtopics/healthyfood/general.htm
7 Rose D. Access to healthy food: a key focus for research on domestic food insecurity. *J Nutr* 2010;140:1167–9.
8 Black C, Moon G, Baird J. Dietary inequalities: what is the evidence for the effect of the neighbourhood food environment? *Health Place* 2014;27:229–42.
9 Story M, Kaphingst KM, Robinson-O'Brien R, *et al*. Creating healthy food and eating environments: policy and environmental approaches. *Annu Rev Public Health* 2008;29:253–72.
10 Giskes K, Kamphuis CBM, van Lenthe FJ, *et al*. A systematic review of associations between environmental factors, energy and fat intakes among adults: is there evidence for environments that encourage obesogenic dietary intakes? *Public Health Nutr* 2007;10:1005–17.
11 Food and Agriculture Organization (FAO). An introduction to the basic concepts of food security, 2008. Available: http://www.fao.org/3/a-al936e.pdf
12 Leroy JL, Ruel M, Frongillo EA, *et al*. Measuring the food access dimension of food security: a critical review and mapping of indicators. *Food Nutr Bull* 2015;36:167–95.
13 Evans A, Banks K, Jennings R, *et al*. Increasing access to healthful foods: a qualitative study with residents of low-income communities. *Int J Behav Nutr Phys Act* 2015;12 Suppl 1:S5.
14 Kim M, Budd N, Batorsky B, *et al*. Barriers to and facilitators of stocking healthy food options: viewpoints of Baltimore City small storeowners. *Ecol Food Nutr* 2017;56:17–30.
15 Grimm KA, Moore LV, Scanlon KS, *et al*. Access to healthier food retailers - United States, 2011. *MMWR Suppl* 2013;62:20–6.
16 Beaulac J, Kristjansson E, Cummins S. A systematic review of food deserts, 1966-2007. *Prev Chronic Dis* 2009;6:A105.
17 Larson N, Story M. A review of environmental influences on food choices. *Ann Behav Med* 2009;38 Suppl 1:56–73.
18 Morland KB, Evenson KR. Obesity prevalence and the local food environment. *Health Place* 2009;15:491–5.
19 Powell LM, Slater S, Mirtcheva D, *et al*. Food store availability and neighborhood characteristics in the United States. *Prev Med* 2007;44:189–95.
20 Zenk SN, Mentz G, Schulz AJ, *et al*. Longitudinal associations between observed and perceived neighborhood food availability and body mass index in a multiethnic urban sample. *Health Educ Behav* 2017;44:41–51.
21 Kumar S, Quinn SC, Kriska AM, *et al*. "Food is directed to the area": African Americans' perceptions of the neighborhood nutrition environment in Pittsburgh. *Health Place* 2011;17:370–8.
22 Bell J, Mora G, Hagan E. *Access to healthy food and why it matters: a research review*. PolicyLink, The Food Trust: Oakland, 2013.
23 Shih M, Dumke KA, Goran MI, *et al*. The association between community-level economic hardship and childhood obesity prevalence in Los Angeles. *Pediatr Obes* 2013;8:411–7.
24 Kwate NOA, Yau C-Y, Loh J-M, *et al*. Inequality in obesigenic environments: fast food density in New York City. *Health Place* 2009;15:364–73.
25 Turner C, Kalamatianou S, Drewnowski A. Erratum to Turner et al. food environment research in low- and middle-income countries: a systematic scoping review. *Adv Nutr* 2019;10:387–97.
26 Downs SM, Ahmed S, Fanzo J, *et al*. Food environment typology: advancing an expanded definition, framework, and methodological approach for improved characterization of wild, cultivated, and built food environments toward sustainable diets. *Foods* 2020;9:532.
27 Keener D, Goodman K, Lowry A. *Recommended community strategies and measurements to prevent obesity in the United States: implementation and measurement guide*. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2009.
28 Giang T, Karpyn A, Laurison HB, *et al*. Closing the grocery gap in underserved communities: the creation of the Pennsylvania fresh food financing initiative. *J Public Health Manag Pract* 2008;14:272–9.
29 Williams J, Scarborough P, Matthews A, *et al*. A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. *Obes Rev* 2014;15:359–74.
30 Engler-Stringer R, Le H, Gerrard A, *et al*. The community and consumer food environment and children's diet: a systematic review. *BMC Public Health* 2014;14:522.
31 da Costa Peres CM, Gardone DS, Costa BVdeL, *et al*. Retail food environment around schools and overweight: a systematic review. *Nutr Rev* 2020;78:841–56.
32 Kenny T-A, Little M, Lemieux T, *et al*. The retail food sector and Indigenous peoples in high-income countries: a systematic scoping review. *Int J Environ Res Public Health* 2020;17:8818.
33 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005;8:19–32.
34 Peters MDJ. In no uncertain terms: the importance of a defined objective in scoping reviews. *JBI Database System Rev Implement Rep* 2016;14:1–4.
35 Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci* 2010;5:1–9.
36 Ouzzani M, Hammady H, Fedorowicz Z, *et al*. Rayyan-a web and mobile APP for systematic reviews. *Syst Rev* 2016;5:210.
37 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med* 2018;169:467–73.
38 Peters M, Godfrey C, McInerney P. Methodology for JBI Scoping Reviews. In: Aromataris E, ed. *The Joanna Briggs Institute reviewers manual*, 2015: 3–24.
39 Bussiek P-BV, De Poli C, Bevan G. A scoping review protocol to map the evidence on interventions to prevent overweight and obesity in children. *BMJ Open* 2018;8:e019311.

Appendix 5: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Page 1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Page 1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Page 4
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 4
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 5
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Page 5 - 6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 5

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Page 5 & supplementary file 1
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Click here to enter text.
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 7
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 7 & supplementary table 2.
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Not done
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Click here to enter text.
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 6-7 & Figure 1
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Page 7-8
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Not done

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Page 7-15
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 7-15 & Table 1-5
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Page 15 -19
Limitations	20	Discuss the limitations of the scoping review process.	Page 19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 19-20
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Page 20

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where sources of evidence (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with information sources (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473.

Appendix 6: Reviewer comments and author responses for published manuscript one (1st round)

Samukelisiwe Madlala | SAMRC

From: BMC Public Health <bmcpublichealth@biomedcentral.com>
Sent: Monday, February 20, 2023 6:13 AM
To: Samukelisiwe Madlala | SAMRC
Subject: [EXTERNAL SENDER] BMC Public Health: Decision on your manuscript

Ref: Submission ID e1613452-1c02-42cb-941d-c4b393644a70

Dear Dr Madlala,

Re: "Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review"

We are pleased to let you know that your manuscript has now passed through the review stage and is ready for revision. Many manuscripts require a round of revisions, so this is a normal but important stage of the editorial process.

Editor comments
Thank you for submitting this very interesting article to BMC Public Health. Please make sure to address reviewer comments and questions. Thank you.

To ensure the Editor and Reviewers will be able to recommend that your revised manuscript is accepted, please pay careful attention to each of the comments that have been pasted underneath this email. This way we can avoid future rounds of clarifications and revisions, moving swiftly to a decision.

Once you have addressed each comment and completed each step listed below, the revised submission and final file can be uploaded via the link below.

If you completed the initial submission, please log in using the same email address. If you did not complete the initial submission, please discuss with the submitting author, who will be able to access the link and resubmit.

https://submission.springernature.com/submit-revision/e1613452-1c02-42cb-941d-c4b393644a70

You can visit https://researcher.nature.com/your-submissions to track progress of this or any other submissions you might have.

CHECKLIST FOR SUBMITTING YOUR REVISION

1. Please upload a point-by-point response to the comments, including a description of any additional experiments that were carried out and a detailed rebuttal of any criticisms or requested revisions that you disagreed with. This must be uploaded as a 'Point-by-point response to reviewers' file.

Please note that we operate a transparent peer review process, where we publish reviewers' reports with the article, together with any responses that you make to reviewers or the handling Editor.

2. Please highlight all the amends on your manuscript or indicate them by using tracked changes.

3. Check the format for revised manuscripts in our submission guidelines, making sure you pay particular attention to the figure resolution requirements:

https://bmcpublichealth.biomedcentral.com/submission-guidelines

Finally, if you have been asked to improve the language or presentation of your manuscript and would like the

assistance of paid editing services, we can recommend our affiliates, Nature Research Editing Service: https://authorservices.springernature.com/language-editing/ and American Journal Experts: https://www.aje.com/go/springernature

Please note that use of an editing service is neither a requirement nor a guarantee of publication. Free assistance is available from our resources page: https://www.springernature.com/gp/researchers/campaigns/english-language-forauthors

To support the continuity of the peer review process, we recommend returning your manuscript to us within 14 days. If you think you will need additional time, please let us know and we will aim to respond within 48 hours.

Kind regards,

Jorge Banda
Editorial Board Member
BMC Public Health

Reviewer Comments:

Reviewer 1
This is an interesting review article and this version really indicated that it has gone through some major revision (amended version).
From this revised version, I feel there is a need for the authors to include the absence of studies from Africa and some countries from other regions. It's not a big issue but it should form part of the "areas for further studies" section of this work because research or article location was not part of your exclusion criteria for this review.
If possible some "limitations of the study" can also be incorporated before the conclusion section.
However, this is really an interesting paper worth publishing. The editor can make final publication decision on this amended version of the manuscript. Thank you.

Reviewer 2
Thank you for the opportunity to review the manuscript titled "Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review". I commend the authors for focusing their review on low-income settings to identify gaps in the literature relevant to discussions of equity and inclusion in modern food systems/food environment intervention designs.

The authors situated the research problem as a paucity of evidence synthesis dedicated to adult food choices in local retail environments in resource poor communities. The methods were published previously in BMJ Open and consisted of a multiple database search designed to solicit observational and/or qualitative papers regarding their research problem of interest. The authors followed PRISMA-ScR guidelines and used a previously published review framework (Arksey and O'Malley) to guide their review.

The majority of studies captured post-screening originated in the USA (Figure 2), and most of the papers evaluated were cross-sectional in nature. A variety of GIS-based approaches, audit instruments, and food consumption instruments were used to assess the relationship between retail food environments and food choices (Lines 278-309). Quantitative findings in community food environment assessments were largely ambiguous given the variety of outcomes and metrics used in the articles under review, likely a reflection of the broader food environment literature's lack of standardization (noted in the manuscript). I want to especially congratulate the authors on effectively synthesizing the qualitative literature they assessed in their review. The barriers and facilitators section of the results was especially useful for researchers and policymakers alike.

The discussion largely iterated findings from previous reviews regarding the inconsistency in directions and effect sizes attributable to observational relationships between food environments and measures of food intake. The authors appropriately situated these findings in the extant literature i.e. inconsistent measurements and infrequent longitudinal studies are problems that predate this review. Further, the findings from this manuscript iterate the need for interventions that address material deprivations and transportation access to impact healthy food consumption. The authors conclude their discussion with a paragraph dedicated to the association between

convenience/corner stores and poor access to healthy foods. The study's conclusion focused on the aforementioned heterogeneity of food environment measurements, and findings from the studies under review suggesting there are store type associations with healthy food access i.e. supermarkets, larger grocers etc., and the greatest barriers to healthy food access are cost and transportation. Finally, the authors highlight the need for greater diversity in regional research, a familiar but necessary call for research in regions outside of the USA to better understand the interactions between food environments and food intakes in a region-specific manner.

Although I think the methods for data collection and synthesis are technically sound, I do have some overarching recommendations regarding the structure of the article and the language used throughout.

First, the terms 'food choices' and 'resource-poor' are relatively ambiguous without the support of the protocol search terms. Particularly given the fact that articles that used proxy measures such as food purchases were excluded. Arguably, a food purchase is still a choice, but is undeniably inequivalent to food consumption. Defining these terms early in the paper and in the abstract would improve readability and make it easier for new readers to find the paper and understand the relevant literature that forms of the scope of the review. I had to review the BMJ protocol terms to get a better understanding of exactly what was being investigated in the manuscript.

Second, throughout the text several common food environment terms are proceeded by bracketed explanatory terms. i.e. accessibility (proximity/distance). I would suggest using the appropriate references to describe these terms in detail as set out in previous work rather than using brackets with extra terms that may or may not always be synonymous with the underlying construct being studied. This should be added to the introduction as a means of providing context for readers new to the field, and to clarify exactly what constructs are under investigation to those familiar to food environments research.

Third, like the observation re: ambiguity of food choice and resource-poor, 'numerical and thematic analysis' is relatively ambiguous. What is meant in explicit terms? Were themes generated a priori or from the ground up? Is there an underlying theory that informs this work? Or does this approach stem from Arkey and O' Malley or the population concept and context framework? If so, were other recommendations from those pieces followed? i.e. was there a consultation process with policymakers etc.? Providing references and clarifying methods to make it clear exactly how the analysis was performed will make it possible for future researchers to replicate this work, and for readers to effectively interpret findings.

Finally, there were a few points in the manuscript that used causal language to describe associations. I caution the authors against this and suggest they review the paper to ensure causality is only referenced with speculation, rather than with certainty. i.e. Line 413 -> "because" implies causality but given the literature surveyed this may be better written as an association rather than a causal relationship between FF access and FF intake. This is particularly important given the papers surveyed for the review did not include experimental studies.

I would like to thank the authors again for their work and for the opportunity to review it, I appreciate their efforts to mitigate the lack of evidence synthesis at an international scale with a focus on lower resourced communities. Below I have added some specific comments, some of which repeat my abovementioned suggestions.

Title
- Suggest rewording the title to reflect more specific terms like 'food intake' instead of 'food choices' and 'low-income' instead of 'resource-poor' -> these terms will be easier to understand for new readers and reflect the underlying search terms stemming from the BMJ protocol paper. Alternatively, explanation of these terms in the abstract is encouraged.

Abstract
- Please include a definition of "resource poor" communities
- What is meant by numerical and thematic analysis?
- How many papers were screened to arrive at 47?
- Food choice and diet may not necessarily be synonymous -> i.e. food choice could be thought of as a purchase while the resultant diet may be defined as what is consumed after purchase.
- What is meant by positive and negative associations? What question was being assessed? I reviewed the aim and objectives listed in the referenced protocol but redefining them here and ensuring the reader understands the key

terms of food choice, and resource poor would ensure they can better evaluate the findings being presented here

Intro
- Lines 72-73 can this assertion be made in such concrete terms?
- Lines 74-84 -> summarizing these definitions and referencing how they were developed rather than using quotations may better serve the reader
- Lines 89-90 -> Reference 13? Can healthy food environments be defined explicitly in this way given the state of the literature or is this how they are conceptualized? The way it is currently written leads the reader to believe we have a concrete grasp on what makes a food environment healthy or not when the data within this review and others suggests that is yet to be fully understood
- Lines 90-93 reflect a much more balanced interpretation of the literature
- More context to the studies being referenced in all of lines 94-101 would be helpful-> these are empirical findings that may or may not be generalizable at the level they are being referenced
- Are there any spatial implications of using community and neighbourhoods interchangeably in assessment of the literature? An activity space vs. an institutionally defined area
- May want to rewrite line 117 to say limited synthesis -> is there a comparative dearth of underlying evidence? If this has been quantified previously then a reference would suffice. Further explanation of what is meant by 'food choices' would also make this more readily interpretable.
- Lines 121-122 What is meant by food access in this context? How does it differ from food environments? Does this imply a measure of consumer utilization? Or is this referring to the consumer food environment (Price, Product, Placement, Promotion)? If the latter, please clarify this distinction.

Methods
- Can the authors provide an argument for the use of scoping methodology vs. systematic review in this context?
- Lines 139-141 -> Suggest stripping the line describing the databases -> listing the databases should be sufficient
- Was a librarian involved in development of search terms?
- Resource-poor communities should be explicitly defined somewhere in the introduction, the literature being investigated and the research problem are not clear by the point of the inclusion/exclusion criteria section
- Why were experimental studies not included? Are there no experiments that exist without an accompanying intervention? Are natural experiments a viable way to assess these types of associations? I am not arguing these should or shouldn't be included I just think it would serve the reader to understand these exclusions.
- Why were studies that only focus on the food environment and nutritional status included, while those studying indirect measures of diet weren't? I think this could be addressed by clearly defining the meaning of 'food choice' early in the manuscript.
- Lines 166-167 -> What falls under 'other' and 'national study' for exclusion? Clarifying this would help the reader understand how the search was performed
- Line 177, was title and abstract screening done independently?
- Bracketed numbers of articles at each stage of screen may help readers navigate the screening of articles
- Lines 181 to 184 are unclear -> "first database search" can read as a single database rather than the first completed screen, suggest rewording for clarification
- Lines 186 to 194 are great, can you report on first round interrater agreement explicitly in brackets? Was this provided by the software used to screen or was this a qualitative assessment of agreement?
- Line 195 -> What is descriptive numerical and thematic analysis? Is there a reference for this approach? Is it Arkey O Malley? Without further explanation or a reference interpretation of the analytic technique is difficult
- Line 196 -> "Data are presented in tables and figures" does not add to the manuscript, suggest removing this line

Results
- Line 274, does a pre-existing definition for 'resource-poor communities exist'? Further, SEP is a relative measure, not one that indicates any absolute value of resources. Individuals belonging to a low SEP in a resource rich community may hypothetically have more resources than high SEP individuals belonging to a resource poor community. Would this affect the findings being reported? Is this still in line with the research question being posed?
- Lines 278-282 -> Does every paper in table 2 use both of these methods (GIS + audits) or is this inclusive of all articles that used either?
- Line 284 -> Are density and availability synonymous? Could there be a raw number indicating availability that has

no spatial denominator such as that referenced in line 292 -> "presence" Further, on line 292 is "variety" considered an absolute count? Clarifying these terms earlier in the manuscript may address this issue.
- I would suggest removing density and distance/proximity from the brackets near each use of availability and accessibility. Lines 289-293 are more specific in their descriptions. An additional reference to previous reviews that included GIS studies (ie Caspi et. al. 2012 etc.) may direct the reader to the relevant literature
- Line 296 please add the reference in question.
- Lines 302-303 -> although these NEMS instruments are predicated on the same design they are denoted as unique instruments i.e. NEMS-R and NEMS-P
- Lines 364 to 370 provide a great synthesis of qualitative findings that will contribute to the literature
- The barriers and facilitators section of the article stood out as a particularly strong part of the manuscript, thank you for synthesizing this

Discussion
- Lines 392-393 -> is this how you are defining resource-poor? If so, please insert this in the abstract, introduction and methods sections of the article to make explicit the criteria that define the scope of this review
- Line 406 -> Generally, recommend against the widespread use of terms followed by bracketed expianatory terms, this may confuse readers and present departures from accepted terminology. I suggest the authors define the components of the 5 As of food environments early in the manuscript and then describe departures from the accepted definitions as necessary rather than excessively relying on brackets to capture more than one idea per term (see above note on density calculations)
- Line 413 -> "because" implies causality but given the literature surveyed this may be better written as an association rather than a causal relationship between FF access and FF intake
- Line 416 -> price and affordability are not synonymous in the literature, food prices refer to the absolute price of a product while affordability is a combination of an individual's ability to pay for a set of foods (income + factors that dictate needs) and food costs (Lee et. al. 2013 Obesity reviews)
- Line 420 -> given the specific nature of the literature reviewed in this manuscript, the suggestion that more studies on these dimensions are needed may require further validation from previous work or need to be qualified as a need within the subset of literature being investigated. Are there references that explicitly support this argument?
- Lines 435-439 -> the point that consumer-side interventions may prove more valuable than supply-side interventions is well put
- Lines 440-453 -> Work in Australia and Canada has demonstrated the potential for independent retailers to act as healthier food retail settings. These findings may provide a quantitative basis for the recommendations made in reference 107 and dovetail with the US literature cited in references 109,110. I leave it to the authors discretion to explore the potential for these articles to buttress points made in this paragraph.

Conclusion
- Line 480-481 is this a finding (most are USA based) from the authors search or a generalization? If it is generalizing, references should be added to validate the argument
- Similar to the above point, any references that can bolster the argument re: regional paucity of evidence should be added to the final lines to inform the reader that the findings within this review are complementary to previous work.

The tables and figures were impressively thorough and will be a significant addition to the literature. Some sections were left blank in the tables, I'm assuming based on the context of the specific paper in question, adding a line to the table title/legend or simply adding N/As may help the reader to better navigate the tables.

Table 4 has a column for food environment exposures and food access exposures. Theoretically, these can both be considered aspects of food environments more broadly speaking. Adding language to the table legend delineating these concepts would help the reader navigate the table. For instance, Breyer and Voss-Andreae concluded from their work that proximity and price are crucial to the assessment of the food environment. The affordability index they built using the difference between the nearest store and the lowest cost grocery store could be defined as a combination of community and consumer food environment metrics rather than a measure of 'food access' per se. Prices, affordability indices etc. (all listed under food access) could all be considered components of the consumer food environment. Suggest the authors revise these column headings for clarification and avoid using potentially synonymous terms to describe column contents.

Thank you again for the opportunity to review your work, I look forward to your responses to the suggested revisions.

6 March 2023

Submission ID e1613452-1c02-42cb-941d-c4b393644a70

Manuscript: Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review

Dear Editor and Reviewers

Thank you for the opportunity to address the comments and concerns raised by the Reviewers. The manuscript has been revised and amendments are indicated using track changes. edited to as per reviewer suggestions and addressed concerns raised. Our point-by-point response is given below. The amendments in the revised manuscript are highlighted. The revised version has been formatted according to the submission guidelines. We hope that we addressed all the revisions, and that the manuscript has fulfilled the criteria for publication.

REVIEWER COMMENTS:

Reviewer 1

Thank you for taking the time and effort to read the manuscript. We appreciate your valuable feedback.

Comment	Response
1. This is an interesting review article and this version really indicated that it has gone through some major revision (amended version). From this revised version, I feel there is a need for the authors to include the absence of studies from Africa and some countries from other regions. It's not a big issue but it should form part of the "areas for further studies" section of this work because research or article location was not part of your exclusion criteria for this review.	Thank you for your positive feedback on the article and suggestion. Regarding the absence of studies from Africa and other countries, the recommendation for further studies to be conducted in Africa and other regions was stated in the discussion section. Please see, page 21, lines 500-502.
2. If possible, some "limitations of the study" can also be incorporated before the conclusion section.	Thank you for suggestion. The limitations to the study are in the last paragraph of the discussion section before the conclusion. Please see page 21, line 485-502.

Reviewer 2

Thank you for taking the opportunity to review the manuscript. We appreciate your valuable feedback and have taken into consideration all the queries raised and suggestions made.

Comment	Response
1. Title Suggest rewording the title to reflect more specific terms like 'food intake' instead of 'food choices' and 'low-income' instead of 'resource-poor' -> these terms will be easier to understand for new readers and reflect the underlying search terms stemming from the BMJ protocol paper. Alternatively, explanation of these terms in the abstract is encouraged.	Thank you for your suggestion. We acknowledge your concerns regarding the use of the term's food choice and resource poor community without explicitly defining these for the reader. We have defined the terms 'food choice' and 'resource poor' in the abstract (page 2, lines 40-42) and introduction (page 6, lines 150 - 154). We prefer not to revise the title; we hope this is acceptable for the Reviewer.
2. Abstract: Please include a definition of "resource poor" communities	Thank you for your comment. Resource poor communities refers to low-income communities and/or low-income households. A short definition has been added to the abstract due to word limit restrictions (page 2, line 40-41).
What is meant by numerical and thematic analysis?	Thank you for your question. Descriptive numerical analysis means that for all included studies the characteristics of included studies are described, i.e. overall number of studies included, types of study design, years of publication, characteristics of the study populations, and countries where studies were conducted. Thematic analysis means that for qualitative studies and mixed method studies the relevant themes are presented. This method of collating, summarizing, and reporting results is described in Arksey H, O'Malley L: Scoping studies: Towards a Methodological Framework. Int J Soc Res Methodol. 2005, 8: 19-32. and Levac *et al*. Scoping studies: advancing the methodology. Implementation Science 2010; 5:1–9. We revised the sentence for better clarity (page 2, lines 51-53).
How many papers were screened to arrive at 47?	Thank you for this question. A total of 2426 records were identified from the primary and updated database search. This information has been added to the abstract (page 2, line 46-47).
Food choice and diet may not necessarily be synonymous -> i.e. food choice could be thought of as a purchase while the resultant diet may be defined as what is consumed after purchase.	Thank you for your pointing this out. We agree that food choice and diet may not necessarily be synonymous. In the literature, food choice (by some referred to as dietary choice), broadly refers to "selection of food for consumption" and is measured by both purchasing and dietary indicators. For this scoping review, we included only dietary indicators. On page 2, lines 39-40 we now indicate that we used dietary intake as measure for food choice.
What is meant by positive and negative associations? What question was being assessed? I reviewed the aim and objectives listed in the referenced protocol but redefining them here and ensuring the reader understands the key terms of food choice, and	Thank you for your comment. The findings reported in the abstract have been revised for better clarity. (page 2, line 56-60).

Comment	Response
resource poor would ensure they can better evaluate the findings being presented here	
3. Intro: Lines 72-73 can this assertion be made in such concrete terms?	Thank you for your pointing this out. We revised the sentence to "Poor food systems and unhealthy food environments contribute to the high global prevalence of poor nutritional status" (page 3, line 73-74).
Lines 74-84 -> summarizing these definitions and referencing how they were developed rather than using quotations may better serve the reader	Thank you for the suggestion. Please see amendment on page 3, line 75-86.
Lines 89-90 -> Reference 13? Can healthy food environments be defined explicitly in this way given the state of the literature or is this how they are conceptualized? The way it is currently written leads the reader to believe we have a concrete grasp on what makes a food environment healthy or not when the data within this review and others suggests that is yet to be fully understood	Thank you for your comment. We revised the sentence to indicate that this is how Story and colleagues (previously ref 13, now ref 20) conceptualized a healthy food environment (page 4, line 106-110).
More context to the studies being referenced in all of lines 94-101 would be helpful-> these are empirical findings that may or may not be generalizable at the level they are being referenced	Thank you for your comment. More context on the studies has been provided (page 4-5, lines 113-125).
Are there any spatial implications of using community and neighbourhoods interchangeably in assessment of the literature? An activity space vs. an institutionally defined area	We acknowledge that there are differences in the strict definition of "community" and "neighborhoods". In literature, the terms community, neighborhood and area are often used synonymously. In some of the articles included in this scoping review, the terms communities, neighborhoods and area are used interchangeably. Please refer to ref [63], Karypn et al 2020, ref [66] Haynes-Maslow, ref [85] Hendrickson et al 2006, ref [90] Valdez et al 2016, ref [98], Diez et al 2017, and ref [101] Child & Lewis 2012). We are not certain whether there are spatial implications of using community and neighborhoods interchangebly.
May want to rewrite line 117 to say limited synthesis -> is there a comparative dearth of underlying evidence? If this has been quantified previously then a reference would suffice. Further explanation of what is meant by 'food choices' would also make this more readily interpretable.	Thank you for the suggestion. We revised the sentence (page 6, line 140) and added two references to support the statement (page 6, line 142). Further explanation of the term 'food choices' is provided on page 6, lines 150-152.
Lines 121-122 What is meant by food access in this context? How does it differ from food environments? Does this imply a measure of consumer utilization? Or is this referring to the consumer food environment (Price, Product, Placement, Promotion)? If the latter, please clarify this distinction	Thank you for the questions. Food access in the context of this study refers to all the dimensions of food access which includes consumer food environment (Price, Product, Placement, Promotion) and perceived availability and accessibility to food stores. In literature the dimensions for the food environment are the same as the dimensions for food access. These

Comment	Response
	dimensions have been defined in the text for more clarity (page 3-4, lines 87-100).
4. Methods	
Can the authors provide an argument for the use of scoping methodology vs. systematic review in this context?	Thank you for your suggestion. A scoping review instead of a systematic review was conducted to scope the body of literature and to identify knowledge gaps on the topic. Please see page 6, line 159-160.
Lines 139-141 -> Suggest stripping the line describing the databases -> listing the databases should be sufficient	Thank you for your suggestion. The amendment has been made to the lines. Please see page 7, lines 171-172.
Was a librarian involved in development of search terms?	A librarian was not involved in the development of the search terms, but the authors developed a terminology list on the topic and searched for Mesh terms on PubMed and also looked at the search terms used in similar reviews.
Resource-poor communities should be explicitly defined somewhere in the introduction, the literature being investigated, and the research problem are not clear by the point of the inclusion/exclusion criteria section	Thank you for your comment. Resource-poor has been defined in the introduction (page 6, lines 152-154).
Why were experimental studies not included? Are there no experiments that exist without an accompanying intervention? Are natural experiments a viable way to assess these types of associations? I am not arguing these should or shouldn't be included I just think it would serve the reader to understand these exclusions	Thank you for your comment. To our knowledge and through reading previous reviews experimental studies are not commonly used to assess these associations. Cross-sectional study designs are most common way to assess these associations. According to a recent review, most experimental studies do accompany intervention and are mostly on children (Westbury et al 2021 BMJ Global Health). One systematic review did however recommend longitudinal and experimental studies to be conducted to determine causality and efficacy of interventions (Lytle & Sokol 2015 Health & Place)
Why were studies that only focus on the food environment and nutritional status included, while those studying indirect measures of diet weren't? I think this could be addressed by clearly defining the meaning of 'food choice' early in the manuscript	Thank you for your comment. For this scoping review, we were particularly interested in food intake as a measure of food choice in adults (now indicated on page 6, lines 150-152). We did not include studies that used food purchase as a measure of food choice, as these purchases would be mostly for the household, including children. Studies that focused on the food environment and nutritional status (e.g. weight status) were excluded as factors other than food choice could affect nutritional status.
Lines 166-167 -> What falls under 'other' and 'national study' for exclusion? Clarifying this would help the reader understand how the search was performed	Thank you for your comment. Other' refers to papers that were irrelevant to the study but could not be classified under any of the listed exclusion criteria. 'National study' refers to studies for which results were reported at national level, with no distinction between groups or settings of different socio-economic status. This is now indicated on page 8, lines 198-201.

Comment	Response
Line 177, was title and abstract screening done independently?	Thank you for your question. The titles and abstracts were screened independently. See amendment on page 8, line 211-213.
Bracketed numbers of articles at each stage of screen may help readers navigate the screening of articles	Thank you for your suggestion. The paragraph has been revised to include the number of articles at each stage of screening however we did not use bracketed numbers. Please see revisions on page 8-9, lines 206-222. Figure 1 was also revised for clarity (page 11-12).
Lines 181 to 184 are unclear -> "first database search" can read as a single database rather than the first completed screen, suggest rewording for clarification	Thank you for your suggestion. First database search reworded to primary search. Please see amendments on page 8-9, lines 209-216.
Lines 186 to 194 are great; can you report on first round interrater agreement explicitly in brackets? Was this provided by the software used to screen or was this a qualitative assessment of agreement?	Thank you for your question. The software does not provide the interrater agreement however it does show the percentage of articles that reviewers agreed on, disagreed on and excluded. The interrater agreement was calculated as 100 percent minus the percentage of studies the reviewers disagreed on. Please see the interrater agreement on page 9, line 231.
Line 195 -> What is descriptive numerical and thematic analysis? Is there a reference for this approach? Is it Arkey O Malley? Without further explanation or a reference interpretation of the analytic technique is difficult	Thank you for your question. This method of collating, summarizing, and reporting results is described in Arkey O Malley 2005 and Levac *et al.* 2010. Descriptive numerical analysis means that for all included studies the researchers describe the characteristics of included studies i.e. overall number of studies included, types of study design, years of publication, characteristics of the study populations, and countries where studies were conducted. Thematic analysis means that the relevant themes for qualitative studies and mixed method studies were presented. The line has been revised for better clarity. Please see page 9, line 233-234.
Line 196 -> "Data are presented in tables and figures" does not add to the manuscript, suggest removing this line	Thank you for your suggestion. The line has been removed from the manuscript.
5. Results: Line 274, does a pre-existing definition for 'resource-poor communities exist'? Further, SEP is a relative measure, not one that indicates any absolute value of resources. Individuals belonging to a low SEP in a resource rich community may hypothetically have more resources than high SEP individuals belonging to a resource poor community. Would this affect the findings being reported? Is this still in line with the research question being posed?	Thank you for your question. To our knowledge there is no pre-existing definition for resource-poor communities. However, resource-poor can be synonymous to low-income, poor, impoverished, lacking, poverty and disadvantaged. We agree that low SEP individuals can belong to a resource-rich community but because of their financial position they still may not have access to resources. Low SEP individuals also are generally not living in high resource communities. We do not think that the inclusion of low SEP individuals will significantly impact the findings and we do think that this is still in line with the research question.
Lines 278-282 -> Does every paper in table 2 use both of these methods (GIS + audits) or is this inclusive of all articles that used either?	Thank you for pointing this out. Not every paper in table 2 and table 4 includes GIS and store audits. The heading has been revised (and / or) for clarity.

Comment	Response
	Please see table 2 on pages 37-44. The heading was also revised in table 4 on pages 51-53.
Line 284 -> Are density and availability synonymous? Could there be a raw number indicating availability that has no spatial denominator such as that referenced in line 292 -> "presence" Further, on line 292 is "variety" considered an absolute count? Clarifying these terms earlier in the manuscript may address this issue.	Thank you for your comment. Density is a measure of availability and in some literature the words are synonymous. Unfortunately, in literature many studies provide construct names without further defining them (Wilkins et al. 2017 Health & Place). This has contributed to more than one way of definition for the same term hence density and availability could be synonymous. The definition of availability is presented in the introduction. Please see page 3, line 88-90. To our knowledge presence can indicate the number of food stores and variety indicates the diversity of food stores and can be measured as raw counts, or as normalised metrics ('densities'), which include count per capita, count per unit area, or count per unit length for buffers around a line (Burgoine et al. 2014 BMJ, Cobb et al., 2015 Obesity).
I would suggest removing density and distance/proximity from the brackets near each use of availability and accessibility. Lines 289-293 are more specific in their descriptions. An additional reference to previous reviews that included GIS studies (ie Caspi et. al. 2012 etc.) may direct the reader to the relevant literature	Thank you for the suggestion. The words density and distance/proximity in brackets next to the words availability and accessibility have been removed in the text but not the tables. The terms availability and accessibility have been described in detail in the introduction. Please see page 3-4, lines 88-94. Additional references of previous reviews that included GIS studies have been added. Please see page 14, lines 324-326.
Line 296 please add the reference in question	Thank you for your comment. The reference has been added (page 14, line 327).
Lines 302-303 -> although these NEMS instruments are predicated on the same design they are denoted as unique instruments i.e., NEMS-R and NEMS-P	Thank you for your comment. We have denoted the NEMS instruments accordingly (page 15, lines 333-334).
Lines 364 to 370 provide a great synthesis of qualitative findings that will contribute to the literature	Thank you for your positive feedback on the synthesis of the qualitative findings.
The barriers and facilitators section of the article stood out as a particularly strong part of the manuscript, thank you for synthesizing this	Thank you for your positive feedback.
6. Discussion: Lines 392-393 -> is this how you are defining resource-poor? If so, please insert this in the abstract, introduction and methods sections of the article to make explicit the criteria that define the scope of this review	Thank you for your comment. This definition for resource-poor can be found in the abstract (page 2, lines 41-42) and introduction (page 6, lines 152-154).
Line 406 -> Generally, recommend against the widespread use of terms followed by bracketed explanatory terms, this may confuse readers and present departures from accepted terminology. I suggest the authors	Thank you for your comment. The terms in brackets have been removed. Please see page 19, line 444. The 5 As of the food environment (availability, accessibility, affordability, acceptability, and accommodation) is now

Comment	Response
define the components of the 5 As of food environments early in the manuscript and then describe departures from the accepted definitions as necessary rather than excessively relying on brackets to capture more than one idea per term (see above note on density calculations)	described in detail in the introduction. Please see page 3-4, lines 87-100.
Line 413 -> "because" implies causality but given the literature surveyed this may be better written as an association rather than a causal relationship between FF access and FF intake.	Thank you for your comment. The sentence has been revised as per suggestion. Please see page 19, lines 441- 443.
Line 416 -> price and affordability are not synonymous in the literature; food prices refer to the absolute price of a product while affordability is a combination of an individual's ability to pay for a set of foods (income + factors that dictate needs) and food costs (Lee et. al. 2013 Obesity reviews)	Thank you for clarifying the distinction between price and affordability. The sentence has been revised accordingly. Please see page 19, line 446.
Line 420 -> given the specific nature of the literature reviewed in this manuscript, the suggestion that more studies on these dimensions are needed may require further validation from previous work or need to be qualified as a need within the subset of literature being investigated. Are there references that explicitly support this argument?	Thank you for your comment. We did not find any evidence to support the suggestion that more studies on these dimensions are needed. Therefore, the suggestion has been removed.
Lines 440-453 -> Work in Australia and Canada has demonstrated the potential for independent retailers to act as healthier food retail settings. These findings may provide a quantitative basis for the recommendations made in reference 107 and dovetail with the US literature cited in references 109,110. I leave it to the authors discretion to explore the potential for these articles to buttress points made in this paragraph.	Thank you for bringing the work in Australia and Canada to our attention. References of studies from Australia and Canada that support reference 113 have been added. Please see page 20, line 472-474.
7. Conclusion Line 480-481 is this a finding (most are USA based) from the authors search or a generalization? If it is generalizing, references should be added to validate the argument	Thank you for your comment. This is a finding from the authors search and not a generalization. However, based on the previous comment on the work done in Australia and Canada we have revised the sentence and adding references that also report on interventions done in other countries such as Australia and Canada. Please see page 22, lines 512-513.
Similar to the above point, any references that can bolster the argument re: regional paucity of evidence should be added to the final lines to inform the reader that the findings within this review are complementary to previous work.	Thank you for your comment. References that support the argument on regional paucity of evidence have been added on page 22, line 516.
The tables and figures were impressively thorough and will be a significant addition to	Thank you for your comment and suggestion. Table 1, 3 and 4 have been revised as suggested. Please

Comment	Response
the literature. Some sections were left blank in the tables, I'm assuming based on the context of the specific paper in question, adding a line to the table title/legend or simply adding N/As may help the reader to better navigate the tables.	see tables on pages 31-36 (table 1) and pages 45-53 (tables 3 and 4).
Table 4 has a column for food environment exposures and food access exposures. Theoretically, these can both be considered aspects of food environments more broadly speaking. Adding language to the table legend delineating these concepts would help the reader navigate the table. Suggest the authors revise these column headings for clarification and avoid using potentially synonymous terms to describe column contents	Thank you for your suggestion. The column headings in table 4 have been revised accordingly. Please see page 51-53.

Yours sincerely,

Miss Samukelisiwe Madlala
PhD student/intern SAMRC and University of the Western Cape
Email: samukelisiwe.madlala@mrc.ac.za

Reviewer comments and author responses for published manuscript 1 (2nd round)

Samukelisiwe Madlala | SAMRC

From: BMC Public Health <bmcpublichealth@biomedcentral.com>
Sent: Tuesday, May 9, 2023 8:38 PM
To: Samukelisiwe Madlala | SAMRC
Subject: [EXTERNAL SENDER] BMC Public Health: Decision on your manuscript

Ref: Submission ID e1613452-1c02-42cb-941d-c4b393644a70

Dear Dr Madlala,

Re: "Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review"

We are pleased to let you know that your manuscript has now passed through the review stage and is ready for revision. Many manuscripts require a round of revisions, so this is a normal but important stage of the editorial process.

Editor comments
Thank you for submitting a well written revision. Please see two additional modifications being requested by a reviewer regarding (1) lines 56-59 and (2) Line 231. Please incorporate these recommended edits if possible.

To ensure the Editor and Reviewers will be able to recommend that your revised manuscript is accepted, please pay careful attention to each of the comments that have been pasted underneath this email. This way we can avoid future rounds of clarifications and revisions, moving swiftly to a decision.

Once you have addressed each comment and completed each step listed below, the revised submission and final file can be uploaded via the link below.

If you completed the initial submission, please log in using the same email address. If you did not complete the initial submission, please discuss with the submitting author, who will be able to access the link and resubmit.

https://submission.springernature.com/submit-revision/e1613452-1c02-42cb-941d-c4b393644a70

You can visit https://researcher.nature.com/your-submissions to track progress of this or any other submissions you might have.

CHECKLIST FOR SUBMITTING YOUR REVISION

1. Please upload a point-by-point response to the comments, including a description of any additional experiments that were carried out and a detailed rebuttal of any criticisms or requested revisions that you disagreed with. This must be uploaded as a 'Point-by-point response to reviewers' file.

Please note that we operate a transparent peer review process, where we publish reviewers' reports with the article, together with any responses that you make to reviewers or the handling Editor.

2. Please highlight all the amends on your manuscript or indicate them by using tracked changes.

3. Check the format for revised manuscripts in our submission guidelines, making sure you pay particular attention to the figure resolution requirements:

https://bmcpublichealth.biomedcentral.com/submission-guidelines

Finally, if you have been asked to improve the language or presentation of your manuscript and would like the

1

assistance of paid editing services, we can recommend our affiliates, Nature Research Editing Service: https://authorservices.springernature.com/language-editing/ and American Journal Experts: https://www.aje.com/go/springernature

Please note that use of an editing service is neither a requirement nor a guarantee of publication. Free assistance is available from our resources page: https://www.springernature.com/gp/researchers/campaigns/english-language-forauthors

To support the continuity of the peer review process, we recommend returning your manuscript to us within 14 days. If you think you will need additional time, please let us know and we will aim to respond within 48 hours.

Kind regards,

Jorge Banda
Editorial Board Member
BMC Public Health

Reviewer Comments:

Reviewer 1
The editor can make final publication decision on this revised version. Thank you.

Reviewer 2
Thank you for your thorough and thoughtful response to the previous reviewer report. Upon reviewing your responses and the revised manuscript I only have two minor suggestions for improvement. I do not expect the authors to undergo another round of revisions on the following points but I believe they will strengthen the readability of the manuscript/abstract.

Lines 56-59 -> these lines are still unclear to me, but I appreciate how difficult it is to capture the complex associations reviewed in the article. Especially with only a couple sentences in an abstract. Unfortunately, it still seems the way it is written has multiple interpretations. i.e. lines 56-57 could be interpreted to mean all foods were positively associated with all food environments rather than what I believe is the intended meaning (from Table 2) of some studies found positive associations between measures of the food environment and healthy food intake, some found positive associations between measures of the food environment and unhealthy food intake etc. I don't know if I have a simple solution for this problem but I suggest the authors reword to "associations in the expected direction" i.e. healthy food environments were associated with healthy food choices and/or unhealthy food environments were associated with unhealthy food choices vs. "associations in the unexpected direction" vs. "associations in both directions". Or find some other way to make this section of the abstract more clear.

Line 231 -> thank you for your thoughtful response to my query re: interrater agreement. Adding the formula for this to the manuscript may help readers understand the origin of the value being provided on this line.

Thank you again for the opportunity to review your work and for your careful consideration of my previous recommendations. I appreciate the work that goes into these responses and applaud the author's efforts.

17 May 2023

Submission ID e1613452-1c02-42cb-941d-c4b393644a70

Manuscript: Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review

Dear Editor and Reviewers

Thank you for the opportunity to address the comments from the Editor and Reviewer 2 on the manuscript. The manuscript has been revised and amendments are highlighted in yellow. The revised version has been formatted according to the submission guidelines. Our point-by-point response is given below. We hope that the editor and reviewers will be satisfied with the amendments which we have made to the manuscript.

REVIEWER COMMENTS:

Reviewer 1

Thank you for your feedback on the manuscript.

Reviewer 2

Thank you for reviewing this manuscript. We are grateful for your comments and suggestions during the first revision round, they significantly improved the reporting of the study. We acknowledge your present concerns and have considered implementing your suggestions.

Comment	**Response**
1. Lines 56-59 -> these lines are still unclear to me, but I appreciate how difficult it is to capture the complex associations reviewed in the article. Especially with only a couple sentences in an abstract. Unfortunately, it still seems the way it is written has multiple interpretations. i.e. lines 56-57 could be interpreted to mean all foods were positively associated with all food environments rather than what I believe is the intended meaning (from Table 2) of some studies found positive associations	Thank you for your suggestion to clarify the reporting of the results in the abstract. As you have pointed out the results on the associations are in the expected direction while some are contradictory. Please see amendments on lines 52-59.

between measures of the food environment and healthy food intake, some found positive associations between measures of the food environment and unhealthy food intake etc. I don't know if I have a simple solution for this problem but I suggest the authors reword to "associations in the expected direction" i.e. healthy food environments were associated with healthy food choices and/or unhealthy food environments were associated with unhealthy food choices vs. "associations in the unexpected direction" vs. "associations in both directions". Or find some other way to make this section of the abstract more clear.	
2. Line 231 -> thank you for your thoughtful response to my query re: interrater agreement. Adding the formula for this to the manuscript may help readers understand the origin of the value being provided on this line.	Thank you for your suggestion. The method used to calculate interrater agreement was percent agreement. The percent agreement is calculated as the number of agreements divided by the sum of the number of agreements and the number of disagreements multiplied by 100. The formula used to calculate the interrater agreement has been added, please see lines 231-234.

Yours sincerely,

Miss Samukelisiwe Madlala
PhD student/intern SAMRC and University of the Western Cape
Email: samukelisiwe.madlala@mrc.ac.za

Samukelisiwe Madlala | SAMRC

From: BMC Public Health <bmcpublichealth@biomedcentral.com>
Sent: Friday, May 26, 2023 11:30 AM
To: Samukelisiwe Madlala | SAMRC
Subject: [EXTERNAL SENDER] BMC Public Health: Decision on your manuscript

Ref: Submission ID e1613452-1c02-42cb-941d-c4b393644a70

Dear Dr Madlala,

Re: "Adult food choices in association with the local retail food environment and food access in resource-poor communities: a scoping review"

We're delighted to let you know that your manuscript has been accepted for publication in BMC Public Health.

Editor comments
Thank you for your submission.

Prior to publication, our production team will check the format of your manuscript to ensure that it conforms to the standards of the journal. They will be in touch shortly to request any necessary changes, or to confirm that none are needed.

Checking the proofs

Once we've prepared your paper for publication, you will receive a proof. At this stage, please check that the author list and affiliations are correct. For the main text, only errors that have been introduced during the production process, or those that directly compromise the scientific integrity of the paper, may be corrected.

Please make sure that only one author communicates with us and that only one set of corrections is returned. As the corresponding (or nominated) author, you are responsible for the accuracy of all content, including spelling of names and current affiliations.

To ensure prompt publication, your proofs should be returned within two working days.

Publication policies

Acceptance of your manuscript is conditional on all authors agreeing to our publication policies at:
https://www.biomedcentral.com/getpublished/editorial-policies

Please note that we operate a transparent peer review process, where we publish reviewers' reports with the article, together with any responses that you may have made to reviewers or the handling Editor.

Licence to Publish and Article Processing Charge

As the corresponding author of an accepted manuscript, your next steps will be to complete an Open Access Licence to publish on behalf of all authors, confirm your institutional affiliation, and arrange payment of your article-processing charge (APC). You will shortly receive an email with more information.

Once again, thank you for choosing BMC Public Health, and we look forward to publishing your article.

Kind regards,

Jorge Banda
Editorial Board Member
BMC Public Health

Reviewer Comments:

Reviewer 1
This revised version is publication-ready.

Reviewer 2
Thank you for your revisions, congratulations on the publication!

P.S. If you wish to co-submit a data note to be published in BMC Research Notes (https://bmcresnotes.biomedcentral.com/about/introducing-data-notes) you can do so by visiting our submission portal http://www.editorialmanager.com/resn/. Data notes support open data (https://www.springernature.com/gp/open-research/open-data) and help authors to comply with funder policies on data sharing. Please note that this additional service is entirely optional.

Appendix 7: Dietary questionnaire

SECTION 9: DIETARY INTAKE	*Office use*
24-HOUR RECALL RECORDING SHEET 1. Tick the day of the week you are recalling Sunday 1 | Monday 2 | Tuesday 3 | Wednesday 4 | Thursday 5 | Friday 6 | Saturday 7 2. Would you describe the food that you ate yesterday as typical of your usual food intake? Yes / No If no, please give the reason.	☐ 16

DIETARY DIVERSITY

Interviewer: explain to respondent: "In the next few questions I want you to think about all the foods and drinks that you consumed yesterday (during the past 24 hours)."

Interviewer Please Note: *This question will be done in* ***TWO*** *steps.*

Step 1

"Now I would like to ask you about the types of foods that you ate yesterday during the day and night? I want you to try and remember what you ate and drank yesterday from the moment you woke up in the morning, right through until you went to bed again last night. Please list all the food items that you ate yesterday, starting early in the morning. If you drank something during the night, we would also like to know that."

Time of Day	What food and/or drink did you consume yesterday
Early morning and Breakfast time	
During the morning	
Lunch time	
During the afternoon	
Supper time	
After supper, and through the night	

Step 2

Interviewer: Refer to the list of food and drinks consumed the previous day (as mentioned in Step 1) and, in the table below, if the respondent ate one or more of the foods listed in the group. Do that for all the foods listed in Step 1. You (as interviewer) then need to probe for the food groups that were not mentioned.

Food Group		Examples	Items eaten previous day	
			Yes	No
A	Maize or maize products	Maize-meal porridge (stiff, crumbly or soft), fermented maize porridge, samp, whole maize (corn-on-the cob)	1	0
B	Cereals, other than maize meal products	Sorghum, rice, pasta, oats, mabella, morvite, wheat, bread, home-made bread, breakfast cereals, rusks	1	0
C	White roots & tubers	Potato, sweet potatoes, potato (either cooked, mashed, fried, potato salad, fries/slap chips)	1	0
D	Yellow/orange coloured vitamin A-rich vegetables & tubers	Yellow/orange coloured vegetables: butternut, carrot, pumpkin, dark-orange sweetpotato	1	0
E	Dark-green leafy vegetables	Spinach, marog, imifino	1	0
F	Vitamin A-rich fruit	Yellow/orange coloured fruit: mango, pawpaw, yellow peach	1	0
G	Other vegetables	Beetroot, broccoli, cabbage, cauliflower, cucumber, green beans, green peas, lettuce, mushrooms, tomato, tomato-and-onions mix	1	0
H	Other fruit	Apple, apricot, banana, grapes, grapefruit, guava, lemon, lime, naartjie, orange, peach, pear, plum, pineapple, prickly pear, raspberries, strawberries, watermelon, wild fruit	1	0
I	Organ meat	Liver, kidney, heart, lung, chicken giblets, intestines	1	0
J	Meat and poultry	Beef, pork, lamb, goat, mutton, sausage, chicken, stew with any meat, canned meats, ham, game	1	0
K	Fish and seafood	Fresh or frozen fish, canned fish (sardines, pilchards, tuna), fish cakes, fish fingers	1	0
L	Eggs	Eggs	1	0
M	Legumes,	Dried beans, sugar beans, baked beans, lentils, dried peas, cowpeas, split peas, soya beans and soya products (e.g. soya mince), soup-mix	1	0
N	Nuts & seeds	Peanuts, nuts, sunflower seeds, pumpkin seeds, peanut butter	1	0
O	Dairy	Milk, amasi/maas, yoghurt, milk powder, cheese Count milk in coffee/tea only if person drank 3 or more cups of tea/coffee with milk	1	0
P	Oils & fat	Any food made with oil, margarine, butter or Holsum; cream, sour cream, mayonnaise, salad dressing	1	0
Q	Condiments and seasoning	Any food item used to add flavour to the food		
R	Sweets, chocolates, foods with added sugar	Sugar added to food, Syrup, jam, sweets (at least 3 "suck" sweets), honey, chocolate, ice cream, milk shake	1	0
S	Biscuits and cakes, confectionary	Sweet biscuits, cookies, cakes, pudding, tarts	1	0
T	Savoury and fried snacks	Chips, Niknaks, savoury biscuits, samosas,	1	0
U	Sugar-sweetened beverages	Tea/coffee with sugar, cool drink, fruit juice	1	0
V	Alcoholic drinks	Beer, wine, cider, whisky, rum, brandy, etc	1	0

FOOD FREQUENCY

During the past seven days, did you eat any of the following food? If yes, how often?

Q56	Food categories	Every day	1-3 times last week	4-6 times last week	None
1.	Processed meat, e.g. sausages, polony, cold cuts, Viennas, Frankfurters, Russians, Salami	1	2	3	4
2.	Food covered with pastry or crumbs, e.g. pies, chicken, beef schnitzel	1	2	3	4
3.	Food deep-fried in oil/fat, e.g. fish, fries/chips, vetkoeks, samosas, doughnuts	1	2	3	4
4.	Butter, ghee, fat, margarine or oil added to vegetables or other food (like meat) during preparation	1	2	3	4
5.	Mayonnaise or salad dressing added to food	1	2	3	4
6.	Cookies, cakes, sweet pastries				
7.	Sweets such as chocolates, fudge or toffees	1	2	3	4
9.	Snacks such as chips/crisps	1	2	3	4
10.	Salty foods, e.g., nuts, peanuts, biltong, dried sausage, dried salted fish	1	2	3	4
8.	Sugar-sweetened cold drink (gas/fizzy cold drink and reconstituted/mixed with water), including energy drinks and favoured water	1	2	3	4
11.	Fruit Juice	1	2	3	4
12.	Food from fast food outlets excluding beverages (take-aways e.g. pizza, chicken, fish)	1	2	3	4
13.	Fried food bought from street vendors, e.g. vetkoeks, chips	1	2	3	4

Q56	Food categories	Every day	1-3 times last week	4-6 times last week	None
	During the past seven days did you eat any **FRESH** FRUIT?	1	2	3	4

If every day, skip next question

	What is the main reason preventing you from eating FRUIT every day?		
	Cost / money	1	
	Health reasons, e.g. flatulence, arthritis, allergies	2	
	Personal preference	3	
	Availability	4	
	Seasonal availability	5	
	Unsure	6	
Other, specify:		7	

		Every day	1-3 times last week	4-6 times last week	None
	During the past seven days did you eat any VEGETABLES?	1	2	3	4

If every day, skip next question

	What is the main reason preventing you from eating VEGETABLES every day?		
	Cost / money	1	
	Health reasons, e.g. flatulence, arthritis, allergies	2	
	Personal preference	3	
	Availability	4	
	Seasonal availability	5	
	Unsure	6	
Other, specify:		7	

24	When you eat red meat (beef, mutton and pork), do you usually eat with the fat on, or do you remove the fat from the meat?	Do not eat red meat ..... 1 Meat with fat on ..... 2 Fat removed from the meat 3	
25	When eat chicken, do you usually eat the chicken with the skin, or without the skin?	Do not eat chicken ..... 1 With the skin ..... 2 Without the skin 3	
26	Do you usually prefer to eat your food very salty, lightly salted or not salted?	Very salty ..... 1 Lightly salted ..... 2 Not salted ..... 3 Don't know 4	
27	How much margarine, butter or fat do you usually spread on your bread, crackers, or scones?	None ..... 1 Very thin / scraped on ..... 2 Thin (just covered) ..... 3 Medium (nicely covered) ..... 4 Thick (see teeth marks) ..... 5 Don't know 6	

Appendix 8: Reviewer comments and author responses for published manuscript two

Samukelisiwe Madlala | SAMRC

From:	lucia.gong@mdpi.com on behalf of Nutrients Editorial Office <nutrients@mdpi.com>
Sent:	Sunday, July 10, 2022 4:31 AM
To:	Samukelisiwe Sthokozisiwe Madlala
Cc:	Samukelisiwe Madlala | SAMRC; Jillian Hill | SAMRC; Ernesta Kunneke; Andre Kengne | SAMRC; Nasheeta Peer | SAMRC; Mieke Faber | SAMRC; Nutrients Editorial Office; Cindy Pang
Subject:	[Nutrients] Manuscript ID: nutrients-1809783 - Minor Revisions

CAUTION: This email originated from outside the organisation. Do not click links or open attachments unless you recognise the sender and know the content is safe.

Dear Ms. Madlala,

Thank you again for your manuscript submission:

Manuscript ID: nutrients-1809783
Type of manuscript: Article
Title: Dietary Diversity and its Association with Nutritional Status, Cardiometabolic Risk Factors and Food Choices of Adults at Risk for Type 2 Diabetes Mellitus in Cape Town, South Africa.
Authors: Samukelisiwe S Madlala *, Jillian Hill, Ernesta Kunneke, Andre P Kengne, Nasheeta Peer, Mieke Faber
Received: 24 June 2022
E-mails: samukelisiwe.madlala@mrc.ac.za, jillian.hill@mrc.ac.za, ekunneke@uwc.ac.za, andre.kengne@mrc.ac.za, nasheeta.peer@mrc.ac.za, mieke.faber@mrc.ac.za
Submitted to section: Nutrition and Diabetes, https://www.mdpi.com/journal/nutrients/sections/Nutrition_Diabetes

Your manuscript has been reviewed by experts in the field. Please find your manuscript with the referee reports at this link: https://susy.mdpi.com/user/manuscripts/resubmit/c667c241888d3acaab83f3effff2e90b

(I) Please revise your manuscript according to the referees' comments and upload the revised file within 5 days.
(II) Please use the version of your manuscript found at the above link for your revisions.
(III) Please check that all references are relevant to the contents of the manuscript.
(IV) Any revisions made to the manuscript should be marked up using the "Track Changes" function if you are using MS Word/LaTeX, such that changes can be easily viewed by the editors and reviewers.
(V) Please provide a short cover letter detailing your changes for the editors' and referees' approval.

If one of the referees has suggested that your manuscript should undergo extensive English revisions, please address this issue during revision. We propose that you use one of the editing services listed at https://www.mdpi.com/authors/english or have your manuscript checked by a native English-speaking colleague.

Please do not hesitate to contact us if you have any questions regarding the revision of your manuscript or if you need more time. We look forward to hearing from you soon.

Kind regards,
Ms. Lucia Gong
Section Managing Editor
E-Mail: lucia.gong@mdpi.com
Announcement: The Newly Released Impact Factor for Nutrients is 6.706 (Journal Citation Report, 2021 Edition). Nutrients now ranks 15/90 (Q1) in the category "Nutrition & Dietetics".

Welcome to access and read high cited articles in Nutrients:
https://www.mdpi.com/journal/nutrients/editors_choice
1. Natural Bioactive Compounds Useful in Clinical Management of Metabolic Syndrome(http://www.mdpi.com/2072-6643/13/2/630)
2. The Relationship between Food Security Status and Fruit and Vegetable Intake during the COVID-19 Pandemic(http://www.mdpi.com/2072-6643/13/3/712)
3. Effect of COVID-19 Lockdown on Dietary Habits and Lifestyle of Food Science Students and Professionals from Spain (http://www.mdpi.com/2072-6643/13/5/1494)

Skype:live:.cid.51027bd951ede165
MDPI
Nutrients Editorial Office

MDPI Branch Office, Beijing
Suite 301, Zhongjia Mansion, Building No.13, Taiyangyuan Community,
Dazhongsi East Road,Haidian District, Beijing 100190, China
Fax: +86 010 6280 0830 (office)
E-Mail: nutrients@mdpi.com
http://www.mdpi.com/journal/nutrients

15 July 2022

Manuscript title: "Dietary Diversity and its Association with Nutritional Status, Cardiometabolic Risk Factors and Food Choices of Adults at Risk for Type 2 Diabetes Mellitus in Cape Town, South Africa."

Dear Editorial Office and Reviewers

Thank you for reviewing this manuscript and for your comments and suggestions. The manuscript has been edited to as per reviewer suggestions and addressed concerns raised. Below is our response to each point raised by the academic editor and reviewers. We hope that we addressed all the concerns, and that the manuscript has fulfilled the criteria for publication.

Editor's comments

Our response:

Thank you for the opportunity to revise the manuscript. Herewith the cover letter detailing revisions made to the manuscript. The manuscript has been revised according to referee's comments. Revisions made to the manuscript marked up using the "Track Changes" function. References were checked for relevance. Several references have been removed from the manuscript. Five new references [reference 7 on page 2, reference 35-37 on page 4 and reference 57 on page 17] were added to address reviewers' comments.

Comments from Reviewer 1

Thank you for reviewing the manuscript. Please see response to comments below.

- Comment 1: Does the introduction provide sufficient background and include all relevant references? – **Can be improved**

  Our response:

  The Introduction was revised by adding additional information and sentences were moved to improve coherence. The following information was added:

  Page 2, line 44 – 46:

  "Quality diets are associated with adequate intake of micro- and macronutrients, healthy dietary patterns, and reduced risk of diet-related diseases. Diet quality consists of four components namely adequacy, moderation, balance and variety [7]."

  Page 2, line 48 – 50:

  While validated dietary diversity (DD) indicators can be used as a proxy for micronutrient adequacy [9], DD scores can also be used to reflect the variety of nutritious food in the diet."

  Page 2, line 63 – 66:

"There is a need to develop better indicators that measure healthy, unhealthy and imbalanced DD. Such indicators would assist in addressing the burden of malnutrition especially in low-income populations [18]."

Page 2, line 69 – 71:

"The lack of dietary diversity among the population may be due to various factors such as low incomes and unemployment, which may limit vulnerable population groups having access to a variety of healthy foods [21]."

- Comment 2: Are all the cited references relevant to the research? - **Can be improved.**

  Our response:

  References have been checked for appropriateness. Several of the references that referred to individual studies on associations of dietary diversity with health outcomes have been replaced with a recent systematic review (reference 57, page 17, line 601). A few references were added to address the reviewers comments on the introduction [reference 7, page 2, line 46] and explaining the use of the MDD-W (references 35- 37 page 4, line 172)

- Comment 3: Is the research design appropriate? - **Must be improved**

  Our response:

  Additional information on the sampling used in the SA-DPP study was added (page 2, line 87-90) "Briefly, Geographical Information Systems mapping was used to randomly select households within 16 suburbs/townships to identify potential participants. When the random sampling was proving to be unsuccessful, self-selection sampling was used to recruit participants in the townships [23]."

  The use of the MDD-W has been revised [page 4, line 167-173] "Dietary diversity of study participants was assessed using the Minimum Dietary Diversity for Women (MDD-W) [9]. The MDD-W is a validated population-level indicator for women of reproductive age and reflects the micronutrient adequacy component of diet quality [9]. There is no DD measure available that has been validated specially for men or older women, and the MDD-W indicator has been used as measure of DD in studies with both men and women of all ages [35-37]. The MDD-W as measure of DD was therefore used in this study, regardless of age and gender".

  Sentences on the statistical analysis section (page 5, line 215 – 216) was revised for better clarity

  "Differences between groups were tested using the Mann Whitney U test for continuous variables that were not normally distributed, and the Pearson chi-square test for categorical variables using Bonferroni corrections."

- Comment 4: Are the results clearly presented? - **Can be improved**

  Our response:

Tables 1-3 were formatted for better presentation of results.

Information previously shown in Table 2: "Percentage of participants who consumed food groups the previous day according to dietary diversity score category" is now presented as clustered bar graphs (Figure 1, page 8; and Figure 2, page 9).

Information previously shown in Table 4: "Selected food categories consumed over a seven-day period" is now presented as clustered bar graphs (Figure 3, page 11 -13; and Figure 4, page 13).

Paragraph discussing results on food choices was revised for clarity (page 10, line 321 – 336).

- Comment 5: Are the conclusions supported by the results? – **Can be improved**

  Our response:

  Conclusion sentences revised according to results reported. Sentences revised:

  Page 18, 635 - 636: "Overall, DD was not associated with nutritional status and cardiometabolic risk factors, except for the association of low DD with increased likelihood of elevated TGs."

  Page 18, line 637- 639:" Adequate DD was associated with both healthy and unhealthy food choices, which further high-lights the need to consider both healthy and unhealthy foods when constructing measures of dietary diversity."

- Comment 6: I have two concerns about this study. MDD-W was used to score DD. The MDD-W is a validated population-level indicator for women of reproductive age. Although authors explained that MDD-W was used regardless of age and gender, authors may supply evidence to support age and gender will not affect the DD scores.

  Our response:

  Thank you for the concern raised. Our reasoning for using the MDD-W is that there is no other dichotomous DD indicator for adults. A national study in South Africa (reference 21) has previously used 9 food groups, with an arbitrary threshold of 4, to determine DD in adults. We believe that using a threshold of 5 for 10 food groups, or a threshold of 4 for 9 food groups, would yield very similar results. We acknowledge that the MDD-W is a validated indicator for the micronutrient adequacy of the diet for women. We did however not use the MDD-W as proxy for micronutrient adequacy but rather as measure of dietary diversity. The MDD-W as measure of DD in adults have been used in other studies (reference 35 -37). Food-based dietary guidelines do not differentiate between males and females with regards dietary diversity and food groups to be consumed.

  Page 4, line 170-172: shows studies using the MDD-W with study population with both women and men. "There is no DD measure available that has been validated specially for men or older women, and the MDD-W indicator has been used as measure of DD in studies with both men and

women of all ages [35-37]. The MDD-W as measure of DD was therefore used in this study, regardless of age and gender."

- Comment 7: Authors used tables to show their results although the manuscripts. Some table can be demonstrated with bar graph or pie chart, which are clearer to state the results.

  Our response

  Please see comment 4 for our response. Information previously shown in Table 2 & Table 4 is presented as clustered bar graphs (Figures 1 – 4, pages 8, 9, 11-13).

Comments from Reviewer 2

Thank you for reviewing the manuscript. Please see response to comments below.

- Comment 1: English language and style are fine/minor spell check required.
  Our response:
  English language was checked by an English-speaking co-author.

- Comment 2: Does the introduction provide sufficient background and include all relevant references? – **Must be improved**
  ***Our response*:**
  Please see comment 1 response for Reviewer 1.

- Comment 3: Are all the cited references relevant to the research? – **Can be improved**
  Our response:
  Please see comment 2 for Reviewer 1.

- Comment 4: Are the methods adequately described? **- Can improved**.
  Our response:
  Please see comment 3 and 6 for Reviewer 1.

- Comment 5: Are the results clearly presented? - **Can be improved.**
  Our response:
  Results section revised to include graphical illustrations as Reviewer 1 recommended (Figure 1 – 4, pages 8, 9, 11-13 in manuscript). Remaining were formatted for better presentation of results.

- Comment 6: Are the conclusions supported by the results? - **Can be improved**
  Our response:
  Please see comment 5 for Reviewer 1.

Sincerely,

Ms. Samukelisiwe Madlala

On behalf of all the authors

Samukelisiwe Madlala | SAMRC

From:	mosa.zhang@mdpi.com on behalf of Nutrients Editorial Office <nutrients@mdpi.com>
Sent:	Sunday, July 17, 2022 2:44 PM
To:	Samukelisiwe Sthokozisiwe Madlala
Cc:	Samukelisiwe Madlala | SAMRC; Jillian Hill | SAMRC; Ernesta Kunneke; Andre Kengne | SAMRC; Nasheeta Peer | SAMRC; Mieke Faber | SAMRC; Nutrients Editorial Office; Cindy Pang
Subject:	[EXTERNAL SENDER] [Nutrients] Manuscript ID: nutrients-1809783 - Accepted for Publication

Dear Ms. Madlala,

Congratulations on the acceptance of your manuscript, and thank you for submitting your work to Nutrients:

Manuscript ID: nutrients-1809783
Type of manuscript: Article
Title: Dietary Diversity and its Association with Nutritional Status, Cardiometabolic Risk Factors and Food Choices of Adults at Risk for Type 2 Diabetes Mellitus in Cape Town, South Africa.
Authors: Samukelisiwe S Madlala *, Jillian Hill, Ernesta Kunneke, Andre P Kengne, Nasheeta Peer, Mieke Faber
Received: 24 June 2022
E-mails: samukelisiwe.madlala@mrc.ac.za, jillian.hill@mrc.ac.za, ekunneke@uwc.ac.za, andre.kengne@mrc.ac.za, nasheeta.peer@mrc.ac.za, mieke.faber@mrc.ac.za
Submitted to section: Nutrition and Diabetes,
https://www.mdpi.com/journal/nutrients/sections/Nutrition_Diabetes
https://susy.mdpi.com/user/manuscripts/review_info/c667c241888d3acaab83f3effff2e90b

We will now edit and finalize your paper, which will then be returned to you for your approval. Within the next couple of days, an invoice concerning the article processing charge (APC) for publication in this open access journal will be sent by email from the Editorial Office in Basel, Switzerland.

If, however, extensive English edits are required to your manuscript, we will need to return the paper requesting improvements throughout.

We encourage you to set up your profile at SciProfiles.com, MDPI's researcher network platform. Articles you publish with MDPI will be linked to your SciProfiles page, where colleagues and peers will be able to see all of your publications, citations, as well as other academic contributions.

We also invite you to contribute to Encyclopedia (https://encyclopedia.pub), a scholarly platform providing accurate information about the latest research results. You can adapt parts of your paper to provide valuable reference information, via Encyclopedia, for others both within the field and beyond.

Kind regards,
Lluis Serra-Majem, Maria Luz Fernandez
Editors-in-Chief

Appendix 9: Corrigendum – Email to Nutrients editor

Samukelisiwe Madlala | SAMRC

From:	Samukelisiwe Madlala | SAMRC
Sent:	Tuesday, May 23, 2023 9:08 AM
To:	Nutrients Editorial Office
Cc:	cindy.pang@mdpi.com
Subject:	Corrigendum : Nutrients 14-03191
Attachments:	Corrigendum- Nutrients 14-03191.pdf
Importance:	High

Dear Editor,

The authors would like to apologize for an error that occurred in the publication: *Madlala SS, Hill J, Kunneke E, Kengne AP, Peer N, Faber M. Dietary Diversity and its Association with Nutritional Status, Cardiometabolic Risk Factors and Food Choices of Adults at Risk for Type 2 Diabetes Mellitus in Cape Town, South Africa. Nutrients. 2022; 14:3191.*

Figure 4 on pages 15 -16 in the published article is incorrect. Please find attached the correct figure.

This error does not change the results reported in the study.

The authors would like to apologize for any inconvenience caused.

Ms. Samukelisiwe Madlala
On behalf of all authors

Appendix 10: Supplemental material for the third manuscript

Supplementary file 1. Focus group discussion guide.

Opening:

- Good morning and thank you for agreeing to take part in this (FGD). We appreciate your time. My name is …… and this is (introduce other people in the room).
- Why don't we go around the room and introduce ourselves?

Introduction

- Explain what the study is about, what information we will be collecting, confidentiality, voluntary participation, risks and benefits.
  - You were invited here today because we are doing a study to better understand the reasons why people eat certain foods. We will use this information to develop a pamphlet to help people making healthy food choices. This study is part of the South African Diabetes Prevention Programme study which you have all previously participated in.
  - We will firstly have a discussion as a group on the type of food you eat, as well the reasons why you eat these foods. The discussion will take us about 90 minutes to complete. Thereafter, you will complete a short questionnaire that asks questions on who buys food at home and where you buy food.
  - Information collected will be strictly confidential, your name will not be used in any of the reports that will be written on the study. We will identify you by using a code and not your name to protect your identity. Participation in this study is voluntary. You may choose to withdraw from the study without any negative consequences.
  - There are no risks to participating. If you feel uncomfortable with any of the questions, you do not have to give an answer.
  - You will not personally benefit from the study, but the information we get from you will help us to better understand the challenges people may face when making food choices. With the information I get from you today we will develop a pamphlet on healthy food choices. As a token of appreciation, you will receive R50 for your time.
  - Allow participants to ask questions and sign consent forms.
- Start the focus group discussion (follow the guide)
- This session will be audio recorded because we want to be sure and get all your comments.

- Everything you say here is confidential, and your names will not be included on the written record of our session.
- Please feel free to answer each question as honestly as you can and remember that there is no right or wrong answers to any of the following questions.
- Facilitator to go over ground rules.

Topics

1. Can you describe your typical day of eating? What do you typically have for breakfast, lunch, and supper?

1.1 What kind of snacks do you often eat?

2.Give participants pack of cards. Ask the participants to look through the cards.

2.1 Pick two cards with foods that you think are healthy. Why do you think the foods are healthy?

2.2 Pick two cards with foods that you think are unhealthy. Why do you think the foods are unhealthy?

3. What is your understanding of eating a variety of food? When I say eating a variety of food what comes to mind?

3.1 Ask participants to look at the pictures with rows of food. Which row of food do you think has a variety of food and why? (Answer C)

3.2 Explain what eating a variety means.

- Eating a variety of foods means eating from each of the food groups (point to the Food based dietary guideline picture)
- Eating a variety of means including foods from two or more food groups at each meal, every day.
- Eating a variety of food means preparing foods in different ways. Can you mention some ways you can prepare food?
- Variety also means eating different coloured foods especially different coloured fruits and vegetables.

3.3 Ask participants again to look at the pictures with rows of food. Which row of food do you think has a variety of food and why? (Answer C)

4. On the wall there are two plates of food, how would you describe them? Potential answers: different foods, different colours on the plate, one plate more colourful than the other, variety on one plate

5. How would you describe the way you eat during the month. Do your meals have variety? Do your meals look like plate A or plate B or both?

6. Do you think it is possible for you to eat a variety of food daily? Like the food in plate A? Probe: would you be able to eat the plate with different kinds of foods, different coloured vegetables, and fruit etc?) (Potential answer yes, or no?)

7. What are the factors that impact your food choices?

7.1 Individual:

a) What are individual factors that you consider when you have to decide what to eat?
   Probe:
   - Eat what is available.
   - Eat what tastes good.
   - Money/Affordability
   - Your health
   - Food preparation, convenience, and time
   - Food storage facilities
   - Nutrition knowledge or knowledge on food

7.2 Interpersonal:

a) How does your family, husband/partner, friends, and co-workers influence what you eat?
b) How do you decide what the family will eat?
   Probe: Do you budget for food in your household? Do you write down a menu?
c) Who in your family is responsible for buying and cooking?
d) Who are the members of the family that influence the type of food bought and cooked in your household?

7.3 Community:

a) Do you experience difficulty buying the kinds of food you want to buy? (Probe transportation challenges, finances, getting preferred foods).
b) Can you describe the types of food stores you have in your community? Would you say they sell variety of food? Do you purchase from these shops why, if not why?
c) Do you compare food prices when shopping?
d) Are there facilities such as community kitchens, community gardens, food markets, groups where people in your community can access food? (What sort of food do you get there?)

7.4 Societal:

a) How do you think tv, advertising and social media influence what you eat?
b) How did the coronavirus pandemic impact what your food choices and food purchasing?

8. What could make it easier for you to eat more variety of food and make better food choices?
   - What could you today as an individual to eat more variety in your food?
   - How do you think food stores can make it easier to eat a variety of food?
   - What change would you like to see in your community that would make it easier for everyone to eat a variety of food?
   - How do think the government can support people to eat variety of food and healthier food?

9. How do you think the way you eat affects your quality of life and health?

10. How do you think it would affect your health if you ate a variety of food similar to plate A? What if you don't eat a variety how do you think your health is affected?
11. Do you feel in general that you have enough information about healthy eating and making good food choices? (If not what would be a best way for you to learn this information e.g clinic, doctor, dietician/nutritionist, community groups, community kitchen, church groups, school, tv, radio, social media, mobile app).

Ending:

- Recap what was discussed
- Do you have any remarks & suggestions based on what we discussed today?
- Complete short questionnaire with participants.
- Thank participants; sign and distribute vouchers.

Supplementary file 2. Food procurement questionnaires

Food procurement questionnaire

Date: Code | P | P | 1 | | | | |

Name: Surname: Age:

1. In your household, who mostly decides what type of food to buy? (Tick all that are applicable to you √)

	Myself
	My partner/ spouse
	My Children
	Other members of my family/household
	Other (please specify):

2. In your household, what factors influence the food you eat? (Tick all that are applicable to you)

	I eat what tastes good
	I eat what is available
	Convenience and time
	Family and/or friends
	Household income
	Food prices
	Culture and/or religion
	Your health
	Knowledge about food

3. In your household, who is mostly responsible for preparing the food? (Tick all that are applicable to you √)

	Myself
	My partner/ spouse
	My Children
	Other members of my family/household
	Other (please specify):

4. Where do you mainly buy your family food? (Tick all that are applicable to you √)

	Supermarket
	Grocery store
	Convenience store/spaza shop
	Other (please specify):

5. Where do you buy your fruits and vegetables? (Tick all that are applicable to you √)

	Supermarket
	Fruit and vegetable market
	Convenience store/spaza shop
	Street vendor
	Other:

6. How do you get to and from the food stores? (Tick all that are applicable to you √)

	Walk
	Bus
	Train
	Taxi
	Private car
	Walk & transport

7. Why do you choose to shop at these food stores? (Tick all that are applicable to you √)

	Price/Value for money
	Close to where I stay
	Quality
	Variety
	I am given credit
	Other (please specify):

Supplementary file 3. Standards for Reporting Qualitative Research (SRQR) checklist.

O'Brien B.C., Harris, I.B., Beckman, T.J., Reed, D.A., & Cook, D.A. (2014). Standards for reporting qualitative research: a synthesis of recommendations. *Academic Medicine, 89(9)*, 1245-1251.

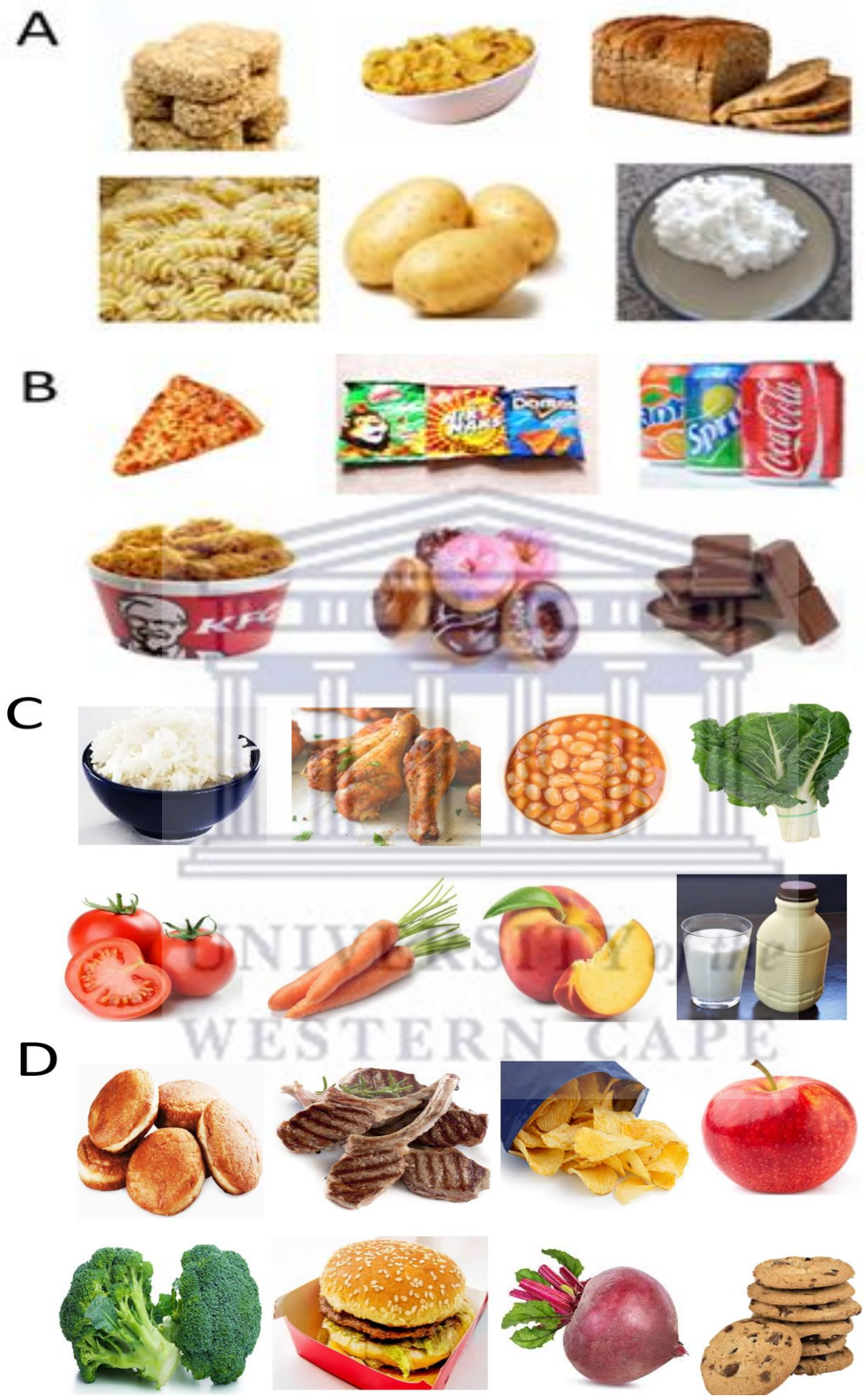
No. Topic	Item	Reported on page #
Title and abstract		
S1 Title	Concise description of the nature and topic of the study identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	Page 1
S2 Abstract	Summary of key elements of the study using the abstract format of the intended publication; typically includes objective, methods, results, and conclusions	Page 3
Introduction		
S3 Problem formulation	Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	• Introduction, paragraph 5, page 5 • Methods, page 7
S4 Purpose or research question	Purpose of the study and specific objectives or questions	Introduction, paragraph 5, page 5
Methods		
S5 Qualitative approach and research paradigm	Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., positivist, constructivist/interpretivist) is also recommended	Methods, Instrument development, page 7
S6 Researcher characteristics and reflexivity	Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, or transferability	Methods, page 9
S7 Context	Setting/site and salient contextual factors; rationale[a]	Methods, page 5-6.
S8 Sampling strategy	How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale[a]	Methods, page 5-6 & 9.

S9 Ethical issues pertaining to human subjects	Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Page 2 & Methods, page 7
S10 Data collection methods	Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale[a]	Methods, page 7-8
S11 Data collection instruments and technologies	Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Methods, page 7
S12 Units of study	Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	Figure 1, page 6 & Results, page 9-10.
S13 Data processing	Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/deidentification of excerpts	Methods, Data analysis page 8-9
S14 Data analysis	Process by which inferences, themes, etc., were identified and developed, including researchers involved in data analysis; usually references a specific paradigm or approach; rationale[a]	Methods, Data analysis page 8-9
S15 Techniques to enhance trustworthiness	Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale[a]	Methods, page 8
Results/Findings		
S16 Synthesis and interpretation	Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Results, page 9-15.
S17 Links to empirical data	Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Tables 4-9.
Discussion		

S18 Integration with prior work, implications, transferability, and contribution(s) to the field	Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Pages 15-18
S19 Limitations	Trustworthiness and limitations of findings	Page 18
Other		
S20 Conflicts of interest	Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Page 2
S21 Funding	Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Page 1

[a]The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Supplementary file 4. Exercise -Which row of foods shows a variety of food?



Supplementary file 5. Exercise – How would you describe the two plates?

Plate A

Plate B

Appendix 11: Translated focus group discussion guide

Appendix 11a: Focus group discussion guide (Afrikaans)

Fokus Groepbesprekingsgids

Opening:

• Goeie môre en dankie dat jy ingestem het om hierin (FGD) deel te neem. Ons waardeer jou tyd. My naam is ..... en dit is (stel ander mense in die kamer voor).

• Waarom gaan ons nie om die kamer en stel onsself voor nie?

Inleiding

• Verduidelik waaroor die studie gaan, watter inligting ons sal versamel, vertroulikheid, vrywillige deelname, risiko's en voordele.

- Jy is vandag hier genooi omdat ons 'n studie doen om die redes beter te verstaan waarom mense sekere kosse eet. Ons sal hierdie inligting gebruik om 'n pamflet te ontwikkel om mense te help om gesonde koskeuses te maak. Hierdie studie is deel van die Suid-Afrikaanse Diabetes voorkomings program studie waaraan u almal voorheen deelgeneem het.
- Ons sal eerstens 'n bespreking hê as 'n groep oor die tipe kos wat jy eet, asook die redes waarom jy hierdie kosse eet. Die bespreking sal ons ongeveer 90 minute neem om te voltooi. Daarna sal u 'n kort vraelys voltooi wat vrae vra oor wie die kos koop by die huis en waar die kos gekoop word.
- Inligting wat ingesamel word, sal streng vertroulik wees, jou naam sal nie gebruik word in enige van die verslae wat oor die studie geskryf sal word nie. Ons sal jou identifiseer deur 'n kode te gebruik en nie jou naam nie om jou identiteit te beskerm. Deelname aan hierdie studie is vrywillig. U kan kies om van die studie te onttrek sonder enige negatiewe gevolge.
- Daar is geen risiko's om deel te neem nie. As jy ongemaklik voel met enige van die vrae, hoef jy nie 'n antwoord te gee nie.
- Jy sal nie persoonlik voordeel trek uit hierdie studie nie, maar die inligting wat ons van jou kry sal ons help om beter te verstaan watter tipe uitdagings mense teekom wanneer hulle besluite oor kos keuses moet maak. Met die inligting wat ek van vandag by jou kry, sal ons 'n pamflet op gesonde koskeuses ontwikkel. As 'n teken van waardering sal jy R50 vir jou tyd ontvang.
- Laat deelnemers toe om vrae te vra en toestemmings vorms te teken.

• Begin die focus groep bespreking (volg die gids)

• Hierdie sessie sal opgeneem word met ‘n klanktoestel, omdat ons seker wil wees dat ons al jou kommentaar kry.

• Alles wat jy hier sê is vertroulik, en u name sal nie op die skriftelike rekord van ons sessie ingesluit word nie.

• Voel asseblief vry om elke vraag so eerlik as wat jy kan te beantwoord en onthou dat daar geen regte of verkeerde antwoorde op enige van die volgende vrae is nie

• Fasiliteerder om oor die grondreëls te gaan.

Onderwerpe

1. Kan u u tipiese dag van eet beskryf? Wat het u gewoonlik vir ontbyt, middagete en aandete?
1.1 Watter soort peuselhappies eet u gereeld?
2. Gee deelnemers 'n pak kaarte. Vra die deelnemers om deur die kaarte te kyk.

2.1 Kies twee kaarte met voedsel wat volgens u gesond is. Waarom dink jy is die kos gesond?

2.2 Kies twee kaarte met voedsel wat volgens u ongesond is. Hoekom dink jy is die voedsel ongesond?

3. Wat is u begrip van die eet van verskillende soorte kos? Wat dink ek aan as ek 'n verskeidenheid kos eet?

3.1 Vra die deelnemers om na die prentjie met rye kos te kyk. Watter ry kos het volgens u 'n verskeidenheid kos en waarom? (Antwoord C)

3.2 Verduidelik wat die eet van 'n variëteit beteken

- Om 'n verskeidenheid kosse te eet, beteken om uit elk van die voedselgroepe te eet (wys op die voedselgebaseerde dieetriglynfoto)

- Om elke dag 'n verskeidenheid middele te eet, insluitend voedsel uit twee of meer voedselgroepe.

- Om 'n verskeidenheid kosse te eet, beteken om voedsel op verskillende maniere voor te berei. Kan u 'n paar maniere noem waarop u voedsel kan voorberei?

- Verskeidenheid beteken ook die eet van verskillende kleure kos, veral verskillende kleure vrugte en groente.

3.3 Vra die deelnemers om weer na die prente met rye kos te kyk. Watter ry kos het volgens u 'n verskeidenheid kos en waarom? (Antwoord C)

4. Teen die muur is daar twee soorte borde met voedsel, hoe sou jy dit beskryf? Potensiële antwoorde: verskillende kosse, verskillende kleure op die bord, een bord meer kleurvol as die ander, verskeidenheid op een bord.

5. Hoe sou u die manier waarop u gedurende die maand eet, beskryf. Het u etes 'n verskeidenheid? Lyk u maaltye soos bord A of bord B of albei?

6. Dink u dit is moontlik vir u om daagliks 'n verskeidenheid voedsel te eet? Soos die kos in bord A? Probe: sou u die bord met verskillende soorte voedsel, verskillende kleure groente en vrugte, ens. Kon eet?) (Moontlike antwoord ja of nee?)

7. Wat is die faktore wat u voedselkeuses beïnvloed?

7.1 Individueel

a) Wat is individuele faktore wat u in ag neem wanneer u moet besluit wat u moet eet?
   Ondersoek : Eet wat beskikbaar is
   Eet wat goed smaak
   Geld / bekostigbaarheid
   Jou gesondheid
   Kosvoorbereiding, gemak en tyd
   Voedselstoorgeriewe
   Voedingskennis of kennis oor voedsel

7.2 *Interpersoonlike*

a) Hoe beïnvloed u gesin, man / lewensmaat, vriende en medewerkers u eet?
b) Hoe besluit u wat die gesin gaan eet?
   Ondersoek: Begroot u kos in u huishouding? Skryf jy 'n spyskaart neer?
c) Wie in u gesin is verantwoordelik vir die koop en kook?
d) Wie is die familielede wat invloed het op die soort kos wat in u huishouding gekoop en gekook word?

7.3 Gemeenskap

a) Ervaar u probleme om die soorte kos wat u wil koop te koop? (ondersoek: vervoeruitdagings, finansies, kry voorkeure).
b) Kan u die soorte voedselwinkels beskryf wat u in u gemeenskap het? Sou u sê dat hulle 'n verskeidenheid kosse verkoop? Koop u by hierdie winkels waarom, indien nie, waarom?
c) Wie in u gesin is verantwoordelik om kos te koop en te kook?
d) Wie in die gesin beïnvloed die soort kos wat in u huishouding gekoop en gekook word?

7.4 Samelewing

a) Hoe dink jy beïnvloed TV, advertensies en sosiale media wat jy eet?
b) Hoe het die koronavirus-pandemie u voedselkeuse en voedselaankope beïnvloed?

8. Wat kan dit vir u makliker maak om 'n verskeidenheid kosse te eet?

a) Wat sou u as individu vandag kon doen om 'n wye verskeidenheid kosse te eet?
b) Hoe dink jy kan voedselwinkels dit makliker maak om verskillende kosse te eet?
c) Watter verandering sou u in u gemeenskap wou sien wat dit vir almal makliker sou maak om 'n verskeidenheid kosse te eet?
d) Hoe dink die regering kan mense ondersteun om 'n verskeidenheid kos en gesonder kos te eet?

9. Hoe dink u beïnvloed die manier waarop u eet u lewensgehalte en gesondheid?

10. Hoe dink jy sal dit jou gesondheid beïnvloed as jy 'n verskeidenheid kos of bord A eet? Wat as u nie 'n variëteit hoe dink u word u gesondheid beïnvloed?

11. Voel u oor die algemeen dat u genoeg inligting het oor gesonde eetgewoontes en die maak van goeie voedselkeuses? (indien nie, wat is die beste manier om hierdie inligting te leer,

byvoorbeeld kliniek, dokter, dieetkundige / voedingsdeskundige, gemeenskapsgroepe, gemeenskapskombuis, kerkgroepe, skool, televisie, radio, sosiale media, mobiele app).

Eindigend:

• Hersien wat bespreek is

• Het u enige opmerkings en voorstelle gebaseer op wat ons vandag bespreek het?

• Volledige kort vraelys met deelnemers

• Sê dankie aan die deelnemers; teken vir koopbewyse

Appendix 11b: Focus group discussion guide (IsiXhosa)

Isikhokelo seNgxoxo yeQela

Ukuvula:

• Molweni kusasa kwaye ndiyabulela ngokuvuma ukuthatha inxaxheba kule ngxoxo (FGD). Siyalixabisa ixesha lakho. Igama lam ngu …… kwaye oku (yazisa abanye abantu egumbini).
• Kutheni singakhe sijikeleze igumbi sizazise?

Intshayelelo

Cacisa ukuba yintoni na isifundo, loluphi ulwazi esiza kuluthatha, imfihlo, ukuthatha inxaxheba ngokuzithandela, umngcipheko, izibonelelo. Vumela abathathi-nxaxheba ukuba babuze imibuzo kwaye basayine iifom zemvume.
Qalisa FGD - Namhlanje njengoko ngaphambili wawumchazela Ndingathanda ukuba sixoxe ngentlobo okutyayo njengomntu umntu nd izinto eziphembelela ukhetho ukutya kwakho .

- Ngolwazi endilufumana kuwe namhlanje siza kuphuhlisa incwadana yokukhetha ukutya okunempilo.
- Ngelixa ndikubuza imibuzo nje embalwa, …… ... izakuthatha amanqaku. Le seshoni iya kuba audio kubhalwe kuba sifuna ukuqiniseka kwaye zonke izimvo zakho.
- Yonke into oyithethayo apha iyimfihlo, kwaye amagama akho awazukufakwa kwirekhodi ebhaliweyo yeseshoni yethu.
- Nceda uzive ukhululekile ukuphendula umbuzo ngamnye ngokunyaniseka kangangoko unako kwaye ukhumbule ukuba akukho mpendulo ichanekileyo okanye engachanekanga kuyo nayiphi na imibuzo elandelayo.
- Umququzeleli wokwenza imithetho engaphantsi.

Imixholo

1. Ukuqhekeka komkhenkce / ukuzilolonga: Nika umntu ngamnye othatha inxaxheba ipakethe yamakhadi. Cela abathathi-nxaxheba ukuba bajonge amakhadi kwaye bachaze ukuba bacinga ntoni ngemini eneentlobo zokutya ezibonakala ngathi.

1.1 Kukuthini ukuqonda kwakho ngokutya iintlobo ngeentlobo zokutya? Vumela umthathi-nxaxheba ngamnye ukuba achaze kwaye achaze ukutya abakukhethileyo emakhadini.

1.2 Ngaba ucinga ukuba ukutya ukutya okwahlukeneyo kubandakanya nokutya ukutya okusempilweni okanye ukutya okungenampilo?

1.3 Usebenzisa amakhadi, kukuphi ukutya ocinga ukuba kusempilweni?

1.4 Usebenzisa amakhadi, kukuphi ukutya ocinga ukuba akunampilo?

2. Edongeni kukho amacwecwe amabini okutya , ungawachaza njani ?

Iimpendulo ezinokubakho: ukutya okwahlukileyo, imibala eyahlukileyo epleyitini, ipleyiti enye inombala ngakumbi kunenye , eyahlukileyo kwipleyiti enye .

3. Ungayichaza njani indlela otya ngayo phakathi enyangeni? Ngaba uyatya ukutya okujongeka njengeplate A okanye isitya B okanye umxube wazo zombini?

4. Ungathi zeziphi izinto ezinefuthe kwisigqibo sakho kumba wokukhetha into oza kuyitya?

Inkqubo:

- Izinto zomntu ngamnye- ukufikeleleka, ukuthanda izinto ozithandayo, ulwazi ngesondlo, lula, ukugcinwa kokutya
- Izinto zokunxibelelana- Impembelelo yosapho, izihlobo, umyeni / umntu osebenza naye
- Ekuhlaleni- Impembelelo yamaqela enkolo, indawo yokusebenzela, ukufikelela kwiivenkile zokutya, iivenkile zokutya kwindawo ohlala kuyo
- Ekuhlaleni- Impembelelo yenkcubeko, intengiso, imidiya yoluntu, ingaba isifo seCoronavirus sibe nefuthe njani kwinto oyityayo?

5. Ngaba ucinga ukuba kunokwenzeka ukuba utye ukutya okwahlukeneyo? Njengokutya kwipleyiti A?

Probe: Ngaba ubuya kukwazi ukwenza ipleyiti eneentlobo ezahlukeneyo zokutya, imifuno enemibala eyahlukeneyo kunye neziqhamo njlnjl.) (Impendulo enokubakho ewe okanye hayi?)

5.1 Yintoni enokwenza kube nzima okanye ikuthintele ekutyeni iintlobo ngeentlobo zokutya?

5.2 Yintoni enokwenza kube lula kuwe ukuba utye iintlobo ngeentlobo zokutya?

Inkqubo:

- Imali
- Amaxabiso okutya athotyiweyo
- Ulwazi olungcono lwesondlo
- Inkxaso evela kusapho / kubahlobo
- Ukwazi apho ukuthenga ukutya okufikelelekayo
- Ukufikelela kokutya okusempilweni ekuhlaleni & ukufikelela kukutya okusempilweni ezivenkileni okanye ubukho babathengisi.
- Izitiya zendlu / zoluntu
- Uncedo lukaRhulumente -iipasile zokutya / iinkqubo zoluntu

6. Ucinga ukuba ingayichaphazela njani impilo yakho xa ungatya ipleyiti A? Uthini ngeplate B?

7. Ucinga ukuba indlela otya ngayo ibuchaphazela njani ubomi bakho kunye nempilo yakho?

Ukuphelisa:

- Phinda ufunde ngokuxoxiwe
- Ngaba unazo naziphi na izimvo kunye neengcebiso ezisekwe kule nto sixoxe ngayo namhlanje?
- Ndingathanda ukunibulela nonke ngokwabelana nani ngezimvo zenu.

Appendix 12: Translated food procurement questionnaire

Appendix 12a: Food procurement questionnaires (Afrikaans)

Food procurement questionnaire (Afrikaans)

Datum: Kode

P	P	1				

Naam: Van:

Ouderdom:

1. In u huishouding, wie besluit meestal watter tipe voedsel gekoop moet word? (Tik alles op u van toepassing √)

	Myself
	My eggenoot / metgesel
	My kinders
	Ander lede van my gesin/ familie
	Ander:

2. In u huishouding, watter faktore beinvloed die voedsel wat geeet word? (Tik alles op u van toepassing √)

	Ek eet wat smaak lekker
	Ek eet wat beskikbaar is
	Gemak en tyd
	Familie en / of vriende
	Huishoudelike inkomste
	Voedselpryse
	Kultuur en / of godsdiens
	Jou gesondheid
	Kennis oor kos

3. In u huishouding, wie is meestal verantwoordelik vir die voorbereiding van die voedsel? (Tik alles op u van toepassing √)

	Myself
	My eggenoot / metgesel
	My kinders
	Ander lede van my gesin/ familie
	Ander:_____

4. Waar koop u familie meestal die voedsel? (Tik alles op u van toepassing √)

	Supermark
	Kruidenierswinkel

	Gerieflikheidswinkel /spaza winkel
	Ander:

5. Waar koop u u vrugte en groente? (Tik alles op u van toepassing √)

	Supermark
	Vrugte en groentemark
	Gerieflikheidswinkel /spaza winkel
	Straat verkoper
	Ander:

6. Hoe kom u tot by en vanaf die winkel? (Tik alles op u van toepassing √)

	Loop
	Bus
	Trein
	Taxi
	Private motor
	Loop & vervoer

7. Waarom kies u om by die betrokke winkel kos te koop? (Tik alles op u van toepassing √)

	Prys/Waarde vir geld
	Naby waar ek bly
	Kwaliteit
	Verskeidenheid
	Ek word krediet gegee
	Ander:

Appendix 12b: Food procurement questionnaires (IsiXhosa)

Food procurement questionnaire (IsiXhosa)

Umhla: Ikhowudi

P	P	1				

Igama: Ifani: Iminyaka yakho:

1. Kwikhaya lakho, ngubani oyena othatha isigqibo kakhulu sokuba kuthengwa hlobo luni lokutya? (Phawula konke okusebenzayo kuwe √)

	Mna
	Iqabane lam
	Bantwana bam
	Amanye amalungu osapho lwam
	Enye:

2. Kwikhaya lakho zeziphi izinto eziphembelela ukuba utya hlobo luphi lokutya? (Phawula konke okusebenzayo kuwe √)

	Nditya izinto ezimnandi
	Nditya okufumanekayo
	Ukusebenziseka kunye nexesha
	Usapho kunye / okanye nabahlobo
	Ingeniso yekhaya
	Amaxabiso okutya
	Inkcubeko kunye / okanye inkolo
	Impilo yakho
	Ulwazi malunga nokutya

3. Kwikhaya lakho, ngubani oyena unoxanduva lokulungisa ukutya? (Phawula konke okusebenzayo kuwe √)

	Mna
	Iqabane lam
	Bantwana bam
	Amanye amalungu osapho lwam
	Enye:

4. Kakhulu ukuthenga phi ukutya kosapho? (Phawula konke okusebenzayo kuwe √)

	Supermarket
	Grocery store
	Convenience store/spaza shop
	Enye:

5. Uyithenga phi ifruit ne veg? (Phawula konke okusebenzayo kuwe √)

	Supermarket
	Fruit and vegetable market
	Convenience store/spaza shop
	Street vendor/ umthengisi wesitalato
	Enye:

6. Uya uye uphinde ubuye ngantoni kwivenkile yokutya? (Phawula konke okusebenzayo kuwe √)

	Ndihamba ngenyawo
	Ibhasi
	Uloliwe
	Iitekisi
	Imoto
	Ndihamba ngenyawo ndiphende ndikhwele

7. Yintoni ebangela ukuba ukhethe ezi venkile? (Phawula konke okusebenzayo kuwe √)

	Ixabiso/Ixabiso lemali
	Kufutshane nalapho ndihlala khona
	Umgangatho
	Okuninzi/Iindidi ukukhetho kuzo
	Ndinikwe ikhredithi
	Enye:

Appendix 13: Standard Operating Procedures

Standard operating procedures for focus group discussions under COVID-19 pandemic

Purpose

The purpose of this guide is to provide the procedures to be followed to protect the health andsafety of research staff and participants during data collection under COVID-19 pandemic.

1. Guidelines for research staff

- All research staff must perform daily self-monitoring for symptoms by using the COVID-19 self-assessment tool. If individuals feel unwell, they should refrain from leaving home or if the feel unwell during fieldwork they should stop work immediately,notify the researcher and go home.
- All staff must be screened and have the temperature checked upon entering the SAMRCNIVS Building.
- If any staff is experiencing symptoms, they should self-quarantine for at least 14 days/until recovered.
- All research staff will have to keep a record of where and when and who they have travelled with.
- A record of the locations of where participants are fetched will be kept.

2. Guidelines for Vehicles

- The vehicles frequently touched surfaces such as the door handles and frames seat belts, steering wheel, window handles must be thoroughly cleaned before and after use by using items such as disinfectant wipes, hand sanitizer with at least 70-80% alcohol and paper towel or clean cloth.
- No more than one other member the research staff should travel with the driver to pick- up participants. The research member will ensure that participants are screened and have their hands sanitized before entering the vehicle.
- The driver, research member and participant must wear a face mask.
- The car ventilation must be set to fresh air only; windows must be open to ensure fresh air flow.
- An alcohol based hand sanitizer must be used immediately before and after each trip.
- A disposable garbage bag must be present in the vehicle.
- Each person must carry their own personal belongings during each trip.

3. Guidelines for Focus Group Discussion Room

- The focus group discussion room must be thoroughly cleaned and disinfected before and after each session.
- Chairs in the room must be placed 1 meter apart to ensure physical distancing from each participant and facilitator.
- An alcohol based hand sanitizer will be placed at the entrance of the focus group discussion room.
- All the windows must be open for the duration of the discussion to ensure clean air flow.
- All research staff and participants must wear a face mask at all times.

- All data collection items such as pens, markers, notebooks, audio recorder must be sanitised before and after each focus group discussion session.
- Each research staff member and participant will be provided with their own pens and pencils to avoid sharing of items.
- After data collection all staff must thoroughly wash their hands with soap (at least 20 seconds).

4. The day before a focus group discussion

- Participants will be called to remind them of the focus group discussion session.
- Participants will be informed that should they feel ill or be exhibiting any Covid-19 symptoms they should stay home.

5. The day of the focus group discussion

- Before entering the vehicle, the participants will be required to complete a self- assessment of their health status. If they answer Yes to any of the questions they will not be allowed inside the vehicle. Temperatures of each participant will also be taken.
- Self-assessment questions include:
  - Have you travelled outside the Western Cape in the past 14 days?
  - Do you have any of the following symptoms? (Fever, cough, sore throat, aches and pains, runny nose & shortness of breath).
  - Has anyone in your house or anyone whom you had recent contact with been diagnosed with COVID-19?
- Each participant must wear a facemask before entering the vehicle, if they don't have a PPE facemask, one will be provided.
- Each participant's hands must be sanitized before entering the vehicle.

6. Arrival of participants to the NIVS Building

- Each participant must sanitize hands with an alcohol-based sanitizer upon entering the building.
- Each participant must complete the COVID-19 screening form and have their temperature taken.
- Each participant will have to sign the visitors register at the reception desk.
- After all participants have completed the register and screening, a member of the research staff will escort them to the focus group discussion room and have them seated 1 meter apart.

Appendix 14: Focus group codebook

Broad Theme: Eating habits and nutrition knowledge	
Code family	Definition
Eating habits _mealtimes	Foods typically consumed at mealtimes.
Eating habits_snacks	Snacks consumed between meals.
Eating habits_quality of life	Perceived impact of eating habits on health and quality of life.
Eating habits_COVID19	Description of food practices and eating habits during COVID19 lockdown.
Healthy food_perceptions	Perceptions on what is healthy food according to food types and nutrients e.g fruits and vegetables, dairy, lean meats, vitamins, minerals, fiber, low calorie, low fat, low sugar, low salt. Reason why foods perceived as healthy e.g parent/nurse/doctor told them food is healthy.
Unhealthy food_perceptions	Perceptions on what is unhealthy food according to food types and nutrients, e.g foods high in sugar, fat and calories, fried foods, fizzy drinks, chips and sweets etc. Reason why foods perceived as unhealthy food.
Nutrition knowledge_gaps	Perceptions on whether there is enough information about healthy eating and making good food choices.
Nutrition knowledge_source of information	Current source of nutrition information e.g clinic, doctor, internet, nurse, neighbour etc.
Nutrition knowledge_nutrition education lessons	What participants want to learn about healthy eating and making good food choices e.g food preparation skills, identifying healthy foods, portion control.
Nutrition knowledge_Access recommendations	Participants recommendations to improve access to nutrition information in community e.g schools, clinics, talks at community hall.
Broad Theme: Dietary diversity perception	
Code family	**Definitions**
Dietary diversity definition	Perception or interpretation on the meaning of the term dietary diversity.
Dietary diversity_rows	Which row was identified as having dietary diversity using food pictures in rows and why row was chosen.
Dietary diversity_plates	Perception of dietary diversity on a plate. Describing plates by distinguishing between different food groups, different colours of foods, different cooking methods.
Dietary diversity_daily possible	Perception on ability to consume a diverse diet daily or during the month.
Dietary diversity_Perceived benefits	Perceived health benefits of consuming diverse diet including meeting nutrient needs, better physical appearance, body weight size, disease prevention, lower cholesterol, increased energy levels, mental alertness, low medication usage and long life.

Dietary diversity_Perceived severity	Perceived consequences on health for not consuming a diverse diet e.g get illness, malnutrition, high sugar levels, high cholesterol, less energy.
Broad Theme: Individual factors	
Code family	**Definitions**
Financial status_barrier	Lack of individual/household income, job loss, no access to social grants, unemployment influence on food choice.
Financial status_enabler	Individual/household Income, jobs, access to social grants, employment influence on food choice.
Individual_Time_barrier	Influence of lack of time and convenience on food choice and food preparation.
Individual_Time_enabler	Influence of time and convenience on food choice and food preparation.
Individual_Taste Preferences_barrier	Preference for the taste of foods perceived as unhealthy such as fatty foods and high sugar foods/beverages. Food likes and dislikes influencing food choice.
Individual_ Taste Preferences _enabler	Preference for the taste of foods perceived as healthy or unhealthy such as fruits/vegetables, whole grains, lean meats, fatty foods and high sugar foods. Food likes and dislikes influencing food choice.
Individual_Dietary restrictions_barrier	Having health condition or health concerns that requires eating or avoiding certain foods.
Individual_Dietary restrictions_enabler	Having health condition or health concerns that requires eating or avoiding certain foods.
Broad Theme: Social influences	
Code family	**Definitions**
Family_structure_barrier	Influence of family size/ lone parent/ husband/ children/ extended family on food choice.
Family_structure_enabler	Influence of family size/ lone parent/ husband/ children/ extended family on food choice.
Family_Taste Preferences_barrier	Influence of family members food preferences (including meal preparation methods) on foods bought and prepared in the household.
Family_Taste Preferences_enabler	Influence of family members food preferences (including meal preparation methods) on foods bought and prepared in the household.
Family_meal preparation and grocery decision making	Decision making on who does food purchasing and where food is bought and who prepares meals. Usage of grocery money saving strategies such as menu/meal planning and food budgeting
Broad Theme: Physical environment influences	
Code family	**Definitions**

Community_Food outlet location_barrier	Accessibility and availability barriers to both formal and informal stores (e.g shops are not available inside the community, can't walk to shops, you have to travel far to buy groceries).
Community_Food outlet location_enabler	Walkability, transportation, proximity (distance) to food stores both formal and informal.
Community_Retail food environment	Perceptions on the type of food stores in the community, includes both formal and informal (food stores/vendors/stalls), food availability, variety, affordability (prices/subsidized prices, discounts, sales), quality of food sold.
Community_Retail food prices	Perceptions on the affordability (prices/subsidized prices, discounts, sales) of food sold in both formal and informal.
Retail food environment_convenience stores	Perception of variety, affordability, quality of food sold in convenience stores/house shops.
Retail food environment_stalls	Perception of variety, affordability, quality of food sold in convenience stalls/vendors.
Community_food aid_barrier	Lack of community soup kitchens, community gardens, non-profit organizations and religious organizations and other sources of food aid in the community.
Community_food aid_enabler	Availability of community soup kitchens, community gardens, non-profit organizations and religious organizations and other sources of food aid in the community.
Community_Home garden	Perceptions on and impact of home gardens on food choices.
Broad Theme: Societal influences	
Societal_COVID19_Eating habits	Description of food practices and eating habits during COVID19 lockdown.
Societal COVID 19_food prices	Perception of food prices during COVID 19 lock down.
Societal_COVID19 food aid_barrier	Lack of food aid and support from non-profit organizations, religious organizations, and government during COVID19 pandemic.
Societal_COVID19 food aid_enabler	Food aid and support received from non-profit organizations, religious organizations, and government during COVID19 pandemic.
Societal_Media_barrier	Negative influence of media on food choices. Media includes tv, radio advertising, marketing, magazines, newspapers, catalogues, and Facebook. Foods advertised during various seasons (summer, winter, holidays etc).
Societal_Media_enabler	Positive influence of media on food choices. Media includes tv, radio advertising, marketing, magazines, newspapers, catalogues, and Facebook. Foods advertised during various seasons (summer, winter, holidays etc).

Broad Theme: Perceived facilitators for diverse diet and food choice	
Code family	**Definitions**
Facilitator_Budgeting for groceries	Usage of grocery money saving strategies such as menu/meal planning and food budgeting
Facilitator_income generation	Employment, Job creation, entrepreneurship
Facilitator_Lower food prices	Strategies that food stores can use to lower the cost of food e.g., sales/discounts/promotions, subsidized food items, store pricing policies
Facilitator_Community projects & home gardens	Home, community, and school gardens, community kitchens.
Facilitator_government support	Participants recommended strategies that can be implemented by government and policy makers to enable participants to consume a diverse diet/healthy foods.

Appendix 15: Draft nutrient density pamphlet

A Guide to Identify Nutrient Dense and Affordable Foods

South African Medical Research Council: Francie van Zijl Drive, Parow Valley, Cape Town, Po Box 19070, 7505 Tygerberg, South Africa Phone: +27 21 938 0911 E-mail: info@mrc.ac.za

NUTRIENT DENSE FOODS

- Nutrient dense foods are foods with a high amount of healthy nutrients in comparison to calories.
- Nutrient dense foods include fruits, vegetables, whole-grains, lentils, beans, soya, lean meats, nuts and seeds, fortified maize meal and bread.
- Eating more nutrient dense foods could prevent weight gain, promote heart health, and reduce the chances of developing diabetes, and cancer.

ENERGY DENSE FOODS

- Energy dense foods are foods with a high number of calories for their weight or volume.
- Energy dense foods are not only high in energy but are also high fat and/or sugar.
- Eating too much energy dense foods could lead to weight gain, poor heart health and the development of diabetes.

1200 calories
Low energy density
Meals For The Entire Day

Nutrient dense

VS

1200 calories
High energy density
One Meal

Nutrient poor
& Energy dense

What is a calorie?

- A calorie is a unit measure for energy.
- The recommended daily calorie intake is 2000 calories a day for adults.

Reference: Drewnowski A, Fulgoni VL. Nutrient profiling of foods: creating a nutrient-rich food index. Nutrition reviews. 2008;66 1:23-39

Buy more of these nutrient dense foods

- ✓ Fruits and vegetables
- ✓ Dried beans, peas & soya
- ✓ Fortified bread, maizemeal & cereals
- ✓ Organ meats (liver, giblets, heart)
- ✓ Chicken
- ✓ Fish/tinned fish
- ✓ Eggs
- ✓ Lean red meat
- ✓ Low fat dairy products

Avoid buying these energy dense foods

- ✗ Fizzy cold drinks
- ✗ Sweets, chocolates & cakes
- ✗ Ice cream
- ✗ Chips
- ✗ Pies & samosas
- ✗ Fried / battered foods
- ✗ Processed meats (sausages, Vienna's, polony, Russians)
- ✗ Hard fats e.g brick margarine, holsum

Appendix 16: Supermarket Food Checklist

Supermarket Food list

Date: Supermarket:

Food Groups	Brand name	Unit/s	Unit price (R/unit)
Grains, white roots, and tubers			
Brown bread			
White bread			
Maize meal (Super)			
Brown rice (long, wholegrain)			
White rice			
Morvite original			
Oats			
Corn Flakes			
Bran Flakes			
Weetbix			
Noodles			
Pasta (Macaroni/Spaghetti)			
Pasta wholewheat			
Samp			
Samp & beans			
Roti			
White potato			
Pulses (beans, peas & lentils)			
Baked beans			
Lentils, whole			
Split peas			
Sugar beans			
Soya mince (Mutton)			
Nuts & seeds			
Peanuts unsalted			
Peanuts salted			
Dairy			
Cheddar cheese			
Gouda cheese			
Processed cheese			
Full cream milk (UHT)			
Low fat milk (UHT)			
Maas			
Low fat fruit yoghurt (Strawberry sweetened)			
Plain yoghurt (double cream)			
Meat, poultry & fish			
Frozen fish (hake)			
Fish medium fat			
Pilchards in tomato sauce			
Tuna, shredded tinned in water			
Chicken breast			
Chicken pieces (fresh)			

Food Groups	Brand name	Unit/s	Unit price (R/unit)
Chicken feet (Heads & feet)			
Chicken liver, frozen			
Bacon, Shoulder			
Beef brisket			
Beef chuck (Stewing beef)			
Beef mince regular			
Beef mince lean			
Beef patty			
Boerewors			
French polony			
Mutton Shoulder			
Mutton chop Lamb leg chop			
Pork chops (Shoulder)			
Viennas (Red Vienna's)			
Eggs			
Chicken egg (Large)			
Dark green vegetables			
Spinach			
Other vitamin A rich fruits & vegetables			
Butternut			
Carrot			
Mango			
Peach			
Pumpkin (diced)			
Yellow fleshed sweet potato			
Other vegetables			
Beetroot			
Broccoli (Frozen)			
Cabbage			
Cauliflower (frozen)			
Cucumber			
Gem Squash			
Green beans (cut green beans, frozen)			
Green pepper			
Lettuce			
Mixed vegetables (frozen)			
Onion			
Peas (frozen)			
Tomatoes			
White sweet potato			
Other fruits			
Apple (Golden delicious)			
Avocado			
Banana			
Grapes (imported) (Red seedless)			
Naartjie			
Nectarine			
Orange			
Pear			
Pineapple			

Food Groups	Brand name	Unit/s	Unit price (R/unit)
Plum (imported)			
Oils & fats			
Butter			
Coffee creamer			
Canola oil			
Sunflower oil			
Brick margarine			
Tub margarine			
Mayonnaise			
Salad dressing (Greek)			
Peanut butter			
Peanut butter (unsalted/unsweetened)			
Savoury and fried foods			
Chicken Pie			
Potato Crisps (creamy cheddar)			
Doughnuts			
French fries			
Maize chips			
Popcorn seeds			
Samosas (beef)			
Vetkoek			
Sweets			
Cakes (Queen cakes)			
Chocolate slab plain (milk chocolate)			
Fruit gummy candies (wine gums)			
Ice cream (Vanilla)			
Jam (apricot)			
Brown Sugar			
White Sugar			
Biscuit with filing (Lemon creams)			
Plain biscuit			
Sweet, hard			
Sugar-sweetened beverages			
Squash			
Cordial diet			
Dairy fruit mix			
Energy drink			
Fruit juice			
Fizzy Drink			
Diet fizzy drink			

Appendix 17: Reviewer comments and author responses for published manuscript four

Samukelisiwe Madlala | SAMRC

From: Journal of Nutritional Science <onbehalfof@manuscriptcentral.com>
Sent: Monday, December 5, 2022 5:23 PM
To: Samukelisiwe Madlala | SAMRC
Cc: Samukelisiwe Madlala | SAMRC; Jillian Hill | SAMRC; Ernesta Kunneke; Mieke Faber | SAMRC
Subject: [EXTERNAL SENDER] Journal of Nutritional Science - Decision on JNS-RA-22-0174

05-Dec-2022

Dear Miss Madlala,

Thank you for submitting your manuscript entitled "Nutrient density and cost of commonly consumed foods: A South African perspective." to the Journal of Nutritional Science. I have now received the editorial review of your paper and am pleased to inform you that it should be acceptable for publication in JNS, subject to satisfactory minor revisions.

Comments from a member of the Editorial Board and referee(s) are included at the foot of this letter; these should be carefully considered when preparing the revised version of your manuscript.

Please submit a copy of the revised manuscript, highlighting (directly in the text using red font) the changes that you have made, and detailing your response to the comments in the box provided. If your paper includes figures or tables that remain unaltered in the revised paper, these will need to be uploaded again.

To speed up the next stages of review, when preparing your revised manuscript please note the following:

1] All references should follow Vancouver style and be numbered consecutively in the order in which they first appear in the text using superscript Arabic numerals in parentheses. (Do not use the author-date referencing system.)
2] Figures should be supplied as separate electronic files. Figure legends should be grouped in a section at the end of the manuscript text.
3] Tables should be placed in the main manuscript file at the end of the document, not within the main text.
4] Your manuscript should include an acknowledgements section between the end of the main text and the references section setting out a) any conflicts of interest, b) any funding received, c) all authorship contributions.
5] Please check the accuracy of all spelling and grammar.

Please upload all the final files in the required formats via the online system, using the following link:

*** PLEASE NOTE: This is a two-step process. After clicking on the link, you will be directed to a webpage to confirm. ***

https://mc.manuscriptcentral.com/jns?URL_MASK=b08c8730f1234e418ae5bab070ddba5c

You may also log in with your user ID and password at https://mc.manuscriptcentral.com/jns and access your Author Centre, where you will find your manuscript in the folder "Manuscripts With Decisions" on your author dashboard; click "create revision" and then follow the steps on the screen.

Please also upload a completed publication agreement form with your revised paper. Please note that this license will not be transferred to the Publisher unless your article is accepted in the journal.

https://www.cambridge.org/core/journals/journal-of-nutritional-science/information/author-publishing-agreement

If English language editing has been requested in the below comments, we list a number of third-party services specialising in language editing and/or translation. Use of any of these services is voluntary, and at your own expense.

https://www.cambridge.org/core/services/authors/language-services

Thank you for submitting your interesting work to the Journal of Nutritional Science. We look forward to receiving the revised version shortly.

Yours sincerely,

Prof. Paul Trayhurn
Editor-in-Chief, Journal of Nutritional Science
jns.edoffice@cambridge.org

Comments to Author:

Abstract - brief details on how costs from the three supermarkets were used to determine cost of a food type.

Introduction - sets the scene well, introducing the reader to the South African context.

Methods - well described on the whole with two issues to highlight.
1. The description of how costs are obtained is not clear - in the methods, the authors refer taking to the lowest cost (lines 81-83). In the discussion, they refer to taking an average (lines 277-8). Please clarify in the methods.
2. I'm not clear on the value of reducing all 166 food types into 7 food groups and focussing the results on those as so much nuance is lost. Whilst dietary guidelines will no doubt focus on those 7 food groups it might still be helpful for consumers to know which items within those 7 food groups are affordable wihlst being of the best nutritional value? This is relegated to the supplementary information it seems.

Results - the authors refer to 'healthier foods [were the most expensive sources of energy]' what do they mean by 'healthier'?

Discussion - again well written. Describes how the current study fits in with existing literature and presents a sensible conclusion.

Tables: Add the South African context to the headings. Also for the international reader it would be helpful to explain some of the lesser known foods such as 'vienna sausage', 'Samp', 'Vetkoek'

Full instructions for contributors can be found at:
http://journals.cambridge.org/action/displayMoreInfo?jid=JNS&type=ifc

9 December 2022

Manuscript ID: JNS-RA-22-0174

Manuscript title: Nutrient density and cost of commonly consumed foods: A South African perspective.

Thank you for the opportunity to address the comments from the Editor and Reviewers. Revisions to the manuscript are indicated by red font. Herewith the response to each of the comments/suggestions as provided by the Reviewers.

- Comment 1: Abstract - brief details on how costs from the three supermarkets were used to determine cost of a food type.

  Our Response:

  Thank you for this comment. Due to word count restrictions, details on the cost were only briefly described. On page, line 18 – 20 sentence was revised to provide a bit more clarity on how the costs from the supermarkets were used. "Food prices were obtained from the websites of three national supermarkets and the average cost per 100 g edible portion was used to calculate cost per 100 kcal (418 kJ) for each food item." More details are added in the methods section of the manuscript (see page 4, line 80 – 87).

- Comment 2: Introduction - sets the scene well, introducing the reader to the South African context.

  Our Response:

  Thank you for your positive feedback on the introduction.

- Comment 3: Methods - well described on the whole with two issues to highlight.

  1. The description of how costs are obtained is not clear - in the methods, the authors refer taking to the lowest cost (lines 81-83). In the discussion, they refer to taking an average (lines 277-8). Please clarify in the methods.

  2. I'm not clear on the value of reducing all 166 food types into 7 food groups and focusing the results on those as so much nuance is lost. Whilst dietary guidelines will no doubt focus on those 7 food groups it might still be helpful for consumers to know which

items within those 7 food groups are affordable whilst being of the best nutritional value? This is relegated to the supplementary information it seems.

Our Response:

Thank you for your comments on the methods section and rising these two issues.

1. The description of how costs of foods were obtained has been revised for clarity in the methods section and discussion.
   [Page 4, line 80 – 87]
   "Food prices were collected for Shoprite first, which generally is cheaper than the other two supermarkets. For packaged food, the price for the brand with the lowest cost was collected. For the other two supermarkets, the price for the same brand used for Shoprite was collected. Only regular prices were recorded, not sale/promotional pricing. Food prices were recorded in ZAR ($0.06). For each food item, the average of the prices collected from the supermarkets was used to calculate the cost (ZAR) per 100 g edible portion using yield factor and retention factors to adjust for preparation and waste [33], which was then used to calculate cost per 100 kcal. Energy density was calculated per 100 g edible portion and per 100 kcal."

2. We agree that it is helpful for consumers to know which food items within the food groups are affordable and have the best nutritional value. The aim of the study was partly to identify foods within food groups with the best nutritional value per cost hence the 116 food types were categorized into the seven food groups in the food based dietary guidelines. Table 3 on page 19 in the main manuscript file shows foods with the best nutritional value per cost within all seven food groups. sugar. In addition, some food groups in Table 3 had subcategorizes; starchy foods group subcategories were fortified, and unfortified starchy foods and vegetables and fruits food group subcategories were vitamin A rich vegetables and fruits, other vegetables, and other fruits. Figures 4-6 displays the foods within healthy food groups with the best nutritional value for cost. The supplementary files only show the ranking according to energy density, nutrient-to-price ratio per price per 100kcal and 100g of the foods without classifying them into food groups.

- Comment 4: Results - the authors refer to 'healthier foods [were the most expensive sources of energy]' what do they mean by 'healthier'?

Our Response:

Thank you for your comment. Healthier foods refer to foods with a high nutrient density score but high energy cost. Please see amendment on page 6, line 148-149, sentence revised to read "Healthier foods such as vegetables and fruits, lean meat, fish and chicken were the most expensive sources of energy."

- Comment 5: Discussion - again well written. Describes how the current study fits in with existing literature and presents a sensible conclusion.

  Our Response:

  Thank you for your positive feedback on the discussion.

- Comment 6: Tables- Add the South African context to the headings. Also, for the international reader it would be helpful to explain some of the lesser known foods such as 'vienna sausage', 'Samp', 'Vetkoek'.

  Our Response:

  Thank you for your suggestion. The headings of tables in the manuscript and supplementary files have been revised to include South African context (indicated as "selected South African foods" in red font). Footnotes have been added to tables to explain lesser known foods such as 'vienna sausage', 'Samp', 'Vetkoek'.

Samukelisiwe Madlala | SAMRC

From:	Journal of Nutritional Science <onbehalfof@manuscriptcentral.com>
Sent:	Monday, December 19, 2022 7:21 PM
To:	Samukelisiwe Madlala | SAMRC
Cc:	Samukelisiwe Madlala | SAMRC; Jillian Hill | SAMRC; Ernesta Kunneke; Mieke Faber | SAMRC
Subject:	Possible-Spam [EXTERNAL SENDER] Journal of Nutritional Science - Decision on JNS-RA-22-0174.R1

19-Dec-2022

Dear Miss Madlala,

We have now been able to assess the revised version of your manuscript entitled "Nutrient density and cost of commonly consumed foods: A South African perspective.", and I am very pleased to tell you that it has been accepted for publication in the Journal of Nutritional Science.

As JNS is an Open Access journal you are responsible for paying the Open Access article processing charge (APC) of US$1,760/£1,100 plus VAT where applicable. You will shortly be contacted by CCC-Rightslink who are acting on our behalf to collect the APCs, please follow their instructions in order to avoid any delays in publication. If you receive a suspicious request for payment, please contact the Editorial Office directly. For further information on copyright and publication charges, including waivers, please see https://www.cambridge.org/core/journals/journal-of-nutritional-science/information/instructions-contributors#copyrightandpublicationcharges

If you or your institution are planning to issue a press release for this article, please inform the Editorial Office at jns.edoffice@cambridge.org. We also promote articles via Twitter, so if you'd like us to retweet your promotional post tag us directly at @NutritionSoc and @CUP_med_health. For more information on how you can promote your work via social media, please visit our social media guide here: http://ow.ly/bhZY30avSus.

The Nutrition Society welcomes new members world wide at all stages of their career, and offers a variety of member benefits. If you would like to become a member of the Nutrition Society, please visit our website here: https://www.nutritionsociety.org/become-member.

Thank you for submitting your interesting study to the Journal of Nutritional Science.

Yours sincerely,

Prof. Paul Trayhurn
Editor-in-Chief, Journal of Nutritional Science
jns.edoffice@cambridge.org

Appendix 18: Media coverage on manuscript four

- Chambers, D. (2023). "SA scientists say pulses – not fruit and veg – have the top nutritional bang for your buck". *NEWS24,* 9 Feb. Available at: https://www.news24.com/life/wellness/diet/this-is-what-you-should-eat-to-get-maximum-nutrition-at-minimum-cost-2023-2 [Accessed 9 February 2023]
- Editor. (2023). "Fortified staple foods best nutritional value for money – SA study." *JUTA Medical Brief*, 15 Feb. Available at: https://www.medicalbrief.co.za/fortified-staple-foods-best-nutritional-value-for-money-sa-study/ [Accessed 22 May 2023].