INVESTIGATING AND MAPPING OUT THE FORMAL URBAN FOOD ENVIRONMENT AND DIET QUALITY OF WOMEN OF REPRODUCTIVE AGE WITHIN THE CITY OF JOHANNESBURG, SOUTH AFRICA

by

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DECLARATION

I, **Kovania Naidoo (student number: 67891055)** hereby declare that the dissertation with the title: **Investigating and mapping out the formal urban food environment and diet quality of women of reproductive age within the City of Johannesburg, South Africa** which I hereby submit for the degree of **Master of Consumer Science** at the University of South Africa, is my own work and has not previously been submitted by me for a degree at this or any other institution.

I declare that the dissertation does not contain any written work presented by other persons whether written, pictures, graphs or data or any other information without acknowledging the source.

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I declare that I have not copied and pasted any information from the Internet, without specifically acknowledging the source and have inserted appropriate references to these sources in the reference section of the dissertation.

I declare that during my study I adhered to the Research Ethics Policy of the University of South Africa, received ethics approval for the duration of my study prior to the commencement of data gathering, and have not acted outside the approval conditions.

I declare that the content of my dissertation has been submitted through an electronic plagiarism detection program before the final submission for examination.

Student signature:

Date: 27 January 2024

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SUMMARY

Background: The health of WRA is important since evidence shows that the diet quality and nutritional status of women, not only during pregnancy but also prior to pregnancy, affects the health of her offspring. One of the major influencing factors to these undesirable conditions is a poor diet quality. Food environments play a significant role in diet quality.

Aim: This study sought to investigate the association between the formal urban food environment and diet quality of WRA within the city of Johannesburg, South Africa.

Methods: In this cross-sectional study, WRA attending the Discoverers Community Health Centre (DCHC) in Roodepoort for family planning or antenatal care were recruited. Socio-demographic data were collected using interviewer-administered questionnaires. Body weight and height measurements were collected from non-pregnant women and mid-upper arm circumference (MUAC) from all women. Diet history was obtained using a multiple-pass 24-hour dietary recall method. Diet quality was measured in two ways: the Dietary Diversity Score (DDS) to categorise scores into the Minimum Dietary Diversity for Women (MDD-W) categories; and the Rapid Eating Assessment for Participants – Shortened Version (REAP-S) survey. The food environment was also measured in two ways: the modified Retail Food Environment Index (mRFEI) and measuring the median Euclidean distance from participant residential addresses to food retailers (grocery stores and fast-food outlets).

Results: The study participants consisted of 427 WRA (142 non-pregnant and 285 pregnant) residing in the Roodepoort area. The mean age of participants was 29.8±6.5 years. Almost half were single (49 %), and although most of the participants had good education (78 % completed matric or a tertiary education), more than half were unemployed (53 %) and a third receiving social grants (33 %). The REAP-S survey results showed that the participants had a moderate diet quality based on dietary behaviours (REAP-S score = 27.1±3.3), with non-pregnant women having a lower REAP-S score than pregnant women (26.5±3.6 vs. 27.3±3.2). It was found that the study population had poor dietary diversity (DDS = 4.1±1.4) with 64 % of the study population not meeting the MDD-W (60 % pregnant and 72 % non-pregnant not meeting the MDD-W). The study found a correlation between the two diet quality scores ($r = 0.159$ $p = 0.001$) indicating the two measures had similar outcomes of diet quality. The environment was found to be an obesogenic food environment indicated by a low mRFEI score (31 %). The median distance from the study participants' residential addresses to grocery stores was 337.6 (193.5–594.2) m and to fast-food outlets was 230.5 (141.4–416.6) m which indicates that a grocery store is as accessible as a fast-food outlet and that consumers may choose to visit either when visiting a food outlet. The study found no associations of either diet quality score with the mRFEI score; or either diet quality score and the median distance to food retailers (grocery stores and fast-food outlets). Even so, many participants were overweight with the MUAC results indicating that 30 % may be obese and the BMI results of non-pregnant women indicating that the majority were overweight or obese (73 %).

Conclusion: The study found that the participants live in an obesogenic food environment, majority did not reach the MDD-W and most non-pregnant participants were overweight or obese indicating that the food environment may have an impact on participant food choices, diet quality and thereby overall health, even though our results did not show an association. Several reasons are possible for our results showing no association between the diet quality and the food environment scores, including measuring a homogenous environment where there is little range of food exposure, as well as the study not considering the impact of the informal food environment (e.g. street vendors) on food choices. The health of WRA is important for the future generation's health since evidence shows that nutritional status of women not only during pregnancy but also prior to pregnancy affects offspring health. It is therefore vital that the influence of the food environment on diet quality be fully understood and measures be taken to improve the health and well-being of WRA.

Keywords: Diet quality; formal urban food environment; women of reproductive age (WRA); dietary diversity score (DDS); minimum dietary diversity for women (MDD-W); modified Retail Food Environment Index (mRFEI); Rapid Eating Assessment for Participants – Shortened Version (REAP-S)

OPSOMMING

Agtergrond: Die gesondheid van vroue van vrugbare ouderdom (VVO) is belangrik omdat daar bewys is dat die dieetkwaliteit en voedingstatus van vroue, nie slegs tydens maar ook vóór swangerskap, die gesondheid van haar kinders beïnvloed. Een van die sleutelfaktore wat hierdie ongewenste toestande beïnvloed is swak dieetkwaliteit. Voedselomgewing speel ’n belangrike rol by dieetkwaliteit.

Doel: Hierdie studie het gepoog om die assosiasie tussen die formele stedelike voedselomgewing en dieetkwaliteit van VVO in die stad Johannesburg, Suid-Afrika, te ondersoek.

Metodes: VVO wat die Discoverers Gemeenskapsgesondheidsentrum in Roodepoort vir gesinsbeplanning of voorgeboortesorg besoek het, is vir hierdie deurnee-studie gewerf. Die sosio-demografiese data is met behulp van onderhoudvoerder-geadministreerde vraelyste ingesamel. Liggaamsgewig en lengtemetings van nie-swanger vroue, sowel as die omtrek van die middel-boarms (OMBA) van al die vroue, is geneem. Dieetgeskiedenis is met behulp van ’n meervoudige toegang, 24-uur dieet-herroepmetode verkry. Dieetkwaliteit is op twee maniere gemeet: die Telling vir Dieetdiversiteit (TDD) om tellings in die kategorieë van die Minimum Dieetdiversiteit vir Vroue (MDD-V) en die Vinnige-eet-assessering van Deelnemers – Verkorte Weergawe (VEAD-V) streekproef te kategoriseer. Die voedselomgewing is ook op twee maniere gemeet: die aangepaste Kleinhandelsvoedselomgewingsindeks (aKVOI) en meting van die euklidiese middelafstand vanaf die deelnemer se huisadres tot voedselkleinhandelaars (kruidenierswinkels en kitskos-afsetpunte).

Resultate: Die deelnemers in die studie was 427 VVO (142 nie-swanger en 285 swanger) wat in die Roodepoort-area gewoon het. Die gemiddelde ouderdom van die deelnemers was 29.8±6.5 jaar. Byna die helfte was enkellopend (49%) en alhoewel die meeste van die deelnemers ’n goeie opvoeding gehad het (78% het matriek of tersiêre onderwys voltooi), was meer as die helfte (53%) werkloos en het ’n derde (33%) maatskaplike toelae gekry. Die resultate van die VEAD-V-streekproef het getoon dat die deelnemers matige/gemiddelde dieetkwaliteit gehad het weens dieetgedrag (VEAD-V-telling = 27.1±3.3), en nie-swanger vroue het ’n laer VEAD-V-telling gehad as swanger vroue (26.5±3.6 vs 27.3±3.2). Daar is bevind dat die studiebevolking swak dieetdiversiteit gehad het (TDD = 4.1±1.4) en 64% van die studiebevolking (60% swanger en 72% nie-swanger) het nie die MDD-V behaal nie. Die studie het ’n korrelasie tussen die twee dieetkwaliteitstellings getoon (r = 0.159, p = 0.001), wat aandui dat die twee metings soortgelyke uitkomste vir dieetkwaliteit gehad het. Daar is bevind dat die omgewing ’n obesogene voedselomgewing gehad het, wat deur ’n lae aKVOI-telling (31%) aangedui is. Die middelafstand vanaf die huisadresse van die deelnemers aan die studie tot by kruidenierswinkels was 337.6 meter (193.5–594.2) en tot by kitskos-afsetpunte was dit 230.5 meter (141.4–416.6), wat aandui dat ’n kruidenierswinkel net so toeganklik was as ’n kitskos-afsetpunt en dat verbruikers kon kies om enigeen van die voedsel-afsetpunte te besoek. Die studie het geen assosiasie tussen die dieetgehaltetelling en die aKVOI-telling, of tussen die dieetkwaliteitstelling en die middelafstand na voedselkleinhandelaars (kruidenierswinkels en kitskos-afsetpunte), gevind nie. Tog was baie deelnemers oorgewig: die MBAO-resultate het aangedui dat 30% vetsugtig kon gewees het en die BMI-resultate van nie-swanger vroue het aangedui dat die meeste van hulle vetsugtig was (73%).

Gevolgtrekking: Die studie het getoon dat die deelnemers in ’n obesogene voedselomgewing gewoon het, dat die meerderheid nie die MDD-V bereik het nie en dat die meeste nie-swanger deelnemers oorgewig of vegsugtig was. Dit het aangedui dat die voedselomgewing ’n impak kon hê op deelnemers se voedelkeuses, dieetkwaliteit en derhalwe algehele gesondheid, alhoewel die resultate nie ’n assosiasie aangedui het nie. Die resultate het om verskillende redes nie ’n assosiasie tussen dieetkwaliteit en die voedselomgewingstellings getoon nie, insluitende die meting van ’n homogene omgewing waar daar beperkte blootstelling aan tipes voedsel was en dat die studie nie die impak van die informele voedselomgewing (byvoorbeeld straatverkopers) op voedselkeuses in ag geneem het nie. Die gesondheid van VVO is belangrik vir die toekomstige generasie se gesondheid, aangesien daar bewys is dat die dieetkwaliteit van vroue nie slegs tydens swangerskap nie, maar ook vóór swangerskap ’n uitwerking op hul kinders se gesondheid gehad het. Dit is derhalwe noodsaaklik dat die voedselomgewing se invloed op dieetkwaliteit volledig begryp word en metings geneem word om die gesondheid en welstand van VVO te verbeter.

Sleutelwoorde: Dieetkwaliteit; formele stedelike voedselomgewing; vroue van voortplantingsouderdom (VVO); telling vir dieetdiversiteit (TDD); minimum dieetdiversiteit vir vroue (MDD-V); aangepaste Kleinhandelvoedselomgewingsindeks (aKVOI); Vinnig-eet-assessering van Deelnemers – Verkorte Weergawe (VEAD-V)

ISIFINYEZO

Isendlalelo: Ibaluleke kakhulu impilo yabesifazane asebengathola abantwana ngokweminyaka yobudala (WRA) njengoba ubufakazi bukhombisa ukuthi iqophelo lokudla kanye nomsoco ekudleni abakudlayo kuyithinta kakhulu inzalo, futhi lokhu akwenzeki nje kuphela ngesikhathi sokukhulelwa kodwa nangaphambi kokukhulelwa. Iqophelo eliphansi lokudla lingezinye zezinto ezihamba phambili ekuphazamisekeni kwenzalo. Izimo zokuthola ukudla zidlala indima enkulu ngokweqophelo lokudla esikudlayo.

Inhloso: Lolu cwaningo luhlose ukuphenya ngobudlelwano phakathi kwesimo sokudla ekutholakala emadolobheni kanye neqophelo lokudla kwabesifazane asebengathola abantwana (WRA) ngaphakathi edolobha eGoli, eNingizimu Afrika.

Izindlela ezisetshenzisiwe: Lapha kusetshenziswe uhlelo lokuqoqa ulwazi eqoqweni labantu, i-WRA kwabahambela i-Discoverers Community Health Centre (DCHC) e-Roodepoort ngaphansi kohlelo lokuhlela umndeni noma ukunakekelwa kwabakhulelwe. Ulwazi ngenhlalo yabantu luqoqwe kusetshenziswa uhlu lwemibuzo olulawulwa yilabo ababuza imibuzo. Lapha kuye kwaqoqwa izisindo zomzimba nezilinganiso zobude kwabesifazane abangakhulelwe kanye nesiyingi sengalo esimaphakathi nendawo (MUAC) kubo bonke abesifazane. Umlando wendlela yokudla utholakale ngokusebenzisa indlela yokukhumbula ukudla okudlile emahoreni angama-24 edlule. Iqophelo lokudla okudliwayo lihlolwe ngezindlela ezimbili: Imiphumela Yendlela Yokudla Okunhlobonhlobo (DDS) ukuze kuhlukaniswe izilinganiso ngezigaba ezithinta Ubumbalwa Bezinhlobonhlobo Zokudla Kwabesifazane (MDD-W); kanye nohlelo Lwenqubo Efinyeziwe – Ngokuhlola Indlela Yokudla Okusheshayo (REAP-S). Isimo sokuthola ukudla sihlolwe ngezindlela ezimbili: Ukulungiswa Kwezindawo Ezithengisa Ukudla (mRFEI) kanye nokuhlolwa kwebanga elimaphakathi le-Euclidean ukusuka lapho kuhlala khona abathengi kuya lapho kudayiswa khona (ezitolo zokudla nasezitolo zokudla okusheshayo).

Imiphumela: Ababambiqhaza kulolu cwaningo kube abangama-427 WRA (abangama-142 babo abangakhulelwa kanye nabangama-285 abakhulelwe) abahlala endaweni yase-Roodepoort. Isilinganiso seminyaka yobudala yababambiqhaza abaneminyaka engama-29.8± 6.5. Cishe ingxenye yabo (49%) ayishadile, kanti nakuba iningi lababambe iqhaza lifundile (78% uphothule umatikuletsheni noma imfundo ephakeme), kodwa bangaphezu kwesigamu kubona abangasebenzi (53%) kanti ingxenye yesithathu yona ithola isibonelelo sikahulumeni (33%). Imiphumela yenhlolovo ye-REAP-S ibonise ukuthi ababambiqhaza badla ukudla okuseqophelweni elimaphakathi kuye ngokuthi ime kanjani indlela abadla ngayo (imiphumela ye-REAP-S = 27.1±3.3), nabesifazane abangakhulelwa abanesilinganiso esiphansi se-REAP-S uma kuqhathaniswa nabesifazane abakhulelwe (26.5±3.6 vs. 27.3±3.2). Ucwaningo luthole ukuthi inani labantu lidla ukudla okunhlobonhlobo okungenampilo (DDS = 4.1±1.4), kanti lapha kunabantu abangama-64% (abakhulelwe abangama-60% kanye nabangama-72% abangakhulelwa) abangasihlanganisi isilinganiso se-MDD-W. Ucwaningo luthole ukuthi kunokuhlobana phakathi kwemiphumela emibili mayelana neqophelo lokudla esikudlayo (r = 0.159, p = 0.001) nokusho ukuthi lezi zindlela ezisetshenzisiwe zozimbili zinemiphumela efanayo yeqophelo lokudla esikudlayo. Isimo siveza ukuthi ukudla okudliwayo yilokho okukhuluphalisa kakhulu uma kususelwa emiphumeleni ye-mRFEI ebonakala iphansi (31%). Ibanga elimaphakathi ukusuka endaweni ehlala abathengi okwenziwe ngabo ucwaningo ukuya ezitolo zokudla lingama-337.6 m (193.5–594.2) kanti ukuya ezitolo zokudla okusheshayo khona ngama-230.5 m (141.4–416.6), okubonisa ukuthi ibanga lokuya ezitolo zokudla lithi alilingane nokuya kwezokudla okusheshayo, kanti-ke abathengi bangakwazi ukuhambela nanoma yisiphi kulezi zitolo. Ngalolu cwaningo akukho ukuhlobana okutholakele phakathi kwemiphumela yeqophelo lokudla esikudlayo kanye neye-mRFEI, noma phakathi kweqophelo lokudla esikudlayo kanye nebanga elimaphakathi lokuhambela lapho kudayisa khona ukudla (izitolo zokudla nezitolo zokudla okusheshayo). Nanoma kunjalo, ababambiqhaza abaningi bakhuluphele ngokweqile, nemiphumela ye-MUAC ekhombisa ukuthi abangama-30% babo banokukhuluphala kanye nemiphumela ye-BMI yabesifazane abangakhulelwe ekhombisa ukuthi iningi labo lisinda ngokweqile noma likhuluphele (73%).

Isiphetho: Ucwaningo luthole ukuthi ababambiqhaza bahlala endaweni enokudla okukhuluphalisayo, iningi labo alinaso isilinganiso esifanele se-MDD-W kanti iningi labangakhulelwe lisinda ngokweqile noma likhuluphele, lokhu-ke kusho ukuthi isimo sokuthola ukudla sinomthelela ekudleni okudliwayo, iqophelo lokudla kanye nempilo jikelele, nakuba imiphumela ingakukhombisi ukuhlobana kulezi zinto. Zikhona-ke izizathu ezimbalwa ezingadala le miphumela nengakhombisi ukuhlobana phakathi kweqophelo lokudla esikudlayo kanye nesimo sokuthola ukudla, okuhlanganisa ukulinganiswa kwendawo enokudla okumbalwa ongakuthola, kanjalo nokuthi ucwaningo aluwubhekanga umthelela wendawo engekho emthethweni okutholakala kuyo ukudla (isib. abathengisi basemgwaqweni). Ibaluleke kakhulu impilo yabesifazane asebengathola abantwana ngokweminyaka yobudala (WRA) uma sibheka ikusasa lempilo yethu njengoba, ubufakazi bukhombisa umsoco ekudleni okudliwayo okungenzeki nje kuphela ngesikhathi sokukhulelwa kodwa nangaphambi kokukhulelwa. Ngakho-ke kubalulekile ukuthi siwuqonde ngokugcwele umthelela wesimo sokutholakala kokudla ngokweqophelo lokudla esikudlayo futhi kuthathwe izinyathelo ezifanele zokwenza ngcono impilo nokuphila kahle ngokwe-WRA.

Amagama amqoka: Iqophelo lokudla esikudlayo; isimo sokutholakala kokudla emadolobheni; abesifazane asebengathola abantwana ngokweminyaka yobudala (WRA); Imiphumela Yendlela Yokudla Okunhlobonhlobo (DDS); Ubumbalwa Bezinhlobonhlobo Zokudla Kwabesifazane (MDD-

W); Ukulungiswa Kwezindawo Ezithengisa Ukudla (mRFEI); Inqubo Efinyeziwe – Ngokuhlola Indlela Yokudla Okusheshayo (REAP-S).

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CHAPTER 1: INTRODUCTION

1.1 Background

The food environment is a component of the larger complex food system (FAO 2016). Food environments can be termed as the combined commercial, socio-cultural, and physical environments, scenarios and circumstances that influence an individual's food selections, and thereby diet quality and nutritional status (Claasen et al. 2016). Food environments convey world-wide food system adjustments in the aspects of food manufacturing, transportation, retail, storage, and transformation to local food environments (Turner et al. 2017). A food environment can also be described as a junction that facilitates an individual's food acquisition and intake within the broader food system. It includes several dimensions such as food affordability, desirability, accessibility, availability, marketing, convenience, and the features of food sources and products (Turner et al. 2017). Food environments permit, restrain and form an individual's food purchase and consumption patterns through providing or hampering food affordability, desirability, accessibility and availability (Kroll et al. 2019).

The food environment in which an individual resides plays a substantial part in determining their diet quality, energy consumption and energy expenditure (Jain & Singh 2015). Thus, an obesogenic environment may stimulate food intake beyond the estimated energy requirements leading to weight gain, obesity, or other non-communicable diseases (NCDs) (Martínez-García et al. 2019). Middle-class countries such as South Africa are experiencing a 'nutrition transition' characterised by the adoption of a more westernised diet which includes high fat, high sugar, high salt, and energy-dense foods and the accompanying rapid increases in NCDs impacting population health (Popkin & Ng 2022), due to a complex set of changes such as urbanisation, globalisation and the rapid advancements of technology (Graham et al. 2018).

The population of concern in this dissertation is women of reproductive age (WRA). The health of women of reproductive age (WRA) is important since evidence shows that the diet quality and nutritional status of women, not only during pregnancy but also prior to pregnancy, affects the health of her offspring (Ramakrishnan et al. 2012). Thus, undesirable conditions during pregnancy such as maternal hypertension and gestational diabetes mellitus, as well as disproportionate weight gain and nutrient deficiencies have short- and long-term health consequences for both the foetus and the mother (Haggblade et al. 2016). One of the major influencing factors to these undesirable conditions is a poor diet quality (Govender et al. 2021). Thus, researchers and health authorities require insights into the degree in which the food environment impacts a populations' diet quality to enable them to update policies that inform healthy eating choices (Claasen et al. 2016), particularly for WRA.

With this in mind, a research team at UNISA has undertaken the cardiovascular, haemostatic and micronutrient status of pregnant women (CHAMP) study. The CHAMP study aims to explore the cardiovascular, haemostatic and micronutrient health of women of reproductive age and birth weight of their infants in the setting of local food environments in the city of Johannesburg, Gauteng. The present study is a sub-study of the CHAMP study and focused on measuring the local formal urban food environment to which women in the CHAMP study are exposed, plus their dietary intake and quality thereof as well as the relationship between the food environment and diet quality.

1.2 Problem statement

Communities function and live within a certain food environment (Wentzel-Viljoen et al. 2011). Food environments are influential in shaping nutritional behaviours and thereby possibly instigating negative health consequences such as obesity and NCDs (Ni Mhurchu et al. 2013). With obesity and NCDs becoming more rampant in South Africa, especially amongst women residing in urban areas (National Department of Health et al. 2019), it is worrisome to realise the consequence this may have on current maternal and foetal health, as well as future population health and well-being. Some of these possible negative health consequences for pregnant women include maternal hypertension, gestational diabetes mellitus and excessive weight gain (Haggblade et al. 2016); as well as potentially higher hospital and medication costs, work absenteeism and reduced productivity (Manyema et al. 2015).

While several South African studies on mapping the food environment and/or measuring food consumption or diet quality have been conducted in Johannesburg and surrounding areas (Duvenage et al. 2023; Conradie et al. 2021; Spires et al. 2020; Kroll et al. 2019; Ndlovu et al. 2018; Drimie et al. 2013; Acham et al. 2012; Oldewage-Theron & Kruger 2011; Feely et al. 2009; Oldewage-Theron & Kruger 2008), and in other provinces like Free State (Jordaan et al. 2020; Beukman 2020), Eastern Cape (Fisher 2021; Okeyo et al. 2020), Western Cape (Madlala et al. 2022; Battersby & Peyton 2014), North-West Province (Wentzel-Viljoen et al. 2011) and KwaZulu-Natal (Chakona & Shackleton 2017; Audain et al. 2014); there is currently a gap in knowledge in understanding the relationship between the food environment and diet quality due to the complex relationship. There was specifically limited research found regarding the influence of the state of healthiness of the formal urban food environment on diet quality to which WRA are exposed in Gauteng. There is also limited information regarding the formal urban food environment in Johannesburg.

This study attempted to fill these gaps in knowledge within the context and limitations of the larger CHAMP study.

1.3 Aim and objectives

The aim of this study was to investigate the association between the formal urban food environment and diet quality in women of reproductive age within the city of Johannesburg, South Africa.

The objectives of the study to meet the above aim were:

a) To determine the diet quality of women of reproductive age within the city of Johannesburg using a Rapid Eating Assessment for Participants – Shortened Version (REAP-S) survey and a 24-hour dietary recall to measure the DDS and classify the score into the Minimum Dietary Diversity for Women (MDD-W) categories.
b) To measure the density of the formal urban food environment in terms of healthy (grocery stores) and less healthy (fast-foods outlets) food retailers using geographic information systems (GIS) technology to calculate the Modified Retail Food Environment Index (mRFEI) within the city of Johannesburg; as well as the distance from participants' residential addresses to food retailers (grocery stores and fast-foods outlets).
c) To determine the relationship between diet quality of women of reproductive age and the formal urban food environment in which they reside within the city of Johannesburg.

1.4 Significance of the study

The present study is significant because it aims to understand the relationship between diet quality of WRA and the food environment in support of achieving the Sustainable Development Goals of the United Nations, particularly no. 3 which states "to ensure healthy lives and promote well-being for all ages". The health of WRA is important for the future generations' health since evidence shows that nutritional status of women not only during pregnancy, but also prior to pregnancy affects offspring health (Ramakrishnan et al. 2012). It is therefore vital that the influence of the food environment be fully understood and measures by taken to improve the health and well-being of WRA as well as future generations. The outcomes of this study can be used as a motivator for changes to the food environment, as to achieve good health and well-being for a population, food system and environmental transformation is necessary.

1.5 Chapter layout

The structure of this dissertation is as follows:

Chapter 1: Introduction – This chapter introduces the topic by providing the background, aims and objectives and motivating the significance of the study.

Chapter 2: Literature review – This chapter presents an analysis of relevant literature. The chapter begins with a comprehensive understanding of the various food system conceptual frameworks; defines the food environment, identifies tools to measure the food environment, with specific focus on the changing South African food environment, the drivers of change and deliberates the relationship between the changing food environment and diet quality. It then moves onto defining diet quality, identifies tools to measure diet quality, and describes the types of malnutrition that may be associated with a poor diet quality.

Chapter 3: Research Methods – The research methodology is described in this chapter. It discusses the study design, study setting, population, sampling, measurement of the food environment and diet quality, statistical analysis, and ethical considerations.

Chapter 4: Results – This chapter highlights the findings of the study. The results are presented according to the study objectives.

Chapter 5: Discussion – The main findings presented in the previous chapter are explained and critically discussed in accordance with the objectives of the study.

Chapter 6: Conclusion and Recommendations – Based on the results and discussion, a conclusion and recommendations are presented in this chapter to fulfil the aim and objectives of the study.

The concluding chapter is followed by a reference list and the appendices for the dissertation.

1.6 Conclusion

This chapter has charted the background and relevance of the study regarding how food environments fit into food systems. Furthermore, these environments impact food choices and therefore diet quality. Measuring the food environment and diet quality of women of reproductive age is important to shed light on how external drivers impact nutritional status during critical periods of life with lasting health implications. This chapter highlighted the motivation and significance for the study, as well as the research problem, aim and objectives which are required throughout this study. The literature review within this context is presented in the following chapter.

CHAPTER 2: LITERATURE REVIEW

The food environment is a component of the larger complex food system. This literature review chapter starts by discussing the food systems and their conceptual frameworks to provide context for food environments, in general and in South Africa. Furthermore, the types of methods to measure food environments will be presented followed by a discussion on the role of changing food environments and the drivers of these changes. How these complex systems relate to diet quality is then discussed. Literature on diet quality is presented and the final sections elaborate on the methods to measure diet quality and the types of malnutrition that may be associated with a poor diet quality for WRA.

2.1 Food systems and their conceptual frameworks

The food environment is one component of a food system (FAO 2016). Food systems integrate the complete series of institutions, individuals and activities implicated in the manufacturing, handling, promotion, utilisation and discarding of food (FAO 2016). It also involves the economic, technological, social, and political settings in which these activities occur and the individuals and organisations that instigate or hinder changes in the system (FAO 2016). A food system encapsulates all the individuals, organisations, settings, infrastructure, and activities that relay to the manufacture, dispensation, circulation, promotion, transactions, preparation, and intake of food products (Fanzo et al. 2020). Food systems hold essential relationships to a region or nation's health, culture, politics, environment, and economy (Fanzo et al. 2020). Food systems influence consumers' food choices and manufacturers' decisions and thereby have profound impact on human and environmental health (HLPE 2017). An array of food systems can co-exist at regional, countrywide, and worldwide levels (HLPE 2017). Several conceptual frameworks describe the relationship between food supply systems, food environments and diet quality. To depict the complexity of the influence the many factors on food environments, five such frameworks are depicted in Figures 2.1, 2.2, 2.3, 2.4, and 2.5 below.

2.1.1 Conceptual Framework for the links between food supply systems, food environments and diet quality

A conceptual framework developed by the Food and Agriculture Organisation (FAO), describing the links between the food supply system, food environment, consumer factors and consumer diet is displayed in Figure 2.1. It describes four food supply subsystems: agricultural production; food storage, transportation, and trade; food transformation; and food retail and provisioning (FAO 2016). All four subsystems have a push-pull effect on the food system. Agricultural production subsystems may influence food prices and access through prioritisation of certain crops over others (FAO 2016). Food storage, transportation and trade subsystems may influence food availability and prices through export or import policies or food safety laws (FAO 2016). The food transformation subsystem may improve the availability of healthful foods through nutrient fortification or regress the availability of healthful foods through highly processing foods with added sugar, salt and/or fats (FAO 2016). Healthful foods can be described as a superior quality or healthy diet; a diversity of food, including plenty of legumes and whole grains, fruits and vegetables, sugar and salt consumed in moderation; using unsaturated fats rather than trans or saturated fats; consuming disease-free (safe) and minimally or unprocessed foods (FAO 2016). The food retail subsystem may hold promotions that improve or regress the availability of healthful foods compared to less healthful foods (FAO 2016). Food environments can be considered as the crossing point or linkage between food supply systems and consumer diets (FAO 2016). As with consumer food choices, food environments are also subjected by the food systems that source them, and vice versa (FAO 2016). The food environment itself may soften the influence of these four supply subsystems on consumers' food choices and diet quality via various aspects such as physical access, product labelling, promotion, price, etc. (FAO 2016). Consumer preferences and culture influence the operation of food systems as consumer demand impacts food system supply (FAO 2016). However, food systems also influence consumer food choices via food environments – the relationship can be viewed as a bi-directional street (FAO 2016). Strengthening the link between the four food supply subsystems and the food environment is imperative to improving the food system, with the predominant aim of providing consumers with superior tools to make more healthful food choices to improve their diet quality (FAO 2016).

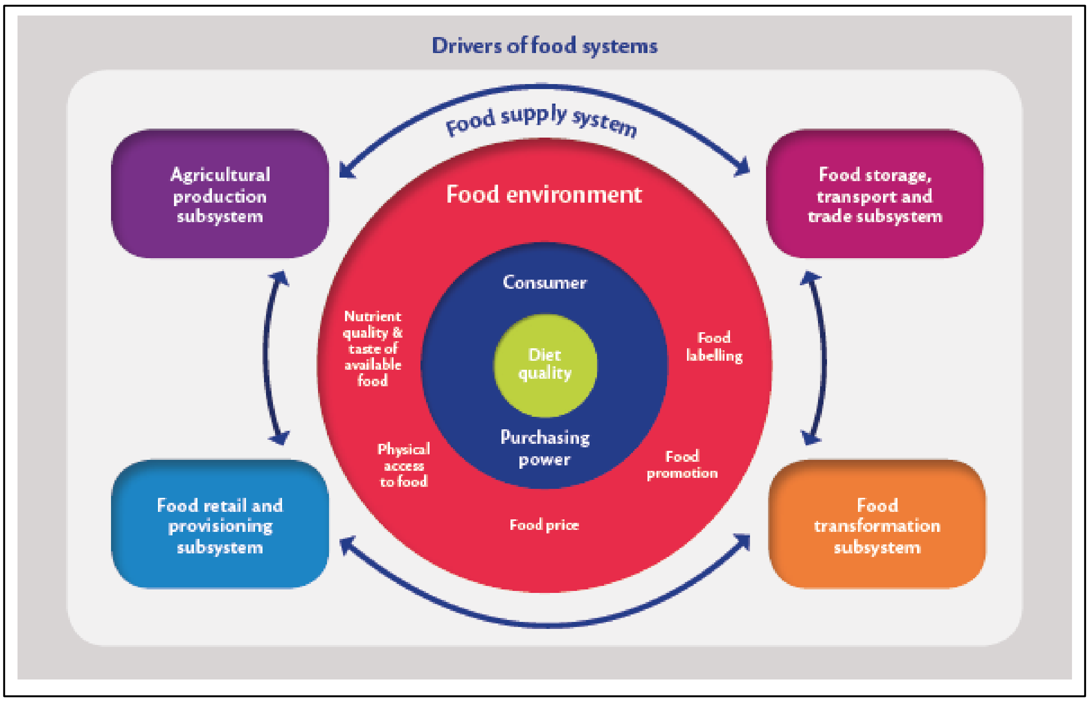


Figure 2.1: Conceptual framework showing the links between food supply systems, food environments and diet quality

Source: FAO (2016)

2.1.2 Conceptual framework of food systems for diets and nutrition

The high-level panel of experts (HLPE) conceptual framework on food and nutrition security as can be seen in Figure 2.2, recognises three interrelating components of a food system: 1) food supply chains, 2) food environments, and 3) consumer behaviour (HLPE 2017). Various drivers impact these components – environmental, innovation, political, socio-cultural, and demographic drivers (HLPE 2017). These drivers profile diets and are therefore significant in establishing the final nutrition, health, social and economic outcomes of food systems (HLPE 2017). The food supply chain consists of the stakeholders and activities involved in the manufacture, processing and packing; handling, storage and delivery; and retailing and marketplaces (HLPE 2017). The food environment facilitates consumer food choices within the food system (HLPE 2017). It consists of various entry points: the built environment in which consumers access food; the physical areas where the food is purchased; personal factors affecting consumer food choices like their values, preferences, education and income; and the political, cultural, and social customs that trigger these relationships (HLPE 2017). The primary features of the food environment that affect consumer food selections, food tolerability and diet quality are physical access (vicinity) and economic access (affordability); food safety; food quality; and marketing and information of food products (HLPE 2017). Consumer behaviour refers to consumer decisions regarding for example, what food to buy, how to prepare it, store it, how to divide the food between family members, etc. (HLPE 2017). Consumer behaviour is underpinned by the consumers personal preferences, culture, values, traditions, and a variety of other personal and interpersonal factors (HLPE 2017). Consumer behaviour gives rise to diets or dietary patterns. Diets refer to the food an individual consumers and dietary patterns refer to the amount, frequency and types of foods consumed habitually (HLPE 2017). Dietary patterns can be thought of as the product of an existing food system but also has an impact on the future food system. Therefore, food systems, through consumer diets, result in an array of consequences like nutrition and health outcomes, sustainability, etc. which then connect backwards to the food system drivers (HLPE 2017). Accomplishing food and nutrition security is not only fundamental to population well-being, but it also impacts sustainable development by improving population health, thereby the health of the workforce/the ability for individuals to work and provide a meaningful contribution towards society – which reduces poverty and promotes economic growth.

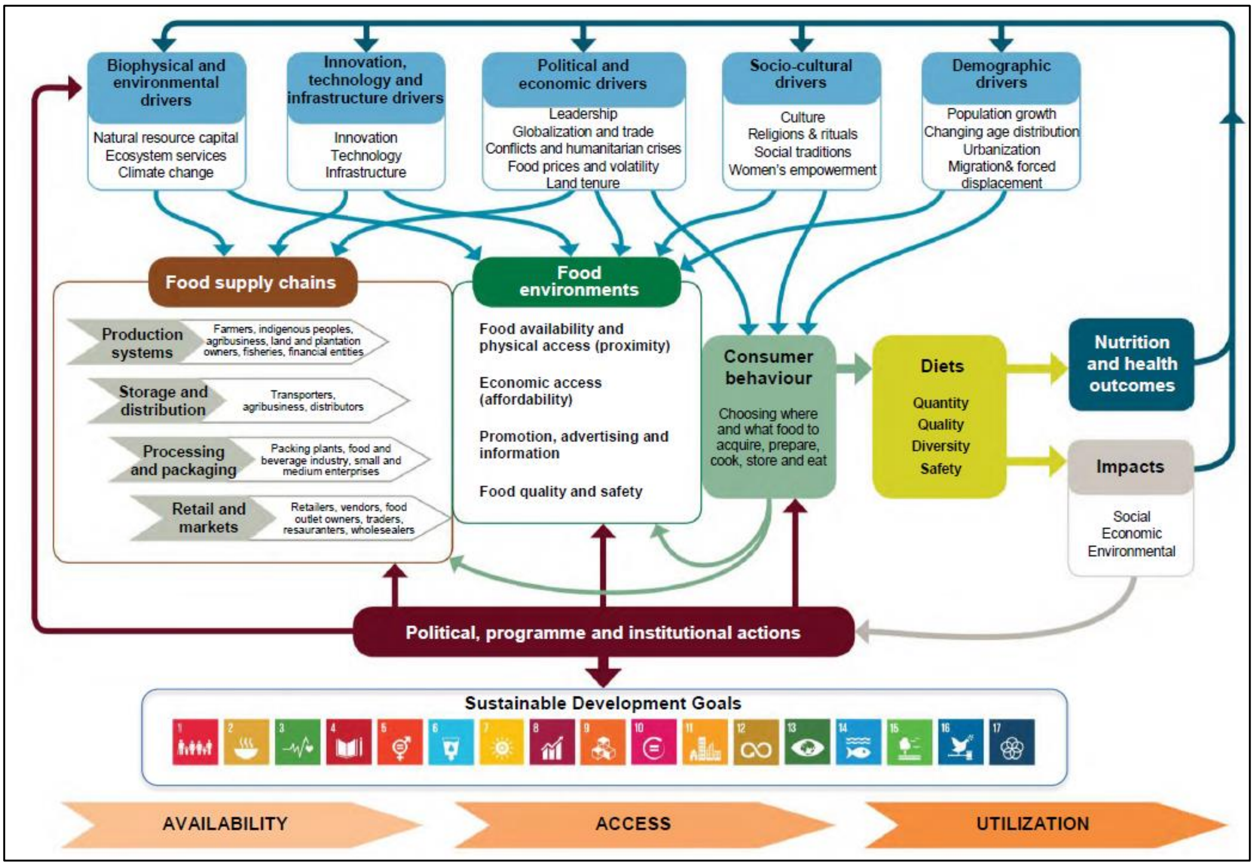


Figure 2.2: Conceptual framework of food systems for diets and nutrition

Source: HLPE (2017)

Fanzo et al (2020) asked permission to adapt the HPLE conceptual framework of food systems for a diets and nutrition framework (Figure 2.2) into Figure 2.3 below. It encapsulates the entire food system including food supply chains, food environments, individual factors, consumer behaviour, consumer diets and nutrition, and the factors that influence the food system (Figure 2.3) i.e., environmental, social, political, and economic drivers (Fanzo et al. 2020). It is a newer instrument that intends to describe regional, national, and global food systems; to evaluate the difficulties encountered for improving consumer diet quality and well-being; and to guide its users to set goals and choose effective plans of action (Fanzo et al. 2020). The authors of the framework envisioned it as a key resource for a nation's decision-makers to produce high-grade data on the state of their national food systems and its impact on the population nutrition and health on which they can make decisions regarding their policies (Fanzo et al. 2020). The adapted framework allows for the comparison of food systems between countries by region, food system typology or income classification (Fanzo et al. 2020). The framework presents data almost world-wide, whereas other food indices and platforms usually only include a select number of high-income countries (Fanzo et al. 2020).

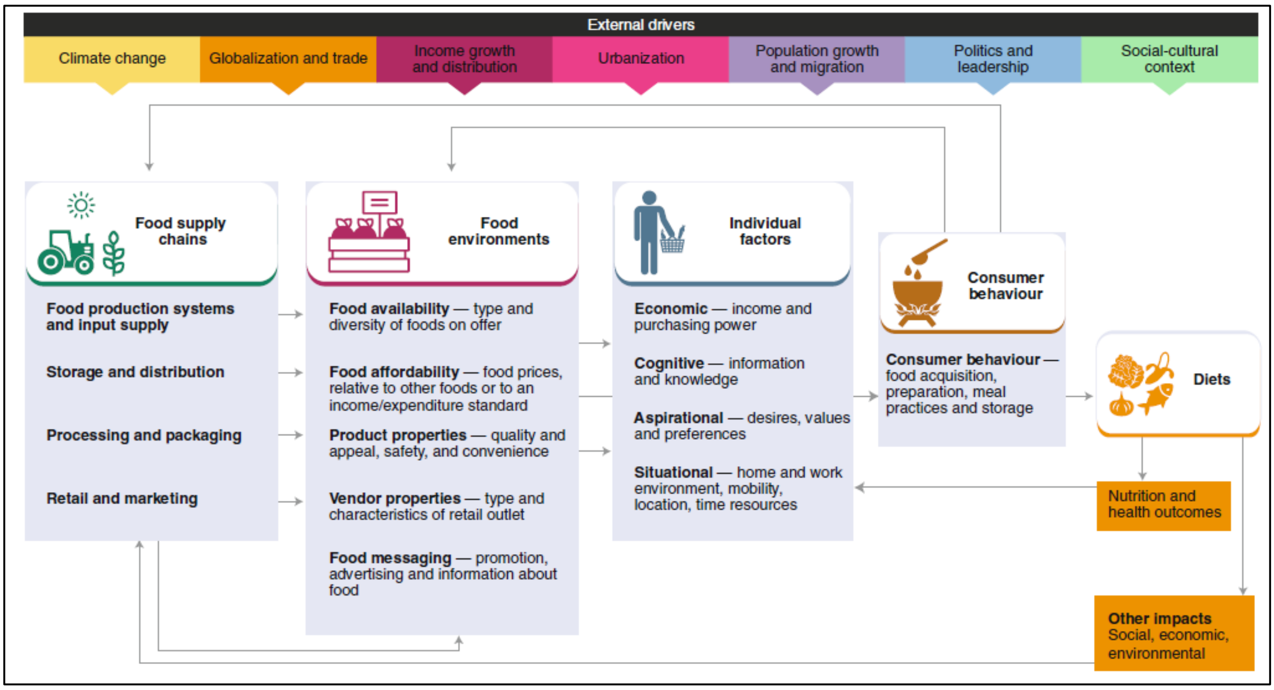


Figure 2.3: Adapted conceptual framework of food systems for diets and nutrition

Source: Fanzo et al. (2020)

2.1.3 The ANH-FEWG food environment conceptual framework

The Agriculture, Nutrition and Health Academy Food Environments Working Group (ANH-FEWG) conceptual framework as illustrated in Figure 2.4 positions the food environment as the port through which consumers purchase foods within the larger food system, thereby impacting their health and nutrition outcomes (Turner et al. 2017). The food environment consists of two spheres (external food environment and internal or personal food environment) that share a related set of socio-cultural, economic, and physical factors. The external food environment sphere includes food prices, food availability, marketing, regulations, vendor and product properties (Turner et al. 2017). The personal food environment domain includes at the individual level, consumer desirability, affordability, accessibility and convenience (Turner et al. 2017). In Figure 2.4, the two orange arrows signify the socio-ecological connections between the external and internal or personal food environment spheres that influence food purchasing (Turner et al. 2017). The ANH-FEWG food environment conceptual framework is intended to support the theoretical constructs of current and developing conceptual frameworks and metrics (Turner et al. 2017).

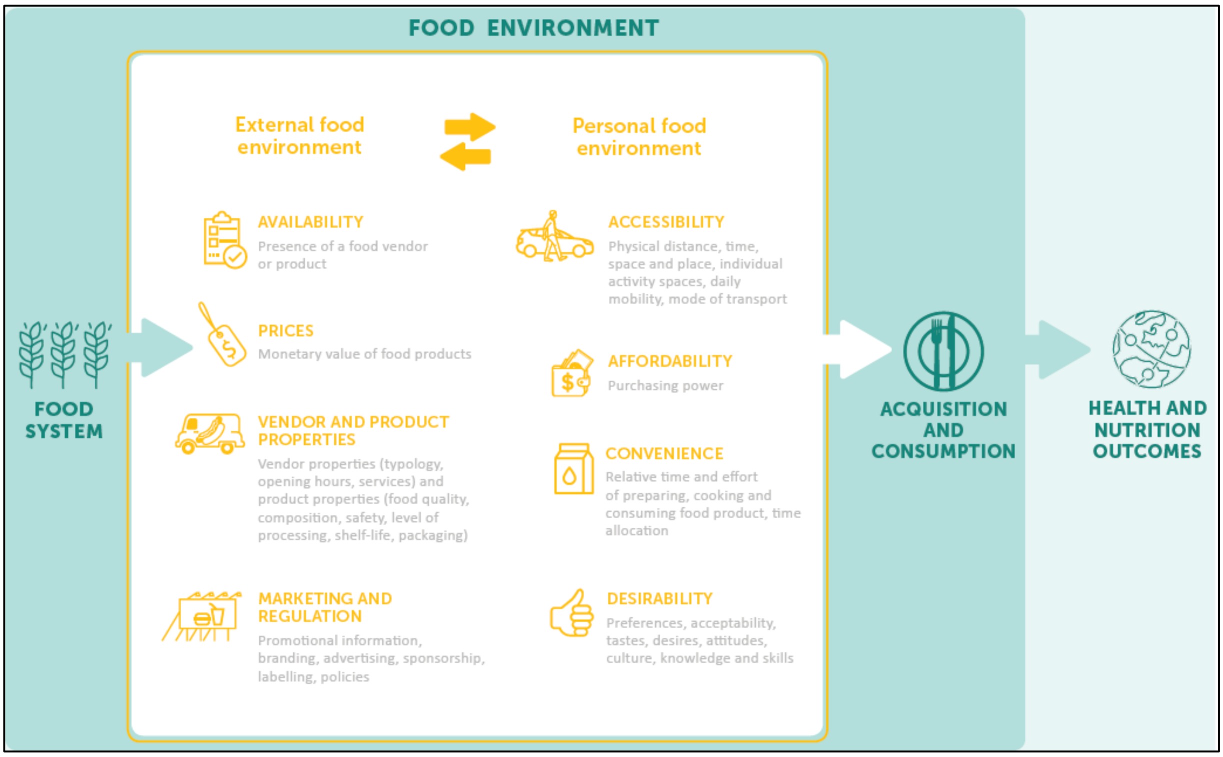


Figure 2.4: The ANH-FEWG food environment conceptual framework

Source: Turner et al. (2017)

2.1.4 The Food System Framework - a South African perspective

Like the HPLE framework, the Food System Framework as shown in Figure 2.5 illustrates the systems (economic, environmental, social, and political systems) and forces (food supply chain, food environment and consumer behaviour) affecting the diet quality and quantity of a population within a food system (Swart 2022). It was developed by Swart (2022) from a South African perspective. It shows that various systems interact and impact how food is made available to an individual, for example, the food source, food access, personal preferences, social norms and how this impacts an individual's health status and nutritional outcome. Compared to the other frameworks discussed above, this framework has more emphasis on social protection, health systems and water, sanitation and hygiene (WASH) since these also ultimately affects nutritional status and plays specific roles in the health of people in South Africa (Swart 2022).

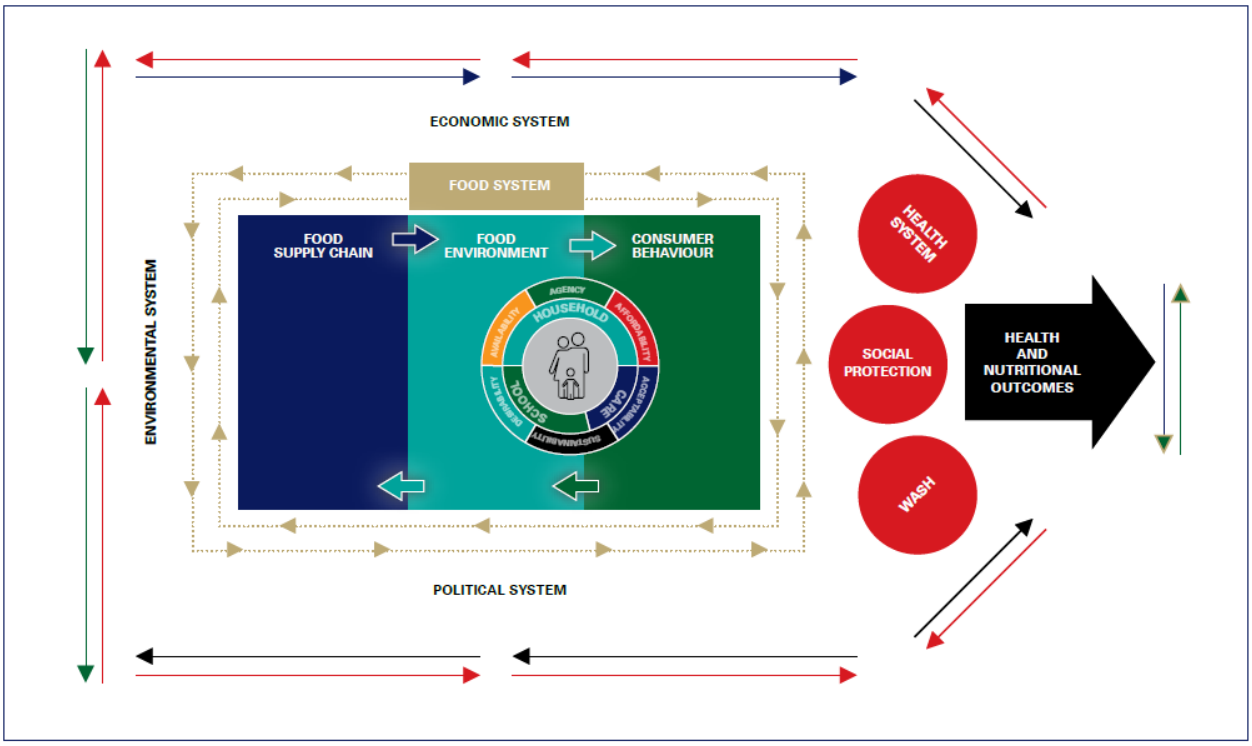


Figure 2.5: Food System Framework from a South African perspective

Source: Swart (2022)

To summarise, all these frameworks adequately describe the relationships linking food supply systems, food environments and diet quality, but differ in describing how they relate to each other. For example, the Conceptual Framework developed by the FAO (Figure 2.1) uses a bottom-up approach and focuses on consumer diet quality as a starting point and how food supply systems and food environments impact this; whereas the other frameworks, the Conceptual Framework developed by HLPE (Figure 2.2), the adapted Conceptual Framework (Figure 2.3), the ANH-FEWG food environment conceptual framework (Figure 2.4) and Food System Framework developed by Swart (2022) (Figure 2.5) uses more of a top-down approach which uses food supply systems and food environments as a starting point and describes how these factors impact consumer diet quality.

2.2 Example of a tool used to assess food systems

2.2.1 The Food Systems Dashboard

The Food Systems Dashboard is led by the Global Alliance for Improved Nutrition, the Columbia Climate School, College of Agriculture and Life Sciences at Cornell University, and FAO with collaborators/partnerships with various other academic institutions (Global Alliance for Improved Nutrition 2023). The dashboard encapsulates data for around 300 indicators to provide a broad view of food systems, including its components, drivers and outcomes (Global Alliance for

Improved Nutrition 2023). It permits stakeholders to organise priorities for action and track its progress to observe whether the implemented policies, strategies, programmes or interventions are effective (Global Alliance for Improved Nutrition 2023). The framework depicts that the food system is composed of three main components: food supply chains, food environments and individual factors which are impacted or driven by four main factors: the environment; health and nutrition; social equity; and the economy and results in positive or negative influences on the outcomes of diet quality and food security (Global Alliance for Improved Nutrition 2023). This dashboard is freely available for use online at https://www.foodsystemsdashboard.org/.

The food environment is a central theme in all these frameworks, and the focus of the current research. Therefore, the following section will discuss food environments and particularly the food environment in South Africa in more detail.

2.3 Food environments

Food environments can be described as the settings in which food is made available and accessible to consumers e.g., supermarkets, workplace canteens, tuck shops, restaurants, fast-food outlets, coffee shops, road-side stalls, and all other avenues where they can buy and eat food (FAO 2016). Food environments therefore influence consumer food choices and thereby diet quality and nutritional status (Claasen et al. 2016). The section below describes the food environment in South Africa specifically.

2.3.1 Food environments in South Africa

Food environments in South Africa can be categorised by a combination of informal and formal food outlets (Kroll et al. 2019). Informality is described as operating without official registering for licensing, tax or the facility of employee benefits such as paid leave or retirement (Kroll et al. 2019). Informal food outlets consist of tuck shops, street vendors, hawkers, spaza shops, small cafes, corner stalls and general dealers (Claasen et al. 2016). The formal food sector includes chain supermarkets, large wholesale and retail outlets, convenience stores, department stores, boutiques, and specialty stores (Claasen et al. 2016). Food environments can also be classified as urban or rural. Urban food environments are found in urban settings and rural food environments in rural settings. The focus of this study is formal urban food environments.

A foodservice channel refers to any business or institution that is responsible for providing meals prepared outside the home (Martínez-García et al. 2019). In formal urban settings, food can be accessed from several foodservice channels in the food environment including in catering establishments like restaurants, canteens, bars, takeaways, and others; in grocery stores, supermarkets, fresh markets; and in institutions like at work, school, or home (Martínez-García et al. 2019).

This study focused on grocery stores as the main source of healthy foods and fast-food outlets as the main source of less healthy foods in the formal urban food environment within the city of Johannesburg as the Centres for Disease Control and Prevention (CDC) also uses these types of establishments to compare healthy versus less healthy foods (CDC 2011).

The nationwide distribution of the grocery retail sector in South Africa is shown in Figure 2.6. The growth of grocery stores (or supermarkets) in urban areas has affected food consumption patterns. Supermarkets have increased the obtainability of healthy foods such as vegetables, fruits, lean meats, etc. (Claasen et al. 2016). By making their foods more accessible and reasonably priced, supermarkets have grown their market share and per capita expenditure on their products. Traditional small convenience stores, informal shops and markets such as 'spaza shops' have been mostly substituted in urban settings by supermarkets as the primary source from which South African consumers obtain their food (Wicks 2017). The main supermarkets in South Africa are Spar Group, Pick n Pay Group, Massmart Group, Woolworths, Choppers, Food Lover's Market and Shoprite Group (Competition Commission South Africa 2019). Major supermarkets such as Spar, Pick n Pay, Checkers, Woolworths, and Shoprite also offer urban consumers increasingly popular prepared-to-eat and on-the-go meals in their deli section, with some even having in-store cafes (Mhlanga 2018).

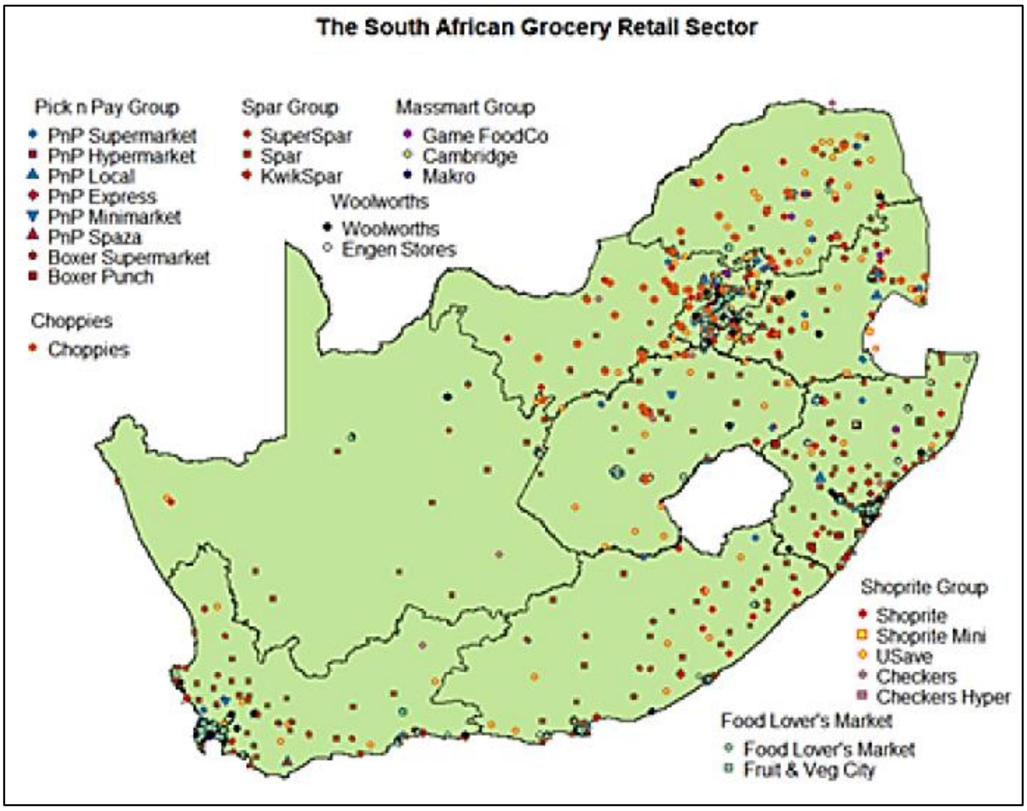


Figure 2.6: The nationwide distribution of the main grocery retailers in South Africa

Source: Competition Commission South Africa (2019)

A food environment's state of healthiness is also impacted by the presence of less healthy food sources like fast-food outlets (Feely et al. 2009). Food deserts are socially vulnerable communities with little to poor access to healthy food and food swamps are areas where unhealthy food selections are more widely available than healthy food selections (Honorio et al. 2021). Fast-foods are convenient foods attained typically in 'take-away' outlets with marginal waiting time (Feely et al. 2009). They are usually categorised as being high in simple sugars, saturated fats, and salt, highly palatable, low in micronutrients and fibre, generally larger in portion size, and more energy dense than home-cooked or restaurant meals (Feely et al. 2009). The consistent intake of meals from fast-food outlets over time have been connected to adult weight gain, with an amplified danger of obesity and NCD occurrence (Burgoine et al. 2014). In South Africa, the fast-food industry is growing at a rapid pace despite the slow-growing economy (Govender 2017). South Africans are progressively consuming inexpensive, speedy, and big-portioned fast-food items (Govender 2017). Taste, convenience, and time are the three primary reasons why consumers eat fast-foods (Govender 2017). Consumption from fast-food outlets permits consumers to appease their appetites as well as their need for social collaboration, entertainment, mood upliftment, pleasure, convenience, and time saving (Govender 2017). Cheap and convenient energy-dense meals such as burgers, chips and sugary drinks are easily available and can be purchased for less than R50 in various fast-food outlets (Motadi et al. 2018). In the formal food environment, the leading fast-food outlets in South Africa are McDonalds, Fish Aways, KFC, Chicken Licken, Steers, Nando's, Wimpy and Debonairs (Govender 2017), although there has been an upsurge of international brands such as Domino's Pizza, Burger King, Starbucks, Pizza Hut, and Dunkin Donuts entering the local market (Mhlanga 2018). These outlets offer wraps, chips, pizzas, burgers, chicken portions, salads, and desserts as well as alcoholic and non-alcoholic beverages (Govender 2017).

2.4 Measuring the food environment

Food environments are multifaceted and encompass all likely elements that influence what people consume that are not distinctly individual factors, such as beliefs, attitudes and preferences (Glanz 2009). Measuring the food environment is a fairly new field of study and there is currently no single authoritative base of evidence available on the historical methods of measuring the food environment (Glanz 2009). As such, researchers conduct their food environment measurements based on how their food environment of interest is conceptualised and understood, with their main emphasis usually being on the community-based and organisational environments (Glanz 2009). Progress in understanding food environment measurements and how to measure them accurately and comparably is crucial in progressing dietary behaviour and addressing public health disparities (Glanz 2009).

Examples of objective food environment assessment tools used by researchers is highlighted in Table 2.1 and the sections that follows explain these in more detail.

Overall, four objectively measurable characteristics of food environments were identified as contributing to diet quality and/or nutrition and health outcomes including: food availability, food affordability, food quality and food access (Minaker et al. 2011). Food availability describes the obtainability of adequate amounts of food of suitable quality. Food affordability is a key component of food access and determines whether consumers have enough money to buy adequate, disease-free, and nutritious food to meet their dietary needs (Minaker et al. 2011). Food quality refers to all the assessable features of a food item (as an illustration, expired canned or packaged foods, rotting meats and damaged fresh vegetables and fruits would be examples of poor food quality) (Minaker et al. 2011). Food access includes measures such as the distance to the nearest food outlet type and frequently point towards the geographic aspect of the food environment (Otterbach et al. 2021), density (the ratio of food stores per area) and variety (number of food stores within an area) (Minaker et al. 2011). To measure the food environment, the current study used the mRFEI.

Table 2.1: Examples of objective food environment assessment tools (taken from Minaker et al. (2011))

Instrument	**Food outlet types assessed**	**Food environment characteristic assessed**	**Methodology**	**Psychometric tests conducted?**	**Expertise and resources required**
NEMS-S Checklist	Stores	-Availability -Affordability -Quality	Objective audits of food stores	Showed good inter-rater reliability; good face and construct validity	Moderate-high
NEMS-R Checklist	Restaurants	-Availability -Affordability	Objective audits of restaurants	Showed good inter-rater reliability; good face and construct validity	Moderate-high
Shelf space measures	Stores	-Availability	Ratio of shelf space of healthy items to sum of shelf space of junk food	Showed good inter-rater and test-retest reliability; good face and construct validity	Moderate
mRFEI Ratio of store types	Stores and restaurants	-Access	Geographic analysis of ratio of number of fast-food outlets to grocery stores	No	Moderate-high

NEMS-S: The Nutrition Environment Measures Study within retail food stores; NEMS-R: The Nutrition Environment Measures Study within restaurants; mRFEI: Modified Retail Food Environment Index

2.4.1 The Nutrition Environment Measures Study within retail food stores (NEMS-S)

The NEMS-S checklist assesses the obtainability or availability of healthy food, quality, price, and options offered in a store. The foods to be examined should be easily defined/identified and include both less healthy and healthy foods that influence the risk of obesity and/or NCDs (Glanz et al. 2007). These include healthy items most recommended for healthful eating such as vegetables and fruits; and less healthy items such as fast-foods, sugar-sweetened beverages, and energy-dense nutrient-poor foods that are clearly linked with an amplified risk of obesity (Glanz et al. 2007).

The American version of NEMS-S includes baked goods, hot dogs, vegetables, fruit, milk, whole grain bread, ground beef, frozen dinners, baked chips, and beverages (soda/juice). However, the final choice of foods to be examined should be based on local food consumption statistics (Glanz et al. 2007). The NEMS-S tool has a great degree of inter-rater and test-retest reliability and discloses variances across store types and regions of opposing socioeconomic statuses (Glanz et al. 2007). The existence of grocery stores and the ease of accessibility to healthy foods in those stores appears to support a population's healthy consumption patterns (Glanz et al. 2007). Active observation of retail food environments allows for: the recognition of food fluctuations over time; suitable targeting of programmes to advance local food environments; contrasts between regions; categorisation of regions regarding its access and availability of healthy and less healthy foods; and the assessment of the influence of retail food environments on population health outcomes (Ni Mhurchu et al. 2013).

2.4.2 The Nutrition Environment Measures Study within restaurants (NEMS-R)

The NEMS-R checklist was constructed to measure the consumer food environment or the features consumers face in restaurants which may influence their food choices (Saelens et al. 2007), including: the enablers and barriers to healthful eating such as its availability, information, promotion, and pricing in restaurants (Carins et al. 2018). The NEMS-R checklist assesses the accessibility of healthful food items in the various menu categories such as entrees, salads, side dishes, main dishes, and beverages (Saelens et al. 2007). In their study on 217 sit-down and fast-food restaurants in four neighbourhoods in the Atlanta metropolitan area in the USA, Saelens et al (2007) found that NEMS-R items were found to be acceptable with particularly good inter-rater and test–retest reliabilities. They concluded that the NEMS-R checklist can be adopted to characterise restaurant environments (Saelens et al. 2007).

2.4.3 Shelf space measures

Consumer food choices are influenced by several factors in both the external food environment (the presence of food outlets and the convenience within these outlets) and factors related to the internal or in-store food environment including promotion, price, quality, and placement (Spires et al. 2020). The four Ps of marketing include some of the influences associated to the in-store environment, namely: the product, placement, price, and promotion of food products (Jaenke et al. 2014). These four Ps affect consumer buying behaviour and any changes to any or all these factors will influence consumer purchasing decisions (Jaenke et al. 2014). Product refers to the range or availability of food products; promotion refers to the displays, labels, and signage in store; price refers to deals, discounts, price increases; and placement refers to the shelf space, store layout, and shelf location (Jaenke et al. 2014). The extent of shelf space is a crucial factor of sales and additional display stands strongly influence purchasing behaviour i.e. more display stands of a product heightens the probability that a consumer will come across it in the store, thus increasing the possibility of its acquisition (Miller et al. 2012).

2.4.4 Ratio of store types - Modified Retail Food Environment Index (mRFEI)

The mRFEI is an environmental gauge of food access (Ndlovu et al. 2018). It illustrates the proportion of retailers classified as 'healthy' out of the total number of food retailers in a specific region (Ndlovu et al. 2018). The classification of 'healthy' and 'less healthy' food retailers is grounded on the CDC definition, which states that healthy food retailers include grocery stores and less healthy food retailers include fast-food outlets (CDC 2011). There are no cut-off scores for what is considered healthy or less healthy food environments, and researchers may categorise their mRFEI scores according to the distribution of their data (Gustafoson et al. 2012) The mRFEI is a noteworthy retail food environment indicator because it takes account of both types of food outlets (healthy and less healthy) in one measurement to provide an all-inclusive food environment representation (Ndlovu et al. 2018). The mRFEI can be used as a measure to understand the influence the food environment has on a population's diet quality.

When using the mRFEI, several methods are available to extract data and measure the food environment. Three such approaches are reviewed in the studies below.

Needham et al. (2020) conducted a study in Melbourne, Australia to document how food environments evolved over time from 2008 to 2016. They used two chief methods to identify and classify food outlets: 1) by extracting data from commercial and government lists of businesses as published by the Yellow Pages and White Pages and 2) virtual ground truthing using Google Street View and "googling" of business names to authenticate the food outlet type (Needham et al. 2020). The type of data extracted included the food outlet name, address, and data source (Needham et al. 2020). Virtual ground truthing involved Google Street View and Google® searches for the food outlets at the stated addresses, store front and internal photos, food offerings, inspection of the retailer's website, and menu if available (Needham et al. 2020). They excluded retailers where food was not the primary product for sale such as pharmacies and liquor stores (Needham et al. 2020). Like other research studies on food environment, the food outlets situated in the central business district were disregarded as they largely service employees and/or tourists (Needham et al. 2020).

Needham et al. (2020) measured the food environment at the local government areas (LGA) level in Melbourne, Australia in two ways: 1) density of food outlets by level of healthiness (i.e. the number of healthy and less healthy outlets per 10 000 people) and type (i.e. supermarket, fresh produce, fast food outlet, etc.); and 2) the ratio of less healthy to healthy food outlets (Needham et al. 2020). The ratio of less healthy outlets in relation to healthy outlets was measured as the number of less healthy outlets divided by the number of healthy outlets (Needham et al. 2020). A higher number represented a more obesogenic food environment. They used the Food Environment Score (FES) instrument to assign a score of healthiness to food outlets. The FES has a 20-point scoring system that ranges between -10 to +10 ((least healthy to most healthy) (Needham et al. 2020). The FES is a scoring system that was developed exclusively for use within the food outlet types found in Australian (Needham et al. 2020). In this study, food outlets were categorised into 1 of 17 outlet types using an adapted version of the FES. Store types were dissolved into seven groups (1. supermarkets, 2. fresh produce, 3. eating out, 4. small goods, 5. fast-food, 6. takeaways and 7. discretionary foods) based on similarity regarding the FES definitions, healthiness score and food offerings; and finally, into three groups (i. healthy FES range: +5 to +10, ii. less healthy FES range: -4 to +4 and iii. less healthy FES range: -10 to -5 according to healthiness score) (Needham et al. 2020). They found that the mRFEI was able to provide convincing evidence as to the increase in the number of food outlets and therefore the increase in food availability in Melbourne between 2008 to 2016, and that there was a unequal predominance of less healthy food outlets in relation to healthy outlets (Needham et al. 2020).

In another study measuring the food environment in Edmonton, Canada, Spence et al. (2009) extracted data on location of food establishments as provided the government and published business directories. From these datasets, based on the North American Industry Classification System codes, they classified food outlets as: supermarkets, fast-food outlets, speciality food stores, and convenience stores (Spence et al. 2009). Supermarkets were defined as stores selling bread, fruits, fresh meat, vegetables, dairy products and had free access to the store. Fast-food outlets were defined as outlets with a walk-up service counter selling mainly prepared-to-order and pre-processed foods (Spence et al. 2009). Specialty food stores were those who sold miscellaneous speciality foods not for immediate consumption (i.e. not prepared-to-order or pre-processed). Convenience stores were defined as those selling a restricted selection which generally included milk, bread, and snacks (Spence et al. 2009). A Retail Food Environment Index (RFEI) was calculated based on the following formula (Spence et al. 2009):

$$RFEI = (F+C)/G$$

- F = the number of fast-food restaurants
- C = the number of convenience stores
- G = the number of grocery stores

A constant of 1 was used if no grocery store was found within a particular buffer. A more obesogenic food environment is indicated by a higher RFEI (Spence et al. 2009). They observed that a lower RFEI index was related to a reduced occurrence of being obese and thereby concluded that the proximity to an obesogenic environment to be an imperative factor in their risk for obesity (Spence et al. 2009).

In their study at ward level in Gauteng, South Africa, Ndlovu et al. (2018) used a different method to classify healthy and less healthy food outlets. To represent healthy food outlets, the four foremost grocery store chains in the South African formal food sector, accounting for 97 % of grocery sales were selected, including: Shoprite Checkers, Pick n Pay, Spar, and Woolworths (Ndlovu et al. 2018). Fast-food outlets were used as a proxy for less healthy foods (Ndlovu et al. 2018). Full-service restaurants were not included as they often provide healthier food options (Ndlovu et al. 2018). The food outlet locations were gathered from Google Maps® as well as retailers' websites and plotted into a map using ArcMap version 10.5.36 software program (Ndlovu et al. 2018). Once the outlets' geographical co-ordinates were mapped, further investigation was completed using the ArcMap program (Ndlovu et al. 2018). They found that in November 2016, there were 709 healthy food outlets and 1 559 less healthy food outlets in Gauteng Province, giving an overall mRFEI score of 33 % (meaning that out of 100 stores, 33 had healthy food options which is an obesogenic food environment) (Ndlovu et al. 2018). They further observed that the dispersal of healthy food outlets was highly unbalanced as the wards in predominantly suburban areas had the larger number of healthy food outlets (Ndlovu et al. 2018). They concluded that the mRFEI tool allows policymakers to have a picture of the food environment, enabling them to plan and establish interventions to reduce obesogenic food environments (Ndlovu et al. 2018).

The current study measured the food environment using the mRFEI score and the median distance from participants' residential addresses to food retailers (grocery stores and fast-food outlets). We also compared the food environment measures (mRFEI score and the median distance from participants' residential addresses to food retailers) to the diet quality measures (DDS or MDD-W and REAP-S score) to understand the relationship between the food environment and the participants' diet quality, which will be discussed in later sections.

2.5 The changing food environment and the drivers of change

The changing food environment is influencing how consumers obtain, cook and eat food (HLPE 2017). The five main categories of drivers of change in food systems and the food environment include: 1) biophysical and environmental drivers; 2) innovation drivers, technology, and infrastructure drivers; 3) economic and political drivers; 4) socio-cultural drivers; and 5) demographic drivers (HLPE 2017). Biophysical and environmental drivers include climate change, natural resources, and ecology services (HLPE 2017). Innovation drivers, technology and infrastructure drivers include for example, advancements and modernisation of processes and processing equipment, nanotechnology, genetic modification, globalisation, trade liberalisation, etc (HLPE 2017). Political and economic drivers include political volatility, food prices, food legislation and policies, globalisation, humanitarian catastrophes and foreign investment and trade (HLPE 2017). Socio-cultural drivers include women's empowerment, religion, traditions, societal behaviours and culture (HLPE 2017). Demographic drivers include age distribution and growth, urbanisation and population migration (HLPE 2017). The effect of each driver on the food system and food environment depends on the type of system or environment, the role players involved and the type of activities and strategies they undertake (HLPE 2017). The changes observed in food environments are therefore derived from a complex array of factors.

2.6 The relationship between the changing food environment and diet quality

The nutrition transition as shown in Figure 2.7 refers to fluctuations in dietary/nutritional and lifestyle patterns led by economic growth, globalisation and urbanisation (HLPE 2017). Middle-class countries such as South Africa are experiencing a 'nutrition transition' which is the adoption of more westernised high salt, high sugar, high fat, energy-dense diets alongside traditional diets and poverty due to processes like urbanisation, globalisation, and the rapid advancements of technology. This has ensued a double burden of nutrition – undernutrition (which includes micronutrient deficiencies and stunting) and overnutrition (and its related diseases including diabetes, hypertension, heart disease) occurring within the same population group (Graham et al. 2018). The chief contributing influences of malnutrition include poverty, limited education, food insecurity, meagre access to healthcare facilities, inadequate infrastructure, and less healthy lifestyles (Govender et al. 2021). A recent study by Kroll et al. (2019) on 83 black households in Khayelitsha showed that a significant percentage of the household food environments were vulnerable to malnutrition (characterised by 71 % of the households meeting or exceeding the intake of highly processed and obesogenic foods) and only 16 % of households meeting or exceeding the consumption of protective foods (such as wholegrain foods, vegetables, fruits, and fish). The most prevalent obesogenic foods were found to be processed meat, sugary drinks, commercial bread, and sugar; and the most prevalent protective foods consumed were cooked and fresh vegetables, and fruit (Kroll et al. 2019). The consumption of obesogenic foods can be understood to be a reaction to the ongoing poverty, as these foods are stereotypically low-priced and do not generally involve much preparation (Kroll et al. 2019). By measuring the healthiness or un-healthiness of a food environment and understanding how much it influences an individual's diet quality, researchers and governments can take steps to improve the health and well-being of its population (Claasen et al. 2016).

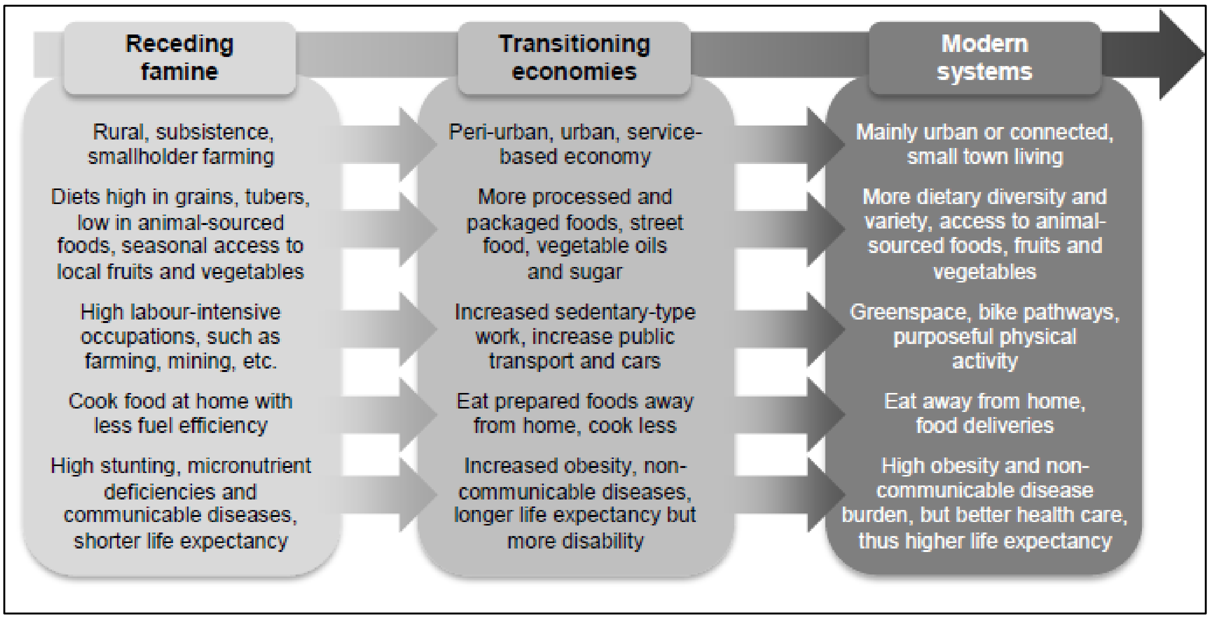


Figure 2.7: The nutrition transition

Source: HLPE (2017)

2.7 Types of malnutrition impacted by poor diet quality

Globally, one in three persons is malnourished and if the existing inclination continues, one in two could be malnourished by 2030 (HLPE 2017). All types of malnutrition are because of multiple factors, including meagre diets, insufficient consumer awareness, understanding or access to informational resources, and less healthy food environments (HLPE 2017). Some of the main contributing factors of malnutrition include less healthy lifestyles, poverty and food and nutrition insecurity (Govender et al. 2021). The burdens formed by malnutrition can be transferred through generations, because malnourished women have a higher possibility of giving birth to and raising malnourished children who have a higher possibility of growing up to be malnourished adults (HLPE 2017). Malnutrition has many different forms including undernutrition; micronutrient deficiencies; and overweight and obesity (HLPE 2017). The following sections will discuss the potential types of malnutrition impacted by poor diet quality.

2.7.1 Micronutrient deficiencies

Micronutrient deficiencies describe the deficit of essential vitamins and minerals in the body (Bailey et al. 2015). The vitamin and mineral deficiencies that are of crucial concern to public health include iron, vitamin A, and iodine (HLPE 2017). A deficiency in iron is a major concern for countless women worldwide as it results in tiredness and reduced work productivity (HLPE 2017). Having an adequate iron intake is particularly important during pregnancy as the body uses iron to produce more red blood cells to supply oxygen to the foetus ensuring appropriate growth and development (Jordaan et al. 2020). Numerous chronic diseases are commonly linked with iron deficiency anaemia such as cancer, chronic kidney disease, inflammatory bowel disease and chronic heart failure, (Lopez et al. 2016). The South African Demographic and Health Survey (SADHS) of 2016 found that 31 % of women age 15+ were anaemic (National Department of Health et al. 2019). vitamin A deficiencies intensifies the threat of and death from infections and/or disease and are the foremost reason for avoidable blindness in children (HLPE 2017). The SADHS of 2016 found that 13 % of women age 15+ were vitamin A deficient (National Department of Health et al. 2019). An iodine deficiency in woman during pregnancy can compromise the baby's physical and mental health and may even result in death (Bailey et al. 2015). Other important deficiencies are vitamins B_{12} and D, zinc, calcium and folate (HLPE 2017).

Even mild micronutrient deficiencies can impact an individual's well-being and development; and in children, it can result in various health disorders including delayed development and growth retardation (Govender et al. 2021). In pregnant women, several micronutrients can also influence both maternal and foetal health: nutrients such as iodine, fatty acids, iron, and zinc play critical roles in development of the brain, nervous system and immune function; vitamins A, B_6, B_{12} and folic acid influence oxidative pathways, embryogenesis and methylation which in turn impacts cell replication and differentiation; and vitamins C, E, B_6, B_{12} and folic acid may lessen oxidative damage to the placenta (Ramakrishnan et al. 2012). Micronutrient deficiencies are caused by several factors including poor diet and underlying diseases. Such deficiencies can be an indication that people consume fewer nutrient-dense foods (rich in micronutrients) and more energy-dense, processed foods (Govender et al. 2021).

2.7.2 Undernutrition

Undernutrition in children is measured and defined by a child being underweight, stunted, and/or wasted, whereas undernutrition in adults refers to an inadequate intake of nutrients and energy required to maintain good health typically reflecting as underweight and/or muscle wasting (WHO 2020). While undernutrition remains the chief form of malnutrition amid children <5 years old, the chief form of malnutrition amongst adults is now overweight and obesity (HLPE 2017). WHO estimates that amongst adults, the incidence of being overweight and obesity are now accountable for a higher number of deaths than the incidence of being underweight (WHO 2020).

2.7.3 Overweight and obesity

Obesity is a complex disorder categorised by an irregular or excessive fat build-up (Owolabi et al. 2017). In 2016, the World Health Organisation (WHO) reported that worldwide there was an estimated 13 % of adults that were obese and 39 % that were overweight (WHO 2017). Without implementing constructive methods to curb the growing trend, the WHO estimated that worldwide by 2030, obesity will impact more than 1.3 billion people (WHO 2008). Historically, in South Africa, obesity was overshadowed by several factors including the high prevalence of tuberculosis, undernutrition, and HIV/AIDS (Sartorius et al. 2015). However, in recent times, there has been an upsurge in overweight and obesity prevalence in Africa in general (Sartorius et al. 2015). The SADHS 2016 found that 3 % of South African women were underweight, 30 % were normal weight, 27 % were overweight and 41 % were obese (National Department of Health et al. 2019). The occurrence of overweight or obesity was found to be more prevalent amongst older women aged 45-64 (81-82%), but 40 % of young women aged 15-24 were also overweight or obese (National Department of Health et al. 2019).

Obesity contributes to the occurrence and progress of NCDs, and in women leads to possible complications during pregnancy and infant health (Haggblade et al. 2016). Obesity can impact a person's immediate health and long-term health through an increased risk of developing NCDs (Biadgilign et al. 2017). Over the past fifteen years, the prevalence of NCDs like cardiovascular disease, hypertension, stroke, and some cancers in South Africa has increased, drastically leading to higher morbidity and mortality rates (Claasen et al. 2016). In 2017, Statistics South Africa (Stats SA 2017) reported that diabetes, cardiovascular diseases, and hypertensive diseases ranked second, third and sixth respectively amid the top ten foremost causes of death in South Africa. Typically, NCDs are promoted by less healthy lifestyles like a poor diet, tobacco use, physical inactivity, and excess alcohol consumption which leads to various metabolic changes such as increased cholesterol, increased blood pressure, increased blood glucose, overweight/obesity and ultimately to the development of NCDs (Motadi et al. 2018). Obesity is also linked to insulin resistance and has significant repercussions in the cause and control of type 2 diabetes. It has been identified as one of the most substantial adjustable risk factors for type 2 diabetes (Adubra et al. 2015). Global projections show that type 2 diabetes predominance is set to increase twofold from 285 million in 2010 to 592 million in 2035, with sub-Saharan Africa feeling the greatest impact of this increase, with South Africa leading (Manyema et al. 2015). Other associated consequences of obesity include experiencing psychological and emotional suffering through developing an adverse body image and diminished self-esteem; developing depression and anxiety disorders, and stigmatisation (Tisane et al. 2017); developing eating disorders; experiencing stress, laziness, fatigue; and possibly suicide (Figueroa et al. 2017). Obesity in childhood and youth is just as dangerous as obesity in adults (Negash et al. 2017). Obesity in children is also associated with a higher risk for the development of high systolic and diastolic blood pressures, insulin resistance, type 2 diabetes mellitus and dyslipidaemia, among other diseases (Negash et al. 2017).

Overall, a high diet quality is critical for human health and a poor diet quality has multiple associated health risks. The sections that follow describe diet quality and the various tools and methods to measure diet quality.

2.8 Diet quality

Diet quality can be broadly described as a gauge of diversity or adequacy across key nutritional groups as recommended in dietary guidelines (Dalwood et al. 2020). The hallmarks of a superior quality or healthy diet are those which provide sufficient healthful food; a diversity of food, including plenty of legumes and whole grains, fruits and vegetables, sugar and salt consumed in moderation; using unsaturated fats rather than trans or saturated fats; consuming disease-free (safe) and minimally or unprocessed foods (FAO 2016). A high diet quality is one where the consumer has an optimal nutritional intake (Dalwood et al. 2020). Diet quality has developed into a substantial health issue in South Africa in the setting of fast-paced urbanisation (Drimie et al. 2013). An individual's diet quality is affected by an array factors as depicted in the presented frameworks (Figures 2.1, 2.2, 2.3, 2.4 and 2.5). These factors include, amongst other, consumers' family and culture; their food environment; their food preferences; their socio-economic status as well as their age and gender (Dalwood et al. 2020). Although diet is recognised as a key influencer to the inception of NCDs, its reliable and valid measurement in research studies remains a struggle, primarily due to its dependence on self-reported data from research participants (Zuppinger et al. 2022). Understanding the diet quality and variety of a population is necessary to evaluate health requirements and assess the value of interventions intended to progress dietary intake or assist decision-makers in designing interventions to improve health (Cleghorn et al. 2016).

Dietary Quality Indices or Indicators (DQIs) are algorithms that evaluate an individual's overall diet to place them into a category based on the degree to which their eating behaviour can be considered healthy which ultimately allows the researcher to understand a population's overall diet quality (Gil et al. 2015). There are several types of DQIs that fall into one of three major categories: 1) nutrient-based indicators; 2) food/food group-based indicators; and 3) combination indicators (Gil et al. 2015). The Mediterranean Diet Score, the Diet Quality Index, The Healthy Eating Index, and the Healthy Diet Indicator are the four 'original' DQIs that have been validated most extensively, although several other indexes have been revised from these originals (Gil et al. 2015). The primary source of data used to calculate DQIs are individual dietary data collection tools such as 24-hour dietary recalls, food frequency questionnaires (FFQs), food surveys and food diaries or dietary records (Gil et al. 2015). The different methods of obtaining dietary intake data and measuring diet quality will be discussed in section 2.9 below.

2.9 Measuring diet quality

Good-quality dietary intake data is vital to investigating the relationship between diet quality and health (Wentzel-Viljoen et al. 2011). There are numerous qualitative and quantitative dietary assessment methods available to acquire dietary intake data from individuals or populations, each with its own advantages, disadvantages, and limitations (Wentzel-Viljoen et al. 2011). The selection of the method to use is reliant on several factors including available resources, the purpose, and intentions of the study; and the features of the individual or study population (Wentzel-Viljoen et al. 2011). Some methods to attain diet history data to measure diet quality include food records, screening tools, 24-hour dietary recalls, FFQs and food diaries (Bailey 2021). Four such methods will be discussed in further detail below: 1) 24-hour dietary recall to calculate the DDS; 2) the REAP-S survey; 3) FFQs; and 4) food diaries.

2.9.1 24-hour dietary recall to calculate the dietary diversity score

Individuals require several nutrients for peak health and since no single food contains all the required nutrients, the consumption of a variety of foods will ensure a suitable provision of all nutrients (Steyn & Ochse 2013). The South African Food-based Dietary Guidelines include the recommendation to "enjoy a variety of foods" (Steyn & Ochse 2013). The terms 'dietary quality' 'nutrient/dietary adequacy,' 'dietary diversity' and 'dietary variety' are often used to define an individual or population's diet. Dietary quality or nutrient/dietary adequacy describes whether a diet meets all nutrient and energy requirements (Steyn & Ochse 2013). Dietary diversity refers to the number of food groups that an individual has eaten over a specific time. Dietary variety is the same as dietary diversity and is often used interchangeably. Dietary diversity can be used as an indication of an individual's dietary micronutrient adequacy (Steyn & Ochse 2013). The adequate provision of all nutrients is of utmost significance to meet the nutritional requirements of an individual for good health, immunity, growth, body maintenance, strength, physical work, and cognitive ability (Habte & Krawinkel 2016). A diet that is low in variety is plausible to be deficient in some nutrients which may result in subsequent malnutrition (Steyn & Ochse 2013). A low dietary diversity in children is connected to stunted growth; and in adults, a greater possibility of metabolic syndrome and cardiovascular risk factors (Drimie et al. 2013).

A DDS measures the number of food groups eaten over a specified time as a gauge of nutritive quality (Habte & Krawinkel 2016). The number of food groups used to measure the dietary diversity score (DDS) as recommended by the FAO and used in different studies is shown in Table 2.2. The optimum selection of food groups for the calculation of the DDS has not yet been comprehensively investigated and regulated (Habte & Krawinkel 2016). The basis for the organising of foods into different food groups lies in their variability of nutrient density – some foods are relatively rich in vitamins, minerals, energy, or protein (Habte & Krawinkel 2016). For a DDS to be applied to a general population, food groups can be classified as: (1) vitamin sources - food of animal origin, vegetables, fruits, green vegetables, etc.; (2) mineral suppliers - food of animal origin, vegetables, milk, pulses, other legumes, etc.; (3) sources of energy - roots, cereals, tubers, etc.; and (4) protein providers - food of animal origin, pulses, etc. Since the number of food classes providing distinct types of nutrients is four, it is sensible to adopt this as the lowest cut-off point for a healthy diet (Habte & Krawinkel 2016).

Table 2.2: Food groups used for the assessment of DDS (Adapted from Habte & Krawinkel (2016))

Groups	***FAO – MDD-W (FAO 2021)***	***FAO – DDS***	***Kennedy et al. (2007)***	***FANTA (Swindale & Bilinsky)***
I	Grains, white roots, and tubers, and plantains	Starchy staples (cereals, roots, tubers)	Cereals, roots, and tubers	Cereals
II	Pulses (beans, peas, and lentils)	Vitamin A rich fruit and vegetables	Vitamin A rich fruit and vegetables	Roots/tubers
III	Nuts and seeds	Other fruits	Other fruits	Vegetables
IV	Milk and milk products	Other vegetables	Other vegetables	Fruits
V	Meat, poultry, and fish	Legumes and nuts	Legumes, pulses, and nuts	Meat/poultry/offal
VI	Eggs	Fats and oils	Oils and fats	Eggs
VII	Dark green leafy vegetables	Meat, poultry, fish	Meat, poultry, fish	Fish/sea food
VIII	Other vitamin A-rich fruits and vegetables	Milk and milk products	Dairy	Legumes/pulses/ nuts
IX	Other vegetables	Eggs	Eggs	Milk/milk products
X	Other fruits		Others (sweets, chips, soda)*	Oil/fats
XI				Sugar/honey
XII				Miscellaneous

DDS: Dietary Diversity Score; FAO: The Food and Agriculture Organisation; MDD-W: Minimum Dietary Diversity for Women; FANTA: Food and Nutrition Technical Assistance Project

**The "other" food group consisting of sugar, non-juice or dairy beverages, condiments and spices, was used in descriptive statistics but was not used to calculate DDS, because these foods do not contribute substantially to micronutrient intake.*

When calculating the DDS, the number of food groups in an individual's or household's daily diet is often obtained using a 24-hour dietary recall. Each participant is asked to specify all foods and drinks ingested on the preceding day without quantifying the amount consumed. A food or drink ingested from a specific food group is tallied only once. The total number of food groups consumed provides the DDS and a score <4 or <5 (depending on the dietary assessment tool used in the study) represents poor dietary diversity (FAO 2021). The DDS can be differentiated as a household dietary diversity score (HDDS); an individual dietary diversity score (IDDS) or MDD-W. The HDDS is an indicator of household food access, the IDDS is an indicator of the nutritional quality of individual's diets (Habte & Krawinkel 2016), and the MDD-W is an indication of micronutrient suitability of diets in WRA.

Numerous studies have taken place in South Africa utilising the DDS as a measure of nutritive appropriateness. In a study by Jordaan et al. (2020) among 134 women aged 25-49 years from rural Free State, they calculated the DDS from dietary data obtained using a 24-hour dietary recall establishing a relationship between the DDS and the prevalence of anaemia and contraception use. They found that although the predominance of anaemia was small in the study population, consideration needs to be given to the women's diets as nearly 50 % of the population consumed a diet of low diversity, and not all of the study participants ate foods high in folate, vitamin B12 or iron (nutrients needed for red blood cell production) (Jordaan et al. 2020). In a study conducted by

Drimie et al. (2013) among 195 urban informal households and 292 urban formal households in Johannesburg, the DDS was calculated using 24-hour dietary recall. The lowest possible DDS is 0 and the highest possible DDS is 9. A DDS <4 was considered a low score and an indication of poor dietary diversity. They found that households in informal settlements ate mainly cereals and foods of animal origin, while households in formal settlements had a wider ranging diet (Drimie et al. 2013). They concluded that households in informal settlements were more nutritionally vulnerable as significantly more of these households consumed a diet of low diversity (68.1 %) versus those residing in formal settlements (15.4 %) (Drimie et al. 2013). In the South African Social Attitudes Survey conducted in 2009, Labadarios et al. (2011) measured the DDS among 3287 adults across all provinces and socioeconomic levels. They found that the mean national DDS was 4.02, with Limpopo Province (61.8 %) and the Eastern Cape (59.6 %) having the highest predominance of poor dietary diversity (Labadarios et al. 2011). A comparison of geographic areas showed that formal urban areas had the highest mean DDS of 4.42 and rural areas had the lowest mean score of 3.17 (Labadarios et al. 2011).

Since this study is focused solely on WRA, we have chosen to use the minimum dietary diversity for women to categorise the DDS.

2.9.1.1 Minimum Dietary Diversity for Women (MDD-W)

The diets of WRA commonly fall short of their nutritional requirements, predominantly in resource-poor settings (Martin-Prevel et al. 2017). The MDD-W is a validated tool for evaluating the diet quality or micronutrient adequacy of WRA (FAO 2021). At this point in time, the MDD-W is the sole standardised dietary diversity assessment that explicitly concentrates on WRA (FAO 2021). It is a food group diversity indicator that echoes micronutrient adequacy as abridged across 11 micronutrients: vitamin A, thiamine, riboflavin, niacin, vitamin B_6, folate, vitamin B_{12}, vitamin C, calcium, iron, and zinc (FAO 2021). Comparable to the traditional DDS, the MDD-W is a dichotomous gauge to measure whether WRA have eaten food from at least five out of ten defined food groups in the last 24 hours (FAO 2021). The ten food groups are: 1) grains, white roots, tubers, and plantains; 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 (FAO 2021). The MDD-W is calculated by adding the scores of the ten defined food groups – a score of 1 is given to each food group consumed and 0 if not consumed. A minimum score of 0 (0 food groups eaten) and maximum of 10 (10 food groups eaten) is possible; an MDD-W of ≥5 is an indication of adequate micronutrient intakes and <5 is an indication of possibly inadequate micronutrient intakes (FAO 2021). In their study on 3164 24–71-month-old non-breast-feeding Filipino children, Kennedy et al. (2007) assessed whether DDS is a good indicator of adequate micronutrient intake in young children and found that the best cut-off points for achieving 50 % probability of adequate micronutrient intake were 5 food groups. FAO uses <4 as the cut-off point for adults (FAO 2021); however, the current study adopted the MDD-W tool and thereby used <5 as the cut-off point.

The MDD-W has been used in several studies. For example, in a study on 286 women from Gauteng and Eastern Cape conducted by Fisher (2021) who also used a 24-hour dietary recall and the MDD-W to determine adequate micronutrient intake. The mean DDS for the group was 3.7 and 75.4 % of women consumed ≤5 food groups and therefore did not achieve the MDD-W (Fisher 2021). She concluded that acceptable dietary diversity and thereby micronutrient adequacy remains a challenge for WRA, particularly for women from vulnerable households (Fisher 2021). Another study on 5046 WRA from Mali also used a 24-hour dietary recall and the MDD-W to determine micronutrient adequacy (Adubra et al. 2019). The authors found that only 27 % of women achieved the MDD-W and concluded that the MDD-W was a valid tool as a representation of micronutrient adequacy amongst WRA (Adubra et al. 2019). In another study, based on a secondary analysis of nine quantitative dietary data sets from WRA (n = 4166) in Asia and Africa, Martin-Prevel et al. (2017) concluded that when resource-intensive nutritional approaches are not practicable, the MDD-W provides a simple dichotomous gauge for the dietary diversity of WRA based on ≥5 of 10 defined food groups reflecting the 'minimum dietary diversity for WRA'.

2.9.2 REAP-S Survey

The notion of diet quality refers to the diversity of food groups consumed, recognised healthy food consumption patterns and the adherence to healthful food choices (Bliss 2015). Methods of evaluating diet quality are used in community, clinical, and research settings (Bliss 2015). Traditional dietary assessment techniques are often challenging, expensive, and time-consuming to administer (Gans et al. 2003). The need for brief diet assessment questionnaires that could be used in clinical settings arose that was: easy to administer and complete; provides feedback that is instant and well-matched with in-office assessments; have a low cost; and addresses nutritional issues that are a national nutrition concern for adults (Gans et al. 2003). To respond to this need, the Nutrition Academic Award developed the Rapid Eating Assessment for Participants (REAP) survey. The survey came about as a partnership among investigators involved in the Nutrition Academic Award which is an enterprise to advance nutrition training across United States medical schools (Segal-Isaacson et al. 2004). The survey intended to evaluate general nationwide nutrition concerns for adults, including issues linked to the Food Guide Pyramid, the US Dietary Guidelines for Americans 2000, and the Healthy People 2010 objectives (Segal-Isaacson et al. 2004).

The REAP survey was initially established in 2003 to assess dietary behaviours with the aim to ascertain a comprehensive nutritional profile (Kurka et al. 2014) and the objectives: 1) to address dietary matters that are national nutrition urgencies for adults; 2) to provide a tool that can be self-administered by participants or easily administered by a health-care provider or interviewer; 3) to be user-friendly; 4) to highlight any nutrition concerns to the healthcare provider; 5) and to provide a patient nutrition summary that could be incorporated in their medical record (Gans et al. 2006). The REAP survey's best use would be during a patient's initial doctor visit or at their annual physical exam where the patient can fill it out in the waiting room or completed at home before their appointment (Gans et al. 2003). The original REAP survey included 27 questions evaluating the eating frequency of breakfast and meals not prepared in the home, intake of whole grains, fruits and vegetables, calcium-rich foods, saturated fat and cholesterol, sugar-rich food and beverages, sodium, alcohol beverages, and physical activity level (Segal-Isaacson et al. 2004). It also contained questions regarding whether the patient shops and prepares his/her own food; ever has any trouble being able to shop or cook; follows a special diet; eats or limits certain foods for health or other reasons; and asks how willing the patient is to amend eat healthier (Gans et al. 2003). The survey takes approximately 10 minutes to complete and is written at the sixth grade reading level (Kurka et al. 2014). There is no cut-off value for the REAP-S score thus to classify the diet quality based on the REAP-S score solely is not possible. However, individual line items in the survey provide insights into the dietary behaviour.

In their research recounting the development of the REAP survey and assessing its reliability, validity, and ease of use, Gans et al. (2006) evaluated the tool in four ways: 1) via a feasibility study among 61 medical students and practicing doctors at several medical schools; 2) via a calibration or validation study with 44 students from Brown University Medical School; 3) via a cognitive assessment among 31 consumers in Rhode Island; the tool was then reviewed based on the results from these three evaluations and then underwent 4) a reliability and calibration or standardization study among 94 consumers in Rhode Island and Massachusetts (Gans et al. 2006). The results showed that in the feasibility study, there were high rankings on the REAP questionnaire's ease of use, practicality, and helpfulness; and the calibration studies showed that REAP had exceptional test-retest reliability and significantly correlated with the Healthy Eating Index (HEI) score (Gans et al. 2006). They concluded that REAP has suitable reliability and validity for use in nutrition assessment and counselling (Gans et al. 2006).

In 2004, the REAP was shortened (REAP-S) to 16 questions and was designed to concentrate on food intake in selected food groups for research purposes. It can be used to quickly assess the relative intake of fat, cholesterol, fibre, sugar, and selected food groups (whole grains, fruits and vegetables, calcium-rich foods, meat, snacks, fat, and sugar-containing foods and beverages) (Segal-Isaacson et al. 2004). Questions were deleted from the original REAP survey on the type of dairy, type of ground beef, removing skin and fat on poultry and meats, fat-free substitutes, alcoholic drinks, and physical activity. The purpose of shortening the survey was to focus solely on food intake and improve its practicality among low-literacy populations (Johnston et al. 2018). In their validation study of the REAP-S survey among first-year medical students at the Albert Einstein

College of Medicine, Segal-Isaacson et al. (2004) compared participant answers of the REAP-S survey to a validated semi-quantitative FFQ. They found statistically significant correlations between the surveys in the range of 0.6 to 0.8 using the Pearson's co-efficient (Segal-Isaacson et al. 2004). They concluded that the REAP-S survey may be beneficial for quick nutrition assessments and participants with low scores could potentially be referred for further nutrition assessment and/or nutrition counselling (Segal-Isaacson et al. 2004).

Another validation study of the REAP-S survey conducted on National Collegiate Athletic Association (NCAA) Division-I male and female athletes in June-August 2011 (n=150) and June-August 2012 (n=241), Kurka et al. (2014) found that REAP-S survey was a valid tool to evaluate dietary behaviours. In her research with the objective to evaluate the effectiveness of the REAP-S and HEI-2010 for scoring the diet quality of omnivorous, vegetarian and vegan diets using 81 healthy participants ±31 years old from Arizona, Bliss (2015) found that the REAP-S is an appropriate tool to quickly evaluate diet quality as it is significantly correlated to the HEI-2010 and entails less time, labour and money to use than the HEI-2010. In their research to determine the degree of correlation between HEI-2010 and REAP-S, Johnston et al. (2018) found that the two methods of scoring diet quality were significantly correlated in a healthy adult population of 81 people consuming both plant and animal-based diets. Additionally, unlike the HEI-2010 measure, the REAP-S survey distinguished between omnivorous and vegan diets and correlated favourably with four other gauges of diet quality (potential renal acid load, urine pH, plasma vitamin C, and nutrient density of the diet) as well as with the consumption of several nutrients including saturated fats (Johnston et al. 2018). They concluded that the REAP-S is a useful tool for assessing diet quality (Johnston et al. 2018). The HEI-2005 and the Diet Quality Index Revised (DQI-R) are tools that efficiently measure diet quality; however, both are difficult to use and are time consuming (Fawcett 2012). In her study evaluating the validity of the REAP-S against the HEI-2005 and the DQI-R using 50 males aged 18-33 years from Arizona USA, Fawcett (2012) had the participants complete the REAP-S survey and a 24-hour dietary recall. HEI-2005 and DQI-R scores were calculated for each 24-hour dietary recall and compared to the REAP-S score. It was found that the REAP-S score had a significant, moderate correlation to both the HEI-2005 and the DQI-R with strong precision. It was concluded that REAP-S is an adequate tool to quickly evaluate diet quality of populations (Fawcett 2012).

2.9.3 Food frequency questionnaires (FFQs)

As with the 24-hour dietary recall, the FFQ is a diet history data collection tool. The dietary data obtained from FFQs still require further analysis to determine diet quality (Gil et al. 2015). FFQs have become the chief means of measuring dietary consumption in epidemiological research studies because of their ease of administration, low cost, and the ability to measure average dietary consumption data over a prolonged time in a substantial number of participants reflecting habitual intakes (Sheehy et al. 2014). FFQs can be quantified or non-quantified and depending on the objectives, resources, or scope of the study, and they can be shortened or not. In a study to measure a diet quality score (DQS) from a shortened food frequency questionnaires (SFFQ) and to validate it against an extensive FFQ and a 24-hour dietary recall among 1999 adults in Northern England, Cleghorn et al. (2016) found there to be significant agreement between the DQS of the SFFQ and the extensive FFQ, but insignificant agreement between the DQS of the SFFQ and 24-hour diet recall. They concluded that although the SFFQ is not suitable for assessing total dietary consumption, it is a suitable method of evaluating diet quality and it offers a method of determining variations in diet quality across and within different populations (Cleghorn et al. 2016).

In South Africa, because of its cultural, ethnic, and geographical variances, it is unsuitable to use an international FFQ to evaluate the diets of various populations; instead, FFQs must be established explicitly for each population group (Sheehy et al. 2014). In a study using a non-quantified FFQ to assess food frequency among 98 grade 9-11 learners from an urban school and 111 grade 9-11 learners from a peri-urban school in Hilton, KwaZulu-Natal, Audain et al. (2014) found the FFQ to be a suitable tool for measuring dietary quality. Another study by Okeyo et al. (2020) used an adapted version of the short unquantified FFQ implemented by Audain et al. (2014) to evaluate the dietary behaviours and weight status of 1360 male and female adolescents at high schools in both rural and urban Eastern Cape. This study collected data on learners' typical eating habits: their breakfast consumption; takeaways; weekly meal pattern; snacks eaten while watching TV; and foods taken to school (Okeyo et al. 2020). They also found the FFQ to be a suitable tool for measuring dietary intake and were able to observe a high incidence of poor dietary behaviours with noteworthy urban-rural and gender variances, with a vast of black female adolescents found to be overweight or obese (Okeyo et al. 2020). The Nutrition during Pregnancy and Early Development (NuPED) study in urban Johannesburg by Symington et al. (2018) used a quantified FFQ to evaluate the diets of pregnant women to determine nutrient intake relationships with maternal health, birth outcomes and offspring well-being and development. This quantified FFQ was an adapted version of the validated quantified FFQ used in the North-West Province for the Transition and Health during Urbanisation of South Africans (THUSA) study (Macintyre et al. 2000). The quantified FFQ was found to be an acceptable tool to measure dietary intake and determine the Diet Quality Index-International (DQI-I) (Conradie et al. 2021).

2.9.4 Food diaries

Food diaries or dietary records are considered with 24-hour dietary recalls and FFQs as primary data sources to determine diet quality (Gil et al. 2015). Food diaries or dietary records are a prospective, open-ended data collection method where consumers are asked to record the foods and beverages consumed in real-time for a specific period (Stewart et al. 2022). Food diaries can be used to estimate an individual's diet as well as a population to identify groups at risk of nutritional inadequacy (Ortega et al. 2015). Depending on the aim/hypothesis of the research, participants are often requested to record comprehensive data about portion sizes, food preparation methods, the brand name of the food products and the ingredients used in home-cooked meals (Ortega et al. 2015). Although food diaries are often considered as a reference method in validation studies and have the strengths that they provide detailed dietary intake data; no interviewer is required and even though there is no recall bias, they are not without limitations (Ortega et al. 2015). Some of these limitations include that: participants need to be trained on how to record their food consumption in their diaries; multiple days are required to evaluate dietary intake; it is expensive and time consuming; participants may report food intake close to what they consider to be socially desirable or acceptable; and it has a relatively large participant burden (they need to have good literacy and be highly motivated to fill in their diaries) (Stewart et al. 2022).

To measure diet quality, the current study used the DDS (categorised into the MDD-W categories) calculated from a 24-hour dietary recall and the REAP-S survey.

2.10 Conclusion

South Africa is undergoing a 'nutrition transition' (Graham et al. 2018), influenced by the growth of commercial food markets in both urban and rural areas which impacts food consumption patterns. While supermarkets increase the availability of healthy foods (Claasen et al. 2016); the fast-food industry is growing at a rapid pace increasing the availability of less healthy foods (Govender 2017). South Africans are progressively consuming inexpensive, speedy, and big-portioned fast-food items (Govender 2017). The consistent intake of meals from fast-food outlets over time have been connected to adult weight gain, with an amplified danger of obesity and NCD occurrence (Burgoine et al. 2014). According to the SADHS of 2016, 68 % of women were found to be overweight or obese (National Department of Health et al. 2019). According to the study by Labadarios et al. (2011), the mean South African national DDS was 4.02, where a score of <4 was considered a poor dietary diversity. One of the probable causes of the high rate of obesity and low dietary diversity of the population could be the food environment. It is important to investigate these factors to understand the relationship between the food environment and diet quality.

CHAPTER 3: RESEARCH METHODS

A detailed outline of the research methodology is described in this chapter. It discusses the study design, study setting, population, and sampling, data collection methods (including diet quality and food environment), data management, statistical analysis, and ethical considerations.

3.1 Study Design

The study had a cross-sectional design as it involved a once-off measurement of the diet quality of WRA and the formal urban food environment to which they were exposed within the city of Johannesburg. Cross-sectional studies are observational by nature and used to describe a situation and/or assess the relationship between an exposure and an outcome occurring at the same time and so they can be descriptive or analytical depending on the nature of the study (Chidambaram & Josephson 2019). The present study was analytical. Cross-sectional designs are best used if a study involves a questionnaire, for example if a researcher wants to understand the risk factors in relation to the onset of a particular disease (Chidambaram & Josephson 2019). The main limitation of a cross-sectional study design is that it takes place at a single point in time and therefore chronological associations cannot be established, such as cause and effect (Chidambaram & Josephson 2019).

3.2 Study Setting

The CHAMP study site for recruitment and data collection was the family planning and antenatal clinics of the DCHC, situated in Florida, Roodepoort, Johannesburg (Figures 3.1 and 3.2). Women who attended this clinic mainly reside in the greater Roodepoort area and, therefore, assessment of the food environment took place in this area.

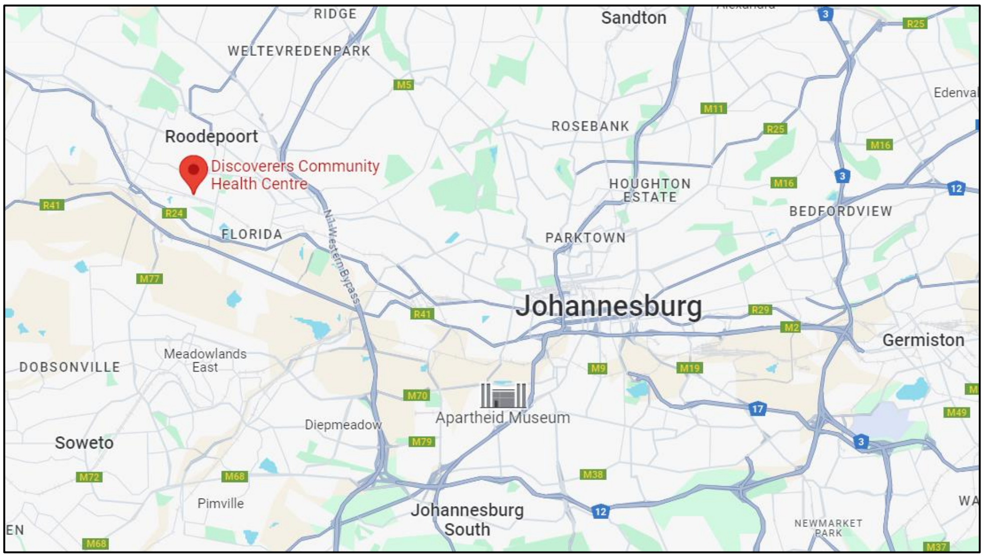


Figure 3.1: Map indicating the location of the DCHC, Johannesburg

Figure 3.2: Photograph of the DCHC entrance

Source: Researcher

3.3 Population and Sampling

The study population consisted of generally healthy women, some of whom live with HIV. Being of reproductive age, they attend the primary healthcare facility specifically the family planning and antenatal care clinics.

Inclusion criteria:

- Women of reproductive age from 18 to 49 years of age
- Study participants could be pregnant or non-pregnant
- Be able to speak and read a local language and respond to the fieldworker and questionnaire

For comparison purposes, these inclusion criteria was that the survey conducted by the National Department of Health in 2016 included women aged 15 to 49 who were considered as women of reproductive age. However, due to consent of minors (<18 years) being more challenging, the age range for the present study was 18 to 49 years. Furthermore, the language requirement was necessary since participants had to be able to understand the interviewer-administered questions and answer accordingly.

Exclusion criteria:

- Known NCDs, such as hypercholesterolemia, renal disease, diabetes, hypertension.
- Known infectious diseases such as hepatitis and/or tuberculosis (HIV infection is not an exclusion criteria).
- Known serious illness such as psychosis, lupus erythematosus, or cancer.

The motivation for the exclusion criteria was that these factors influence dietary practices and for the larger CHAMP study had implications on cardiovascular health outcomes.

Sample size calculation for the present study was conducted *a priori* using the G*Power 3.1.9.4 statistical programme. The calculation involved an independent t-test and was based on a small to medium effect size of 0.3, probability error (alpha) of 5 % and a power of 80 %. This resulted in a minimum required sample size of 139 women who should participate in the study.

Participant recruitment was conducted from September 2022 to May 2023. Consecutive sampling was used (a type of non-probability sampling) where women attending family planning and antenatal care clinics at DCHC had the chance to form part of the study population. Consecutive sampling is a type of convenience sampling and means that participants selected to take part in a study in order of appearance, based on their convenient availability (Martínez-Mesa et al. 2016). The consecutive sampling process ends when the study time limit is reached or when the required number of participants is attained (Martínez-Mesa et al. 2016).

The researcher included all available women meeting the inclusion criteria and who agreed to partake in the study. As women entered the family planning and antenatal care waiting area, they were informed of the study and asked whether they would like to participate. The women who agreed to participate were screened for inclusion according to criteria using a quick screening form (Appendix 1) and informed about the details of the study, read and signed an informed consent form before being enrolled in the study. Enrolment numbers are reported in Chapter 4.

3.4 Data collection methods

Study participants were consulted one-on-one in an allocated space closed off from the general clinic area at the DCHC. The fieldworker discussed the written informed consent form (Appendix 2: Informed consent form). Only once written consent was provided were the women enrolled in the study. The procedures were explained using good clinical practice guidelines (as per the content of the information sheet with the consent form), and explained in their own language by trained fieldworkers, if required. Participants were given the opportunity to ask questions. It was made clear to all participants that they were able to withdraw from the study at any time without any consequences.

Study data were collected from responses to questionnaires administered by an interviewer who was a trained fieldworker. Data included socio-demographic details such as residential address, date of birth, ethnicity, country of birth, educational level, marital status, living standards measure and whether the household receives a social grant. See section A of Appendix 3. The participant date of birth was used to calculate her age on the day of data collection. The living standards data were attained to categorise participants into the Living Standards Measure (LSM) scale developed by the Marketing Research Foundation (Ncube & Serumaga-Zake 2015). The LSM scale is used in South Africa to describe the socioeconomic status of the population, as an indication of wealth rather than income (Labadarios et al. 2011). It includes 29 attributes such as access to basic sanitation like running water and flush toilets, a car, mobile phones, laptops, having domestic and security services, etc. (Labadarios et al. 2011). Such data allow for classification of participants into 10 LSM groups. Those in LSM groups 1-4 have the least access to wealth and those in groups 8-10 have the most access to wealth (Ntloedibe & Ngqinani 2020). See Appendix 3: CHAMP Participant Questionnaire & Data Collection Sheet (TP1).

Furthermore, since women were recruited from both family planning and antenatal clinics, pregnancy status was obtained from the medical file with permission from the participant.

Anthropometrical data were collected from both pregnant and non-pregnant women (see section E of Appendix 3). Participant weight (kg) was measured on a calibrated flat, electronic scale (SECA 813, Seca GmbH & Co. KG, Hamburg, Germany) with the participant wearing light clothing and being barefoot. A portable stadiometer (SECA 213, Seca GmbH & Co. KG, Hamburg, Germany) braced against a wall and on an even, solid surface was used to measure participant height. Participants were requested to stand upright with their feet together, buttocks against the stadiometer rod and head positioned so that the Frankfort plan was parallel to the floor. The stadiometer headpiece was then brought down to firmly compress the hair until it rested on the head. Each height measurement was recorded to the nearest 0.1 cm.

Body mass index (BMI) was calculated by dividing weight (in kg) by height (in m) squared (kg/m^2) for non-pregnant women only since unadjusted pregnancy weight is not an accurate reflection of nutritional status during second and third trimester. Participant BMI was categorised as: underweight <18.5 kg/m^2; normal weight 18.5-24.9 kg/m^2; overweight 25.0-29.9 kg/m^2 and obese ≥30.0 kg/m^2 (WHO 2017). Since BMI is not an accurate reflection of weight status during pregnancy, Mid-Upper Arm Circumference (MUAC) was used. The MUAC was measured on the left arm of participants using a spring-wound measuring tape (Wenhold et al. 2022). Participants were asked to uncover their entire arm, from fingers to shoulder and to bend their arm at a 90-degree angle with their palms facing up (Wenhold et al. 2022). The upper reference point was found by feeling for the furthest bony point of the shoulder blade and marking it with a cosmetic pencil (Wenhold et al. 2022). The lower reference point was found by feeling for the lowest bony edge of the elbow and marking it with a cosmetic pencil (Wenhold et al. 2022). The tape was placed between these two points to measure the distance with the zero being at the shoulder. The midpoint was calculated by dividing the distance by 2 and marking it with a cosmetic pencil (Wenhold et al. 2022). The participant was then asked to let her arm hang loose at their side and the arm circumference was measured with the measuring tape at the marked mid-point (Wenhold et al.

2022). A participant MUAC <23 cm was considered to suggest underweight, while >33 cm suggested obesity, and a MUAC of 23-33 cm suggested to not be at risk of malnutrition (Fakier et al. 2017). As part of quality control, all measurements were taken twice. If the two weight measurements differed by >0.1 kg, the height measurements differed by >5 cm or if the MUAC measurements differed by >1.5 cm, then a third measurement was taken. The mean of two or three measurements was used for analysis.

3.5 Measuring diet quality of WRA

Dietary consumption data were acquired by means of two dietary evaluation methods: the 24-hour dietary recall allowing the calculation of the DDS and categorise into the MDD-W categories; and the REAP-S survey which is explained in detail in the following sections. Trained fieldworkers administered both dietary evaluation methods.

3.5.1 24-hour dietary recall to calculate DDS

During the 24-hour dietary recall (see section C of Appendix 3), each participant was asked to recall all foods and drinks they consumed the previous day from when they woke up until the day of interview at the same time (approximately 24 hours later). Misreporting food intake is one of the main inaccuracies of dietary assessment, therefore using a multi-pass method can greatly reduce bias and more accurately estimate nutrient intake (Fawcett 2012). In the current study, a multiple pass method was used to capture dietary intake data. During the first pass, the fieldworker encouraged the participant to freely recall all food and drink for the previous 24 hours and did not interrupt the study participant (Nightingale et al. 2016). During the second pass, the fieldworker enquired if the study participant has further details, for example, the exact time and type of foods or drinks consumed (Nightingale et al. 2016). During the third pass, fieldworker and participant reviewed and reported all food and drinks in order, clearing up any uncertainties and prompting for anything that may have been left out (Nightingale et al. 2016).

Table 3.1 below describes the number of food groups and food group descriptions The data from the 24-hour dietary recall were used to calculate the DDS and categorise it into the MDD-W categories using the guidelines developed by FAO (FAO 2021). These guidelines summarise the number of food groups obtained from the 24-hour dietary recall into ten standardised food groups to allow for the DDS calculation: 1) grains (cereals), white roots, tubers and plantains; 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 (FAO 2021). No minimum quantity consumed was considered and, therefore, any quantity of the food consumed counted once towards the food group. Mixed dishes were disaggregated to record the individual food items consumed. However, milk in tea and coffee was not counted as consuming dairy by virtue of the small milk volumes typically used during tea and coffee consumption, as per FAO guidelines. Foods such as sweets, cooldrinks, tea or coffee are not considered to contribute meaningfully to micronutrient intake and are therefore not included in the FAO food groups (FAO 2021) and are not analysed from the 24-hour dietary recall in this study. Every food group was tallied only once when determining the DDS (FAO 2021). The lowest possible DDS therefore is 0 which reflects poor dietary diversity and the highest possible score is 10 which reflects a highly varied diet and therefore exceptional dietary diversity/micronutrient intake (FAO 2021). According to this instrument, a DDS score of ≥5 indicates that the MDD-W was achieved (an indication of adequate nutritional intake) and a score of <5 indicates that the MDD-W was not achieved (an indication of inadequate nutritional intake) (FAO 2021).

Table 3.1 Number of food groups and food group descriptions

Food Group No.	Food Group Description	Examples
1	Grains, white roots and tubers, and plantains	Porridge, bread, rice, pasta/noodles, sorghum, millet, corn, couscous, barley, white potatoes, white yams, manioc/cassava/yucca, plantains
2	Pulses (beans, peas or lentils)	Beans, lentils, hummus, tofu, tempeh
3	Nuts and seeds	Groundnut/peanut, cashew, walnut, baobab seeds, chia seeds, flaxseed
4	Dairy	Milk, cheese , yoghurt, custard
5	Meat, poultry and fish	Sausage (boerewors), gizzard, heart, kidney, liver, beef, goat, lamb, mutton, pork, rabbit, yak, salami, bacon, bologna, hot dogs (viennas) chicken, duck, goose, guinea fowl, fresh, frozen, canned or dried fish, shrimp, clams
6	Eggs	Eggs from poultry or any other bird
7	Dark green leafy vegetables	Kale, mustard greens, morogo, spinach, amaranth greens, chicory, broccoli, Swiss chard
8	Vitamin A-rich fruits and vegetables	Pumpkin, carrots, squash or sweet potatoes, ripe mango, ripe papaya
9	Other vegetables	Beets, cabbage, cauliflower, celery, cucumbers, eggplant, zucchini, radish, tomato, mushroom
10	Other fruits	Apple, avocado, banana, baobab fruit, berries, pineapple, orange, watermelon, berries, guava, coconut flesh, tangerine, naartjie

3.5.2 REAP-S Survey

The REAP-S questionnaire allows for rating a high-quality diet as one high in whole grain/high fibre starches, vegetables, fruit, and low-fat dairy; moderate in fish and lean meats; and mostly without the consumption of fried foods, sweets (including sugar-sweetened beverages), processed meats, savoury snacks, foods eaten away from home, highly processed foods; and in addition, skipping breakfast (Mayra et al. 2019). The REAP-S survey used in this study consisted of sixteen items regarding food intake (see section D of Appendix 3).

The questionnaire was interviewer-administered based on the participants' food intake the previous week (Bliss 2015). The first few questions of the survey pertained to breakfast consumption as well as ordering-in and eating out patterns. The remaining questions pertained to the consumption of whole grain products, fruits, vegetables, dairy products, meats, poultry or fish, processed meats, fried foods, snack items, fat spreads, sweets, and sugar-sweetened beverages (Mayra et al. 2019). The last three questions were behavioural questions and queried whether the participant or a family member usually shops and cooks rather than eats out; whether the participant usually feels well enough to shop and cook; and how willing the participant was to make changes in their eating habits to be healthier (Johnston et al. 2018). Questions 1-13 are scored as: usually/often = 1 point, sometimes = 2 points, and rarely/never = 3 points. The sum of questions 1 through 13 determine the total REAP-S score. The total possible points range from 13 to 39 (Fawcett 2012). No cut-off points have thus far been established to differentiate a high-quality vs. a poor-quality diet; however, a lower score depicts poorer diet quality and a higher score higher diet quality and individual line items in the survey provided insights into the dietary behaviour (Fawcett 2012).

The questionnaire was contextualised to the South African environment by 1) changing the unit of measure from ounces to grams; and 2) by replacing some of the food items with those more popular in South Africa e.g. All bran flakes, Weetbix, boerewors, viennas, vetkoek, kota, samoosas, etc. Questions 3-6 were changed to the positive ('how often do you eat more than' instead of 'how often do you eat less than') for ease of understanding. Due to this, the point system was reversed for Questions 3-6 – therefore for Questions 1-2 and 7-13, points were allocated as explained above, however for Questions 3-6, points were allocated as follows: usually/often = 3 points, sometimes = 2 points, and rarely/never = 1 point. The "does not apply to me" column was removed from the survey as the other three options (usually/often, sometimes, and rarely/never) covers all possible participant responses. If a question was unanswered or missing, the 24-hour dietary recall data were used to make an assumption. If no 24-hour dietary recall data was available, the REAP-S score was set to missing.

Face validity involves evaluating the item/s used to measure a concept and is considered to transpire when an item's content reasonably reflects what was proposed to be measured (Carins et al. 2018). The survey was verified for face validity by evaluating it among nutrition colleagues as well as friends of the researchers.

3.6 Measuring the food environment

To measure the food environment, the study defined the search terms for grocery stores and fast-food outlets, mapped the data on Google Maps® and Google Earth® and developed Kernel density heat maps using GIS. Thereafter the mRFEI score and median distance to food retailers could be calculated. This is explained in further detail in the sections that follow.

3.6.1 Defining the search terms

Fast-food outlets were used as a measure of less healthy food outlets. Fast-food outlets in "Johannesburg" were searched using Google® based on the following search terms: "fast-food outlets;" "fast-food shop;" "fast-food store;" "self-service restaurant;" "quick-service restaurant;" "take-away food store;" "take-out food store;" "drive-in restaurant;" "drive-thru restaurant;" "food truck;" "quick-lunch counter" and "cafeteria." The data from search results were cleaned to remove any graphics, addresses and hyperlinks and added to an Excel spreadsheet to form a standardised list for fast-food outlets in the Johannesburg area. Virtual ground truthing involved Google Street View and Google® searches of each food outlet at the stated addresses, examination of the operating hours and front and inside of store photographs. Exclusion criteria included removing full-service restaurants with no take-aways, and any repeats and outlets that were temporarily or permanently closed.

Further refining of the search terms was required as most participants lived in the Roodepoort area (participant home addresses were recorded in the CHAMP Participant Questionnaire). The standardised list for Johannesburg was therefore applied to specific areas surrounding Roodepoort: "Horison Roodepoort;" "Florida Roodepoort;" "Florida Lake Roodepoort;" "Discovery Roodepoort;" and "Hamberg Roodepoort." For example, the following search terms were added to the Excel spreadsheet for Fish & Chips Take Away: "Fish & Chips Take Away Roodepoort;" "Fish & Chips Take Away Horison Roodepoort;" "Fish & Chips Take Away Florida Roodepoort;" "Fish & Chips Take Away Florida Lake Roodepoort;" "Fish & Chips Take Away Discovery Roodepoort" and "Fish & Chips Take Away Hamberg Roodepoort."

Grocery stores were used as a measure of healthy food outlets. Developing the list for grocery stores followed the same process as fast-food outlets, the only difference being the search terms and the exclusion criteria. The following search terms were used for grocery stores: "grocery store;" "grocery shop;" "convenience store;" "convenience shop;" "retail food store;" "retail food shop;" "hypermarket;" "supermarket;" "minimarket"; "food mart"; "food store"; "food shop"; "super food store"; "chain food store" and "greengrocer." For example, the following search terms were used for USave: "USave Roodepoort;" "USave Horison Roodepoort;" "USave Florida Roodepoort;" "USave Florida Lake Roodepoort;" "USave Discovery Roodepoort;" and "USave Hamberg Roodepoort." Exclusion criteria included removing any repeats, grocery stores that were temporarily or permanently closed, removing garage shops, quick shops, general dealers, wholesalers, liquor shops, spice shops, cafes, bazaars, spaza shops, tuck shops, delis, pharmacies, health shops, roadside markets, weekend markets and fruit and vegetable stalls.

A final search terms list was created for participant home addresses, fast-food outlets and grocery stores on separate Excel spreadsheets and the files were uploaded and pinned onto Google Maps®. The output file was saved in Keyhole Markup Language and Keyhole Markup Language Zipped formats and were sent to a mapping specialist in the Department of Geography at UNISA for heat mapping using GIS. After removing duplicates and retailers that did not fall within the area of residence of the women a total number of 423 fast-food outlets and 190 grocery stores were included. A full list of the definition and search terms can be found in Appendix 4: Definition of mRFEI Search Terms.

3.6.2 Kernel-density maps

The kernel density mapping process as well as the mapping data analysis is explained in Figure 3.2. The location data for grocery stores and fast-food outlets was sourced from Google Maps® and Google Earth®. The Keyhole Markup Language Zipped files were imported into QGIS 3.28.7, and the location points were reprojected to EPSG:32735 - WGS 84 / UTM zone 35S, which has a prominent level of accuracy at 2m. The location layers were subsequently clipped to the boundary of Roodepoort, Wards JHB 70, JHB 71, JHB 83, JHB 84, JHB 85, JHB 89, JHB 97, JHB 100, JHB 114, JHB 126, JHB 127, and JHB 134. Nearest neighbour analyses were conducted on the fast-food and grocery store locations, using the tool provided in the base version of QGIS 3.28.7. Basic statistics were computed on the Euclidean distance between outlets and residential addresses to determine the median distance between grocery stores and fast-food outlets to residential addresses. Kernel density heat maps were presented graphically to depict the density of food retailers (grocery stores and fast-food outlets) in relation to participants' residential addresses. The heat maps presented in Chapter 4 show the density of food retailers by colour – yellow depicts the lowest density, green-blue represents medium density and orange-red represents the highest density.

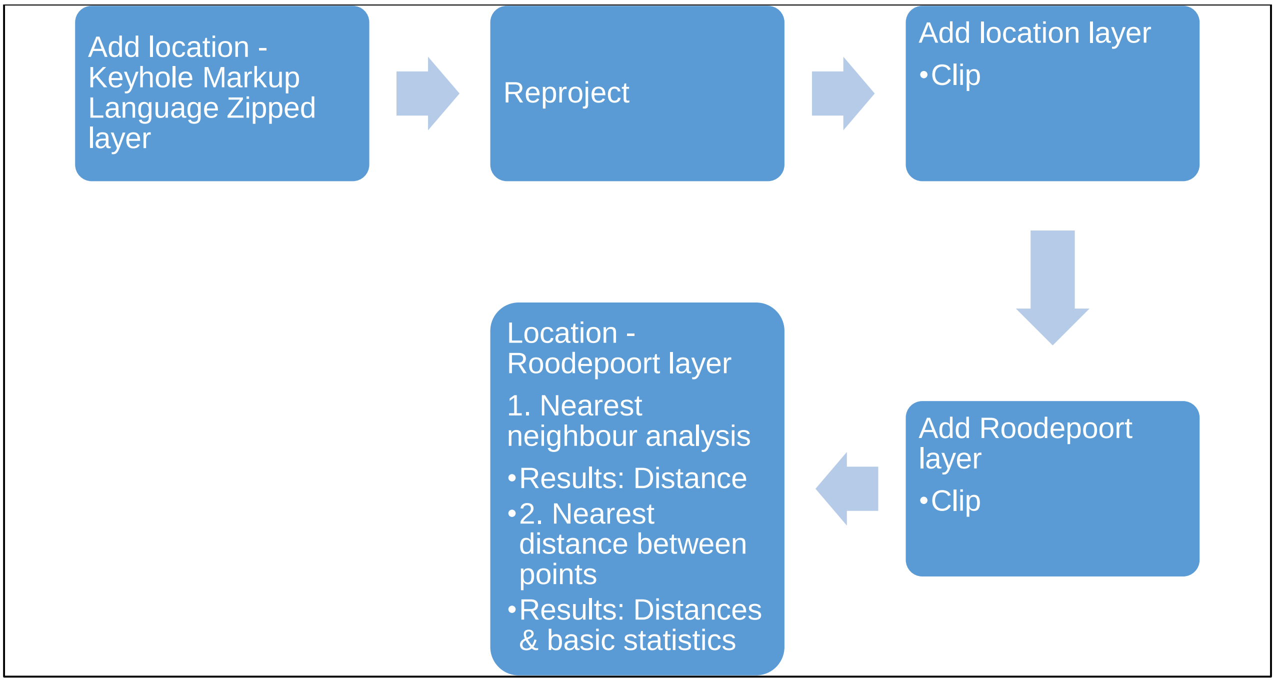


Figure 3.3: Kernel-density mapping process

3.6.3 Ratio of store types - Modified Retail Food Environment Index (mRFEI)

The density of food outlets (grocery stores and fast-food outlets) was measured within a distinct geographic area within Johannesburg using GIS technology (Google Earth®). The mRFEI was calculated using the GIS data to determine the number of healthy formal food outlets out of the total number of outlets within a certain area. Participant residential addresses were also mapped, to ensure that we only include the food outlets that are in the areas where the women reside. A healthy formal food outlet can be described as a grocery store and a less healthy formal food outlet can be described as a fast-food outlet. From the total number of food retailers in that area considered either healthy or less healthy, the mRFEI score signifies the percentage of healthy food retailers available in the area under investigation.

The formula below was used to calculate the mRFEI score:

mRFEI = Total healthy food outlets / (Total healthy + less healthy food outlets) x 100

An mRFEI score of zero indicates that there are no healthful food retailers within the area. There are currently no cut-offs that categorises a healthy food environment from a less healthy food environment, however, a lower score indicates a more obesogenic food environment or that the area contains relatively many fast-food outlets compared to the number of healthful food retailers.

3.7 Data Management

Fieldworkers collected data on hard copy questionnaires which were then transcribed into a protected online Excel sheet. Postgraduate students checked a minimum of 10 % of captured data for accuracy according to hard copies. Implausible results were checked according to hard copy and if a result was still implausible it was deleted (for example: weight = 12 kg). The original online Excel data sheets were locked and data cleaning continued using an online electronic copy to warrant the safe keeping of the original data. Excel sheets were then downloaded into the IBM® Statistical Package for the Social Sciences (SPSS® version 27) (IBM, Armonk, NY) for further analyses.

In terms of mapping the food environment, data were collected online by using the defined search terms (mention in Section 3.5.1) in Google® and Google Earth®. A second and third researcher cross-checked the collected data by comparing some of the data points with general food outlet search terms as well as with available food outlet data sets within the ESRI's ArcGISpro® program. Food outlets that did not fall within the main residential areas (Roodepoort) where the women lived were excluded.

3.8 Statistical analysis

The statistical package SPSS (version 27) was used to conduct all statistical tests. Table 3.1 below summarises the statistical analysis conducted to address the research objectives. Continuous variables were assessed for normal distribution by examining Q-Q plots and histograms. Normally distributed data were reported as means and standard deviation (SD) and non-normally distributed data were reported as medians and interquartile ranges (IQR). For correlation analysis, the Pearson's correlation co-efficient was computed for normally distributed data and Spearman's correlation co-efficient for non-normally distributed data where $r < 0.3$ indicates a very weak relationship, $0.3 < r < 0.5$ weak, $0.5 < r < 0.7$ moderate, and $r > 0.7$ a strong relationship (Moore et al. 2013). For the independent t-tests conducted, normally distributed data were computed using Levene's test for equality of variances where, if the *p*-value was <0.05, the assumption was not met and reported as "equal variances not assumed." To determine differences between groups with non-normally distributed data, the Mann-Whitney U test was computed, where, if the *p*-value was <0.05, it was reported that there was a significant difference between the groups and if the *p*-value was <0.05, it was reported as no significant difference between the groups.

Table 3.2: Statistical Analysis for Objectives 1-3

Objective	Variables	Statistical test
Describe the participant characteristics*	Age; living standards; population group; employment status; pregnancy status; tobacco use, education level, anthropometric measurements	Normality tests Descriptive statistics (mean/medians and standard deviations for continuous variables, frequencies and percentages for categorical data)
a) To determine the diet quality of women of reproductive age within the city of Johannesburg using a Rapid Eating Assessment for Participants – Shortened Version (REAP-S) survey and a 24-hour dietary recall to measure the DDS and classify the score into the Minimum Dietary Diversity for Women (MDD-W) categories.	DDS calculated from the 24-hour dietary recall and categorised into the MDD-W categories. REAP-S scores	Normality tests Descriptive statistics (mean/medians and standard deviations for continuous variables, frequencies and percentages for categorical data) Independent t-test and Chi-square test for comparison of continuous and categorical variables, respectively, between non-pregnant and pregnant women; and comparisons between the two MDD-W categories Pearson's (or Spearman's) correlation coefficients to describe the relationship between the two diet quality measures - DDS and REAP-S; and MUAC and dietary behaviour as reported in the REAP-S survey. Independent t-tests to compare MUAC between the two MDD-W categories; and MUAC and the consumption of each specific food groups as reported in the 24-hour dietary recall
b) To measure the density of the formal urban food environment in terms of healthy (grocery stores) and less healthy (fast-foods outlets) food retailers using geographic information systems (GIS) technology to calculate the Modified Retail Food Environment Index (mRFEI) within the city of Johannesburg; as well as the distance from participants' residential addresses to food retailers (grocery stores and fast-foods outlets).	mFREI score Mean Euclidean distance from the participants' residential addresses to food retailers (grocery stores and fast-food outlets)	Visual assessments of Kernel density heat maps created using GIS data. Median (IQR) Euclidean distance from the participants' residential addresses to food retailers
c) To determine the relationship between diet quality of women of reproductive age and the formal urban food environment in which they reside within the city of Johannesburg.	DDS, MDD-W and REAP-S scores with mRFEI, mean Euclidean distance from the participants' residential addresses to food retailers (grocery stores and fast-food outlets)	Spearman's correlation coefficient to describe the relationship between the distance to grocery stores and the distance to fast-food outlets; and the relationship between the two diet quality measures - DDS and REAP-S and the distance to food retailers (grocery stores and fast-food outlets) Mann-Whitney U-test to compare the distance to grocery stores and distance to fast-food outlets to the two MDD-W categories

mRFEI: Modified Retail Food Environment Index; GIS: Geographic Information Systems; REAP-S: Rapid Eating Assessment for Participants – Shortened Version; MDD-W: Minimum Dietary Diversity for Women; DDS: Dietary Diversity Score

**Not a study objective but included in the table to summarise analyses conducted on sample characteristics.*

3.9 Ethical considerations

Ethical clearance was acquired for the greater CHAMP study (2020/CAES_HREC/093) as well as for this research study (2022/CAES_HREC/046). See Appendix 5: Student Ethics Certificate. Women who showed an interest and volunteered to take part in the study received a written informed consent form (Appendix 2: Informed consent form) which was discussed in detail and they were given the opportunity to ask questions. Only women who signed a written informed consent were enrolled in the study. The informed consent form included in Appendix 3 is for the larger CHAMP study and includes components that were not measured as part of the present study. Participant numbers were provided to ensure anonymity. Privacy of the participants was ensured by using either private rooms or a dedicated space closed off from the general clinic area, thus passers-by could not overhear conversations between the participant and interviewer. Fieldworkers were all qualified with a minimum of a Bachelor of Consumer Sciences degree or a Bachelor's of Science Honours in Life Sciences degree and received a 3-day training on how to conduct anthropometrical measurements, diet history interviews using the REAP-S survey and 24-hour dietary recall to measure the DDS. Data was kept safe by securing hard copies in locked cabinets at the researchers' offices. Electronic data and physical copies will be retained for five years after the study has ended, thereafter it will be destroyed.

The research was conducted according to the ethical principles for medical research involving human subjects as described in the World Medical Association Declaration of Helsinki (World Medical Association 2013).

Due to the COVID-19 regulations, and to minimise any risk of contracting COVID-19, all fieldworkers received at least one COVID vaccine and the following measures were implemented (in accordance with the toolkit provided in section 4 of the UNISA COVID-19 guidelines dated 26 June 2020, version 2.0):

1. Recruitment and data collection only continued during lockdown level 1 (where all sectors were permitted to work) or if lockdown was completely lifted.
2. All research members and participants sanitised their hands.
3. All research team members (including fieldworkers) received training on the COVID-19 protocols during the designated training period and hand hygiene, wearing of masks, and cough etiquette were implemented.
4. Data collection spaces and equipment were sanitised between data collection from each participant.

5. Papers used in recruitment and data collection were placed in a designated container immediately after data collection and dated. Papers were only removed from the container after a minimum of 3 days.
6. The team had access to the health facility's COVID-19 register in case retrospective contact tracing became necessary. At healthcare facilities, patients attending for routine care were screened for symptoms as per the Gauteng COVID-19 Hospital Preparedness Guide.

3.10 Conclusion

This study had a cross-sectional design as it involved a once-off measurement of the diet quality of WRA and the formal urban food environment to which they were exposed within the city of Johannesburg, specifically those attending the DCHC in Florida, Roodepoort during the period of September 2022 to May 2023. The research was conducted according to the ethical principles of the UNISA Ethics Committee as well as the ethical principles for medical research involving human subjects as described in the World Medical Association Declaration of Helsinki (World Medical Association 2013).

CHAPTER 4: RESULTS

This chapter presents the findings of the research study conducted according to the methods explained in chapter 3. Firstly, the participant socio-demographic characteristics are reported and then the outcomes of the diet quality measures (DDS and REAP-S); followed by the mRFEI score; the grocery stores and fast-food outlet heat maps and median distance from residential addresses to food retailers are presented. Lastly, to address the objective regarding the relationship between the food environment and diet quality, the t-tests and correlation analysis results are presented.

4.1 Participant socio-demographic characteristics

Figure 4.1 displays a flow-chart of participant enrolment of WRA attending DCHC in the Florida region of Roodepoort, Johannesburg. A total of 468 participants were enrolled in the study, however based on exclusion criteria, 8 participants were excluded (3 for age range; 3 for diagnosed diseases; 1 for duplicate enrolment and 1 was referred to another clinic). Furthermore, participants who could not complete data collection and who had missing data for dietary intake were removed from the dataset (n=33). Therefore, a total sample of 427 participants were included for analysis (142 non-pregnant and 285 pregnant women).

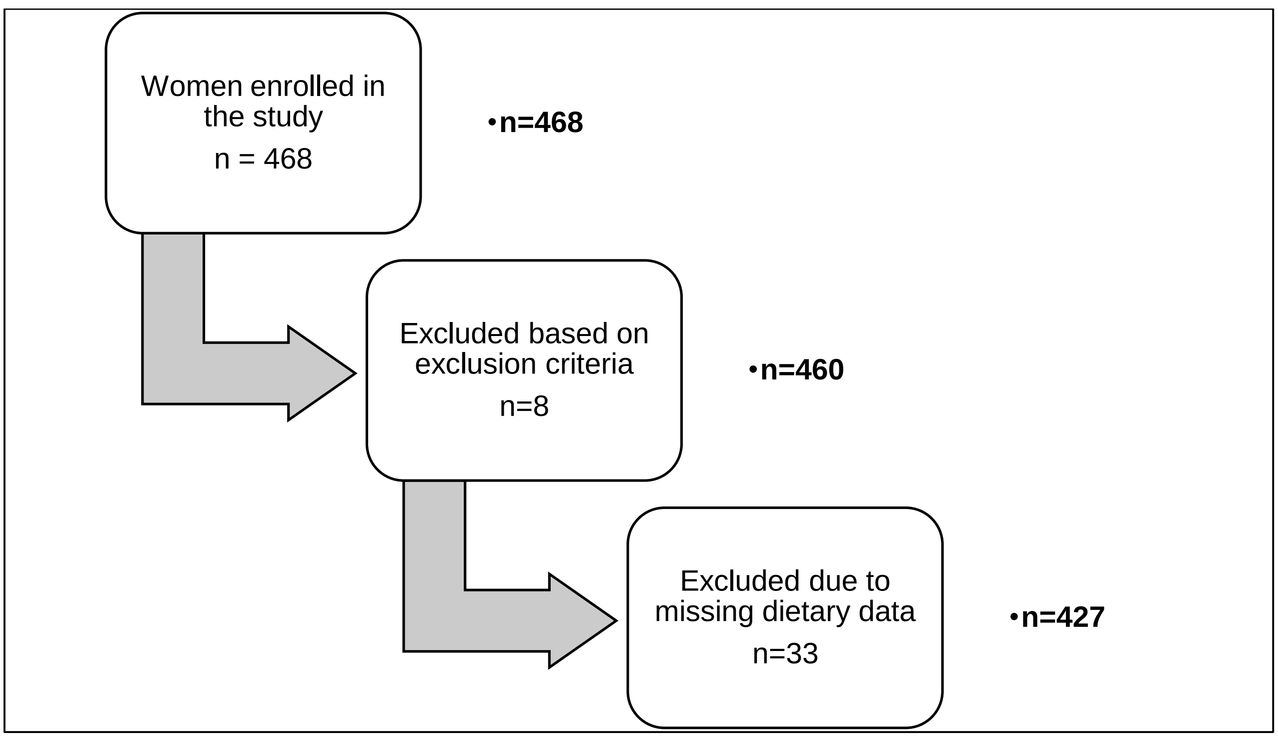


Figure 4.1: Flow-chart of participant enrolment of WRA attending DCHC, Johannesburg

Table 4.1 is a summary of the socio-demographic characteristics of the study participants. Their mean age was 29.8±6.5 years. Most were from South Africa (66 %), although a sizeable portion was born in Zimbabwe (25 %). Most participants were Black African (89 %), pregnant (67 %), married or living with a partner (51 %) and unemployed (53 %). The majority completed matric or a tertiary education (78 %) and a third of the participants' households (33 %) received a social grant. As explained in Chapter 3, the BMI results reflect non-pregnant women (n=142) only and MUAC results reflect both pregnant and non-pregnant women (n=407; n=20 had missing MUAC data). The mean BMI of the non-pregnant women was 28.8±5.9 kg/m^2, with none being underweight, some normal weight (27 %) and majority were overweight or obese (73 %). The mean MUAC for pregnant and non-pregnant women was 30.7±4.6 cm. The MUAC results show that 2 % of the women may be undernourished and 30 % may be obese.

Table 4.1: Participant socio-demographic characteristics of women of reproductive age in Johannesburg

Characteristic	**Mean (±SD) or n (%)**
Age (years) (n=426)	29.8 (±6.5)
Pregnancy status (n=427)	
Non-pregnant	142 (33)
Pregnant	285 (67)
Ethnicity (n=427)	
Black African	378 (89)
Coloured	31 (7)
Indian	7 (1)
White	10 (2)
Other	1 (<1)
Country born (n=427)	
South Africa	282 (66)
Zimbabwe	108 (25)
Lesotho	6 (1)
Botswana	1 (<1)
Malawi	12 (3)
Mozambique	6 (1)
Other	12 (3)
Highest education level completed (n=427)	
Primary School	13 (3)
Grade 8-11	79 (19)
Grade 12	219 (51)
Post-school education	116 (27)
Marital status (n=426)	
Single	208 (49)
Married	90 (21)
Living with a partner	128 (30)
Employment (n=427)	
Unemployed	225 (53)
Employed	192 (45)
Student	9 (2)
Receiving social grant (n=426)	
Yes	143 (33)
Living Standards Measure (n=426)	
Low socio-economic group	9 (2)
Medium socio-economic group	227 (53)
High socio-economic group	190 (45)
Anthropometrical status	
*BMI (kg/m^2) (n=139) - Underweight <18.5 - Normal weight 18.5-24.9 - Overweight 25.0-29.9 - Obese ≥30.0	28.8 (±5.9) 0 (0) 37 (27) 56 (40) 46 (33)
MUAC (cm) (n=407) - <23 cm - 23-33 cm - >33 cm	30.7 (±4.6) 9 (2) 275 (68) 123 (30)

BMI: body mass index; MUAC: mid-upper arm circumference; SD: standard deviation

4.2 Diet quality measures

Table 4.2 present the diet quality measures of the participants. The mean DDS for all the participants was 4.1±1.4, with non-pregnant women having a lower DDS (3.8±1.5) than pregnant women (4.2±1.4, p = 0.007). In the total group, 64 % did not meet the MDD-W (they consumed from <5 food groups the previous day). More non-pregnant women did not meet the MDD-W score compared to pregnant women (72 % vs. 60%, p = 0.018). The mean REAP-S score for all the participants was 27.1±3.3, with non-pregnant women having a lower REAP-S score (26.5±3.6) than pregnant women (27.3±3.2, p = 0.019). A Pearson's correlation coefficient was computed to determine the relationship between the two dietary quality measures, REAP-S score and DDS. The results indicate a positive correlation between the REAP-S score and DDS [r(424) = 0.159, p = 0.001].

Table 4.2: Diet quality measures of WRA in Johannesburg

Diet quality measure	**Mean (±SD) or n (%)**			
	Total group	**Non-pregnant**	**Pregnant**	***p*-value**
Dietary Diversity Score (n=424)	4.1 (±1.4)	3.8 (±1.5) (n = 141)	4.2 (±1.4) (n = 283)	**0.007**
MDD-W (n=424)				
Category <5	273 (64)	102 (72)	171 (60)	**0.018**
Category 5–10	151 (36)	39 (28)	112 (40)	
REAP-S Score (n=427)	27.1 (±3.3)	26.5 (±3.6) (n=142)	27.3 (±3.2) (n=285)	**0.019**
	Pearson's Correlation Co-efficient			
Correlation between REAP-S Score and DDS (n=424)	r = 0.159, ***p* = 0.001**			

MDD-W: Minimum Dietary Diversity for Women; Continuous variables compared using an independent t-test; Categorical variables compared using a Chi-square test; p <0.05 = significant difference

Table 4.3 presents the results of an independent t-test performed to compare MUAC between the women who met the MDD-W (MDD-W category 5-10) with those who did not meet the MDD-W (MDD-W category <5). This was done to understand whether meeting the MDD-W was associated with their anthropometrical status as reflected by MUAC. The results showed that the women who did not meet the MDD-W had a significantly larger MUAC than those who met the MDD-W (31.1±4.4 cm vs. 30.1±5.0 cm, p = 0.045).

Table 4.3: Comparison of MUAC by MDD-W categories among WRA in Johannesburg (n=405)

MDD-W Categories	MUAC (cm) Mean (±SD)	t-stat	p-value
MDD-W <5 (n=260)	31.1 (±4.4)	2.013	**0.045**
MDD-W 5-10 (n=145)	30.1 (±5.0)		

MDD-W: Minimum Dietary Diversity for Women; MUAC: mid-upper arm circumference; SD: standard deviation; p <0.05 = significant difference

Figure 4.2 displays the 24-hour dietary recall results according to the food groups relevant to the DDS calculation (FAO 2021). It shows that most of the participants' diets consisted of grains, white roots, and tubers (99 %); meat, poultry, and fish (83 %); and other vegetables (61 %). A few participants reported to have consumed eggs (17 %); pulses (beans, peas, or lentils) (15 %); and nuts and seeds (12 %) in the 24 hours of recall.

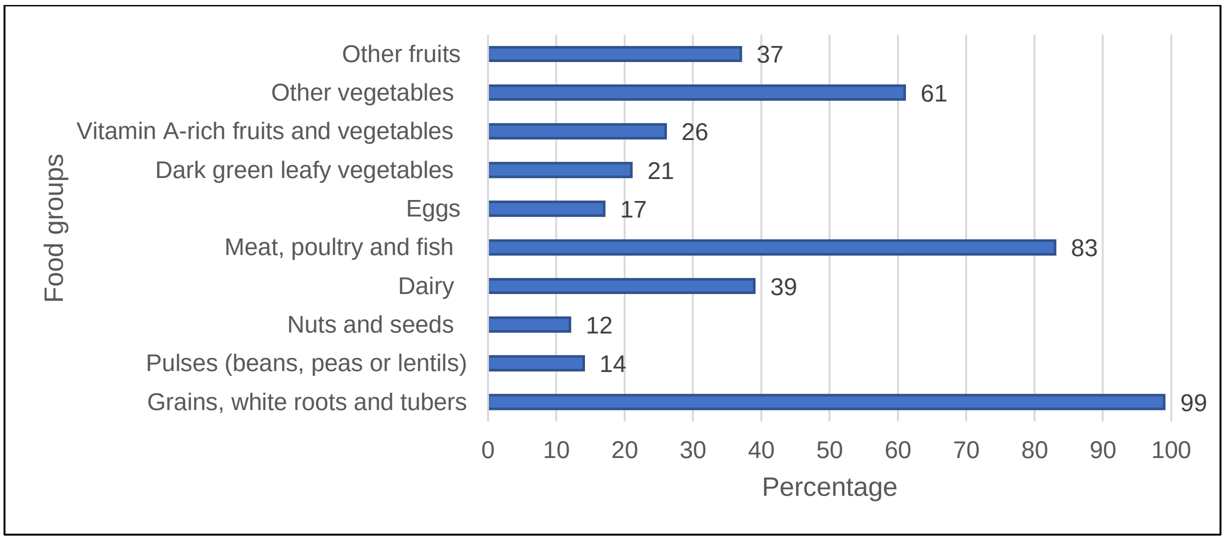


Figure 4.2*:* Food group consumption based on 24-hour dietary recall by WRA in Johannesburg (n=424)

Figure 4.3 displays responses from the REAP-S survey. Some healthy eating habits were reported, with 50 % indicating that they do not skip breakfast and 76 % reported that they rarely/never eat 4 or more meals/week from sit down restaurants or take away outlets. Almost half the participants (48 %) reported that they usually/often eat ≥2 fruit/day and 41 % reported that they usually/often eat ≥2 portions of vegetables/day. The unhealthier behaviours reported were that 65 % of participants usually/often add fats to their meals at the time of eating; almost half (42 %) rarely/never use low-fat processed meats instead of regular processed meats; and 45% indicated that they rarely/never consume ≥2 wholegrains per day.

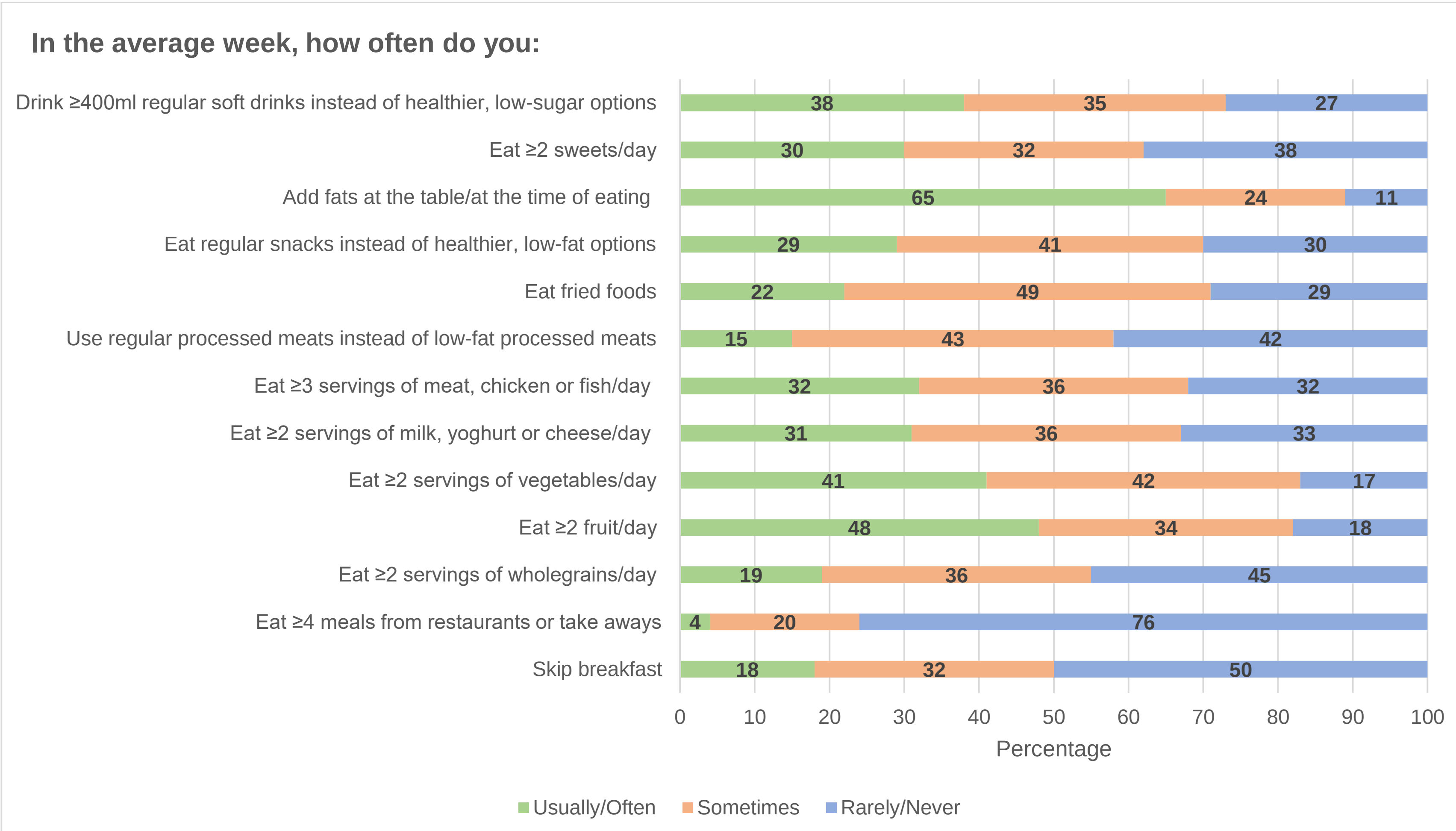


Figure 4.3*:* REAP-S survey responses from WRA in Johannesburg (n=427)

Table 4.4 shows the responses from the REAP-S behavioural questions from WRA in this study. It shows that most participants stated that they or a family member prepare their own meals (96 %), usually feel well enough to shop for and prepare their own meals (93 %) and most were somewhat to very willing (67 %) to amend their eating habits to be healthier.

Table 4.4: Behavioural REAP-S survey responses from WRA in Johannesburg

Behaviour question	**Mean (±SD) or n (%)**
Do you or a family member usually shop for and prepare your own meals rather than eating from sit down restaurants or take away outlets? (n=426)	
Yes	408 (96)
No	18 (4)
Do you usually feel well enough to shop for and prepare your own meals? (n=425)	
Yes	394 (93)
No	31 (7)
How willing are you to make changes in your eating habits to be healthier? (n=426)	
Not willing	113 (27)
Somewhat unwilling	27 (6)
Somewhat willing	91 (21)
Willing	46 (11)
Very willing	149 (35)

SD: standard deviation

Table 4.5 shows the results of an independent t-test comparing MUAC between women who consumed or not consumed specific food groups as reported in the 24-hour dietary recall. This was done to examine whether there was a difference in MUAC (as an indication of the women's nutritional status) between those who consumed certain food groups or not . The women who consumed the following five food groups, had a significantly smaller MUAC compared to those who did not consume these foods the previous day: grains, white roots and tubers, and plantains (30.7±4.6 cm vs. 36.5±4.0 cm, $p = 0.005$); dairy (30.1±4.8 cm vs. 31.2±4.4 cm, $p = 0.024$); meat, poultry and fish (30.5±4.6 cm vs. 31.9± 4.6 cm, $p = 0.023$); vitamin A-rich fruit and vegetables (29.9±4.5 cm vs. 31.0±4.6 cm, $p = 0.031$); and vegetables other than vitamin A-rich vegetables (30.4±4.7 cm vs. 31.4±4.4 cm, $p = 0.018$).

Table 4.5: Relationship between MUAC and food group consumption among WRA in Johannesburg (n=405)

Food groups (n=405)	**MUAC (cm) Mean (±SD)**		**t-test results**	
	Not consumed	**Consumed**	**t-stat**	***p*-value**
Grains, white roots and tubers, and plantains	36.5 (±4.0)	30.7 (±4.6)	2.818	**0.005**
Pulses (beans, peas or lentils)	30.7 (±4.7)	30.8 (±4.4)	-0.038	0.970
Nuts and seeds	30.8 (±4.6)	30.5 (±4.9)	0.451	0.652
Dairy	31.2 (±4.4)	30.1 (±4.8)	2.262	**0.024**
Meat, poultry and fish	31.9 (±4.6)	30.5 (±4.6)	2.277	**0.023**
Eggs	30.6 (±4.5)	31.2 (±5.1)	-0.904	0.366
Dark green leafy vegetables	30.6 (±4.6)	31.1 (±4.6)	-0.885	0.377
Vitamin A-rich fruits and vegetables	31.0 (±4.6)	29.9 (±4.5)	2.167	**0.031**
Other vegetables	31.4 (±4.4)	30.4 (±4.7)	2.372	**0.018**
Other fruits	30.7 (±4.5)	30.8 (±4.9)	-0.197	0.844

Independent t-tests conducted to compare mid-upper arm circumference means between women who consumed and did not consume the different food groups. MUAC: mid-upper arm circumference; SD: standard deviation

Table 4.6 shows the results of a Pearson's correlation coefficient which was conducted to determine the relationship between MUAC and dietary behaviour as reported in the REAP-S survey. None showed a significant relationship, except three questions. There was a negative relationship between MUAC and consuming ≥2 servings of milk, yoghurt or cheese/day [r(407) = -0.132, p = 0.007]; and there were positive relationships between MUAC and eating fried foods [r(407) = 0.110, p = 0.026], as well as eating ≥2 sweets/day [r(407) = 0.129, p = 0.009].

Table 4.6: Correlation between MUAC and dietary behaviour as reported in the REAP-S survey among WRA in Johannesburg

REAP-S survey results (n=407)	**r-stat**	***p*-value**
Skipping breakfast	-0.065	0.192
Eating ≥4 meals from restaurants or take aways	0.010	0.834
Eating ≥2 servings of wholegrains/day	-0.041	0.407
Eating ≥2 fruit/day	-0.007	0.888
Eating ≥2 servings of vegetables/day	0.055	0.265
Eating ≥2 servings of milk, yoghurt or cheese/day	-0.132	**0.007**
Eating ≥3 servings of meat, chicken or fish/day	0.031	0.534
Using regular processed meats instead of low-fat processed meats	0.067	0.179
Eating fried foods	0.110	**0.026**
Eating regular snacks instead of healthier, low-fat options	0.055	0.267
Adding fats at the table/at the time of eating	0.072	0.145
Eating ≥2 sweets/day	0.129	**0.009**
Drinking ≥400ml regular soft drinks instead of healthier, low-sugar options	0.026	0.607

4.3 mRFEI kernel density maps and statistical analysis

Figure 4.4 below is an illustration of the Roodepoort area, showing the location of participants' residential addresses (purple), fast-food outlets (green) and grocery stores (yellow).

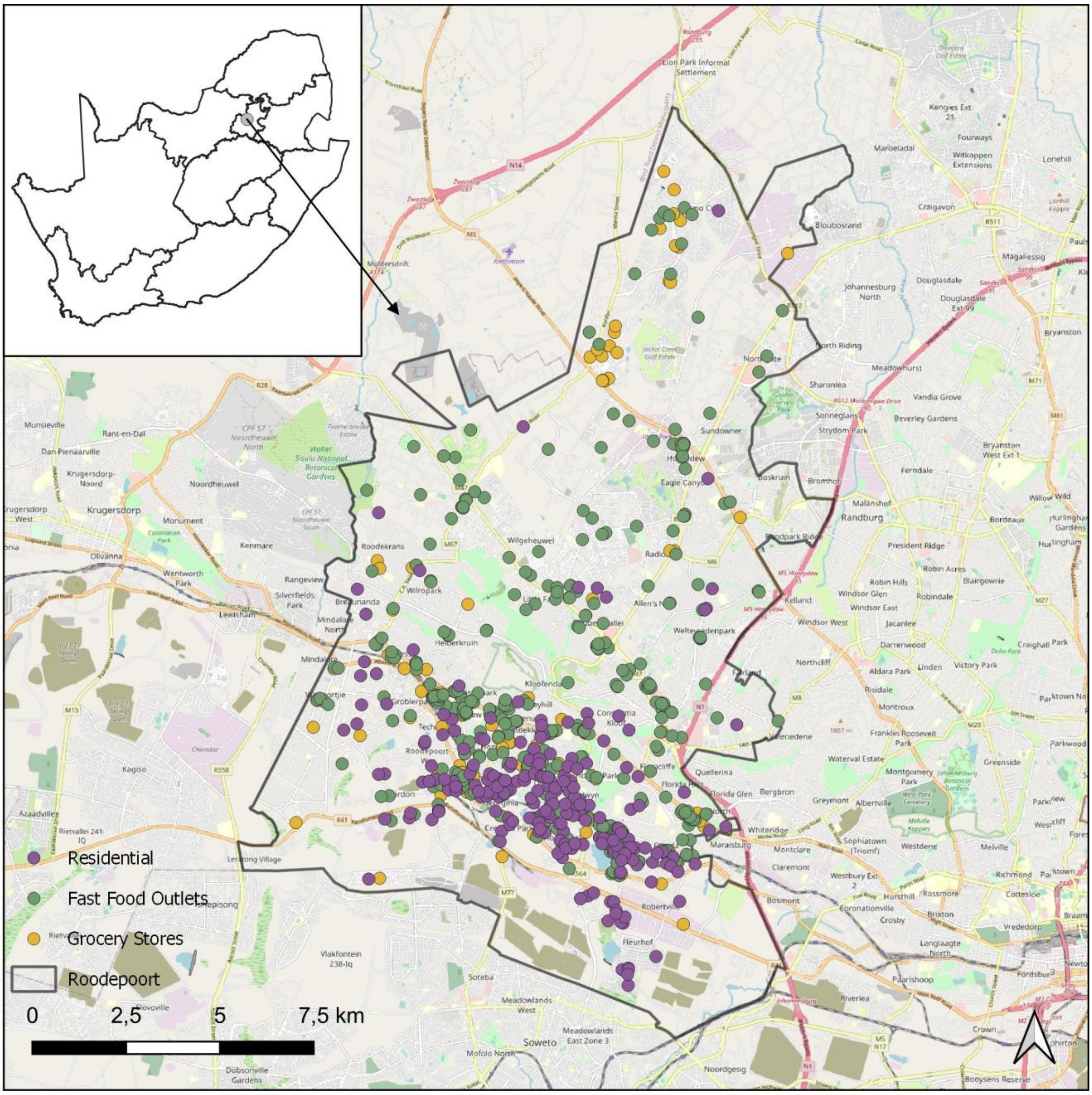
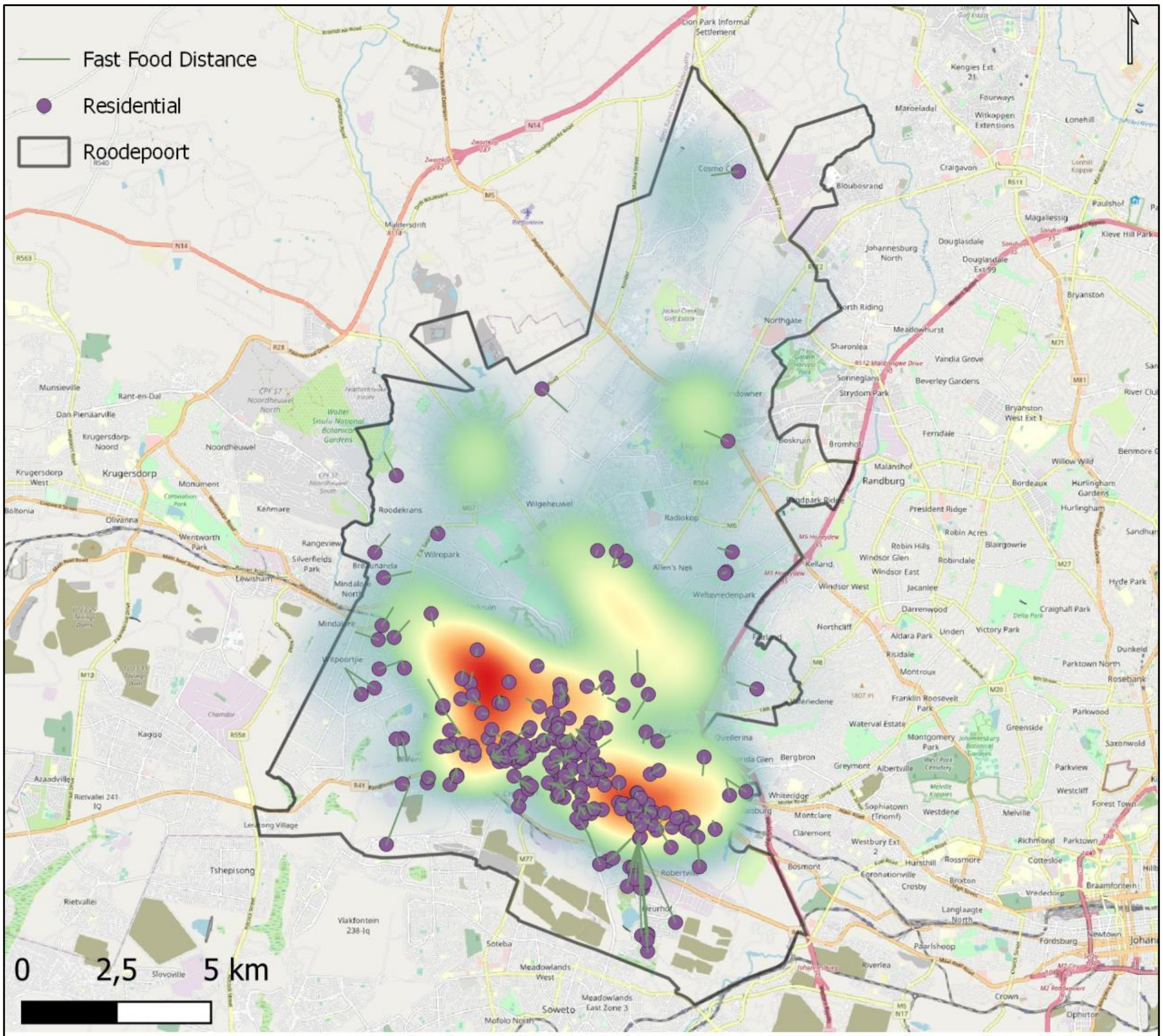


Figure 4.4: Location of residential addresses, grocery stores and fast-food outlets within study location (Roodepoort) area.

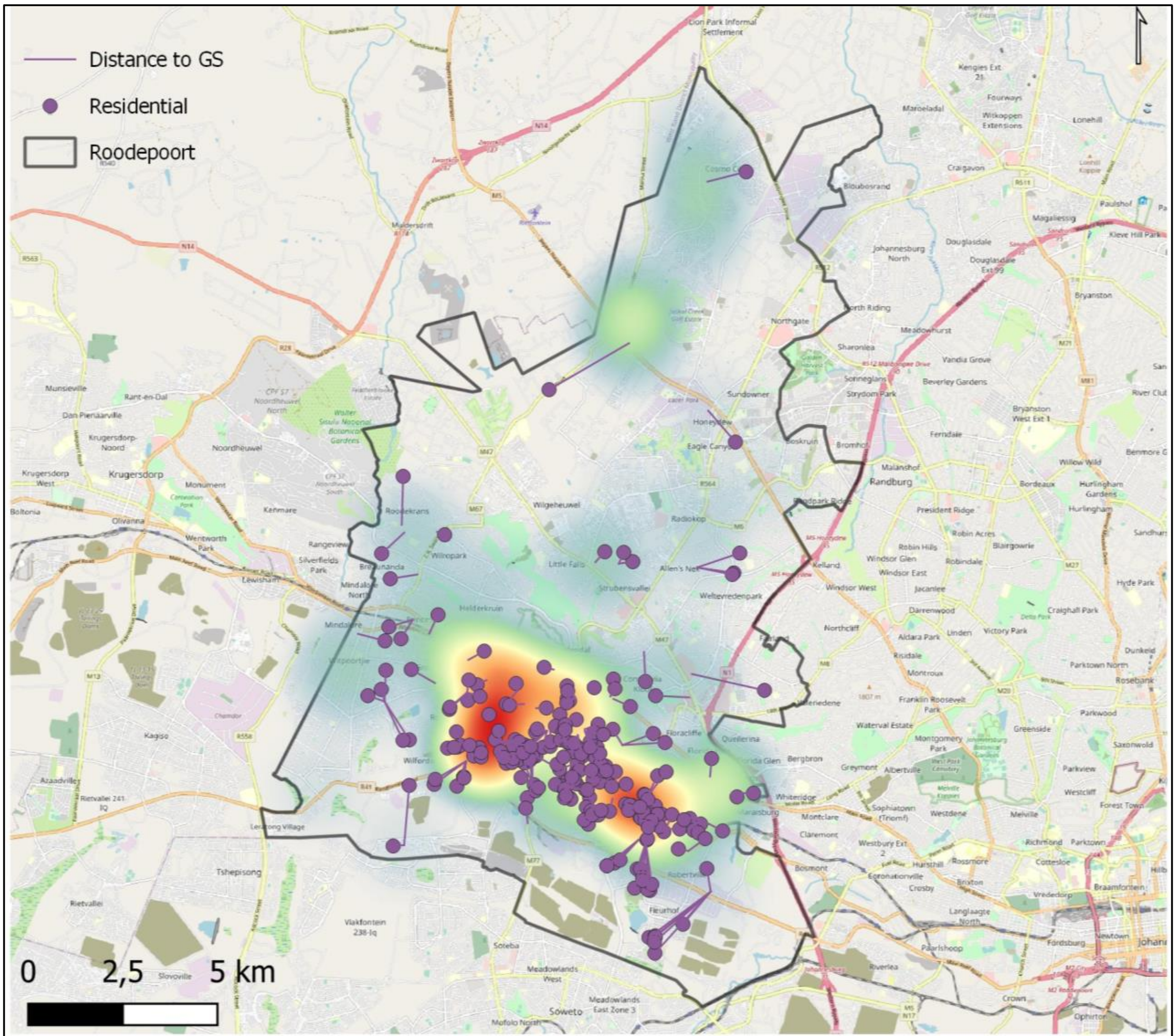
Figure 4.5 below is a kernel density heat map showing the residential addresses relative to the location of fast-food outlets. The yellow represents the lowest density, green-blue represents medium density and orange-red represents the highest density of fast-food outlets.



Mean Distance (m) to FF	Mean distance (m) between Stores	Number of Stores	Number of Address
374.81	177.72	423	226

Figure 4.5: Kernel density heat map of residential addresses vs. fast-food outlets

Figure 4.6 below is a kernel density heat map showing the residential addresses in relation to the location of grocery stores. The yellow represents the lowest density, green-blue represents medium density and orange-red represents the highest density of grocery stores.



Mean Distance (m) to GS	Mean distance (m) between Stores	Number of Stores	Number of Address
464.37	282.91	190	226

Figure 4.6: Kernel density heat map of residential addresses vs. grocery stores

Table 4.7 indicates the median distances from residential addresses to grocery stores and fast-food outlets, as well as the reported mRFEI score. The median (IQR) Euclidean distance from the study participants' residential addresses to grocery stores was 337.6 (193.5–594.2) m and to fast-food outlets was 230.5 (141.4–416.6) m. A Spearman correlation coefficient was computed to determine the relationship between the distance of residential addresses to grocery stores and to fast-food outlets. The results indicate a moderate positive relationship [r(226) = 0.627, p = 0.001] indicating that participants were similarly distanced from grocery stores and fast-food outlets. There was a total of 190 grocery stores in the Roodepoort study area and a total of 423 fast-food outlets, resulting in an mFREI score of 31 % which indicates that only 31 % of the retailers in the study area are classified as healthy retailers. Only residential addresses that could be located on Google Maps® (n=226) were used to calculate the mean distance to a grocery and fast-food outlets.

Table 4.7: Grocery store and fast-food outlet distances & mRFEI score

Food establishment distance from residential address (n=266)	**Median (IQR)**	
Distance to a grocery store (m)	337.6 (193.5 – 594.2)	
Distance to a fast-food outlet (m)	230.5 (141.4 – 416.6)	
Spearman correlation coefficient		
	r-stat	***p*-value**
Distance to grocery store and distance to fast-food outlet (n=226)	0.627	**0.001**
mFREI Score	**n or %**	
Total grocery stores in study area	190	
Total fast-food outlets in study area	423	
mFREI %	31	

mFREI: modified Food Retailer Environmental Index

Table 4.8 shows the results of a Mann-Whitney U-test which was performed to compare the distance to grocery stores and distance to fast-food outlets between the two MDD-W categories (MDD-W <5 and MDD-W 5-10). This test was conducted to understand whether the distance to a grocery store or fast-food outlet was significantly different between participants from the two MDD-W categories. The results indicate that there was no significant difference in distance to either grocery store or fast-food outlet between participants from the two MDD-W categories.

Table 4.8: Relationship between grocery store/ fast-food outlet distances and MDD-W categories

	MDD-W Categories		**Mann-Whitney U test results**	
	MDD-W <5 (n=139)	**MDD-W 5-10 (n=85)**	**Z-stat**	***p*-value**
Distance to a grocery store Mean Rank (m) (n=224)	115.8	107.1	-0.968	0.334
Distance to a fast-food outlet Mean Rank (m) (n=224)	117.1	105.1	-1.344	0.180

MDD-W: Minimum Dietary Diversity for Women; Mann-Whitney U test used to compare MDD-W categories to distance to grocery store and distance to fast-food outlet, $p < 0.05$ = significant difference

In Table 4.9, the results of a Spearman's correlation coefficient are displayed. It was computed to determine the relationship between the diet quality scores and the distance to grocery stores and fast-food outlets. The results indicate no correlation between diet quality scores and distances to grocery stores or to fast-food outlets.

Table 4.9: Relationship between diet quality scores (REAP-S score and DDS) and distances to grocery stores and fast-food outlets

	r-stat	***p*-value**
REAP-S Score and Distance to grocery store (n=226)	-0.022	0.740
REAP-S Score and Distance to fast-food outlet (n=226)	-0.036	0.592
DDS and Distance to grocery store (n=224)	-0.065	0.333
DDS and Distance to fast-food outlet (n=224)	-0.039	0.563

Spearman's correlation co-efficient was used to compare the dietary diversity scores (REAP-S and DDS) to the distance to grocery store and fast-food outlet; REAP-S: Rapid Eating Assessment for Participants (Shortened); DDS: Dietary Diversity Score

4.4 Conclusion

The study sample included 427 women (142 non-pregnant and 285 pregnant) who attended the DCHC situated in the Florida region of Roodepoort, Johannesburg. Most of the participants were black South African women aged ±30 years, pregnant, unemployed and married or living with a partner. The MUAC results indicated that 2 % of the women may be undernourished and 30 % may be obese. The mean REAP-S score was 27.1, the mean DDS was 4.1 (which is the same as the national average) (Labadarios et al. 2011) and 64 % of the participants did not achieve the MDD-W and ate from <5 food groups the previous day. The mFREI score of 31 % leans towards an obesogenic food environment. The results also indicated no correlation between diet quality scores and the relative concentration of stores/outlets in or around the participants' residences, although the participants are still living in an obesogenic environment which might explain the poor DDS and high incidence of being overweight.

CHAPTER 5: DISCUSSION

5.1 Introduction

This study sought to investigate the association between the formal urban food environment and diet quality in women of reproductive age within the city of Johannesburg, South Africa. Therefore, the present chapter seeks to relate the results of this study to that of the existing literature. In doing so, this chapter will inspect the findings based on each of the objectives initially presented in Chapter 1 and provided below again for ease of reference:

a) To determine the diet quality of WRA within the city of Johannesburg using a Rapid Eating Assessment for Participants – Shortened Version (REAP-S) survey and a 24-hour dietary recall to measure the DDS and classify the score into the Minimum Dietary Diversity for Women (MDD-W) categories.
b) To measure the density of the formal urban food environment in terms of healthy (grocery stores) and less healthy (fast-foods outlets) food retailers using geographic information systems (GIS) technology to calculate the Modified Retail Food Environment Index (mRFEI) within the city of Johannesburg; as well as the distance from participants' residential addresses to food retailers (grocery stores and fast-foods outlets).
c) To determine the relationship between diet quality of WRA and the formal urban food environment in which they reside within the city of Johannesburg.

The results presented in the preceding chapter are interpreted and discussed against the literature provided in Chapter Two of this study.

5.2 Participant socio-demographic characteristics

The socio-demographic characteristics of the study participants are similar to national and other comparable regional studies. Our study participants consisted of 427 WRA (142 non-pregnant and 285 pregnant) residing in the Roodepoort area. The mean age of participants was 29.8±6.5 years and expected to be young since younger women tend to be pregnant and pre-menopausal to attend a family planning clinic. According to Stats SA (2022), the median ages of mothers for the years 2000 to 2020 ranged from 26-28 years old. Most of our study sample was pregnant (67%) which may have impacted some of the results since pregnant women generally tend to eat differently compared to non-pregnant women (Savard et al. 2020), however the dietary matters are discussed in more detail later. About one third of the women were non-nationals which is aligned with earlier studies which found that the percentage of migrant women in South Africa was estimated to be between 43-45 % (Makandwa & Vearey 2017). Even though many of the participants had a good education (78 % completed matric or had tertiary education), more than half were unemployed and a third received social grants. According to Stats SA (2023), the unemployment rate during Q3:2023 was found to be 31.9 %. It was also found that almost half (49 %) were single. It is common in South Africa that children are raised by their mothers alone – according to Stats SA (2019), 42% of children aged ≤17 years old live alone with their mothers and by comparison, 33% live with both parents. This may impact the resources such as time and money which women have available to make better food choices.

As explained in Chapter 3, the BMI results reflect non-pregnant women only (n=142) and MUAC results reflect both pregnant and non-pregnant women (n=407). The mean BMI of the women was 28.8±5.9 kg/m^2. The BMI results show none of the non-pregnant women were underweight, some were normal weight (27 %) and the majority were overweight or obese (73 %), which agrees with the SADHS of 2016 which found that 68 % of women to be overweight or obese (National Department of Health et al. 2019). The mean MUAC for pregnant and non-pregnant women was 30.7±4.6 cm. The MUAC results show that 2 % of the women may be undernourished and 30 % may be obese. The % of women in the MUAC >33 cm group (30 %) is similar to the BMI obese group (33 %) in this study, indicating that MUAC may be a useful, easily applicable tool to assess overnutrition in pregnant women as found by others (Fakier et al. 2017). One of the reasons for the high instance of obesity observed in this study group may be that middle-class countries such as South Africa are experiencing a 'nutrition transition' which is characterised by the adoption of a more westernised diet which includes high fat, high sugar, high salt, and energy-dense foods (Popkin & Ng 2022), due to a complex set of changes such as urbanisation, globalisation and the rapid advancements of technology (Graham et al. 2018).

5.3 Diet Quality Measures

Diet quality can be broadly described as a gauge of diversity across key nutritional groups as recommended in dietary guidelines (Dalwood et al. 2020). Eating a diversity of healthful foods is globally endorsed through food-based dietary guidelines (Madlala et al. 2022). Diet plays a key role in the development or prevention of numerous diseases including NCDs such as obesity, heart disease, hypertension, certain cancers, type 2 diabetes mellitus and stroke (Gans et al. 2003). High quality diets relate to healthy dietary patterns and a sufficient intake of micro- and macronutrients (Madlala et al. 2022), with a reduced risk for cardiovascular disease, diabetes and mortality (Duvenage et al. 2023). A high DDS is correlated with nutrient adequacy which is essential for growth, strength, body maintenance, physical work, cognitive ability, immunity and decent health (Sambo et al. 2022). Poor dietary diversity is associated with an elevated risk of chronic diseases such as cardiovascular disease, diabetes and obesity, in addition to depression and anxiety (Sambo et al. 2022). This study measured diet quality in two ways: the DDS to categorise scores into the MDD-W and the REAP-S survey.

Table 5.1 was drawn to compare the current study results to other studies using diet quality scores (DDS and MDD-W) in South Africa and other countries in Africa. The table shows that in the current study, the mean DDS for all the participants was 4.1±1.4 and 64 % of participants did not achieve the MDD-W. For reference, in the latest national South African Social Attitudes Survey among 3287 adults across all provinces and socioeconomic levels conducted in 2009, Labadarios et al. (2011) measured the mean DDS to be 4.02±0.55 and found that 38.3 % of participants did not achieve the MDD-W. Low dietary diversity and women not achieving the MDD-W is evident in several studies throughout South Africa with DDS figures between 2.82-4.99 and 70-96 % of participants not achieving the MDD-W (Duvenage et al. 2023; Madlala et al. 2022; Fisher 2021; Jordaan et al. 2020; Chakona & Shackleton 2017; Shisana et al. 2014; Drimie et al. 2013; Oldewage-Theron & Kruger 2011; Oldewage-Theron & Kruger 2008). In studies conducted in various other countries in Africa, the mean DDS was between 3.45-4.69 and 40-90 % of participants did not achieve the MDD-W (Nkoko et al. 2023; Georgina et al. 2023; Koppmair et al. 2023; Askeer et al. 2023; Mesfin et al. 2023; Alamirew et al. 2023; Custodio et al. 2020; Bellows et al. 2020; Adubra et al. 2019; Tine et al. 2018; Saaka et al. 2017; Amagusi et al. 2016). There was only one study in South Africa in which the mean DDS was >5 (6.7) (Acham et al. 2012) and six studies in Africa in which the DDS was between 5.78-6.84 and it was found that 11-39 % of participants did not meet the MDD-W (meaning that 61-89 % of participants met the MDD-W) (Onyeji & Sanusi 2022; Merga et al. 2022; Saaka et al. 2021; Tamale & Kagoro-Rugunda 2019; Marinda et al. 2018; Willy et al. 2016).

Table 5.1: Dietary diversity score (DDS) from the current study compared to other South African and African studies

Study Area	Urban or Rural	No. of participants	Age (years)	No. of total food groups	Data collection method to calculate DDS	Mean DDS (±SD)	% of participants <5 MDD-W	Citation
Roodepoort, Johannesburg	Urban	427 women	18-49	10 (MDD-W)	24-hour dietary recall	4.10±1.4	64.0	Current study
Other studies in South Africa								
Tshwane district, Gauteng province	Urban	77 men and women	40-70	7	24-hour dietary recall	4.99±0.93	n/a	Duvenage et al. (2023)
Cape Town	Urban	693 men and women	25-65	10 (MDD-W)	24-hour dietary recall	n/a	70.4	Madlala et al. (2022)
Gauteng and Eastern Cape	Both	286 women	18-49	10 (MDD-W)	24-hour dietary recall	3.70±1.3	75.4	Fisher (2021)
Free State province	Rural	134 women	25-49	9 (FAO)	24-hour dietary recall	n/a	96.3	Jordaan et al. (2020)
Richards Bay, Dundee, and Harrismith	Both	554 women	15-49	10 (MDD-W)	48-hour food recall	3.46±0.99	75.0	Chakona & Shackleton (2017)
South Africa – SANHANES-1	Both	13 357 men and women	15-65+	9 (FAO)	24-hour dietary recall	4.20	39.7 (<4)	Shisana et al. (2014)
Johannesburg	Urban	487 men and women	-	9 (FAO)	24-hour dietary recall	4.10±1.5	36.8 (<4)	Drimie et al. (2013)
Alexandra, Johannesburg	Urban	260 women	19-69	9 (FAO)	Food frequency questionnaire	6.70±2.22	19.6 (<4)	Acham et. al (2012)
South Africa - nationally representative	Both	3287 men and women	16+	9 (FAO)	24-hour dietary recall	4.02±0.55	38.3	Labadarios et al. (2011)
Vaal region, Johannesburg	Peri-urban	1261 women	-	6	24-hour dietary recall	2.82±0.99	n/a	Oldewage-Theron & Kruger (2011)
Sharpeville, Johannesburg	Urban	169 men and women	60-110	9 (FAO)	24-hour dietary recall	3.41±1.34	92.7	Oldewage-Theron & Kruger (2008)
Other studies in Africa								
*Lesotho	Rural	199 women	15-49	10 (MDD-W)	24-hour dietary recall	3.45±1.42	79.4	Nkoko et al. (2023)
Ogun State in Nigeria	Urban	170 women	18-59	10 (MDD-W)	24-hour dietary recall	3.92	71.8	Georgina et al. (2023)
*Malawi	Rural	408 women	-	12	24-hour dietary recall	4.11±1.67	40.0	Koppmair et al. (2023)

Study Area	Urban or Rural	No. of participants	Age (years)	No. of total food groups	Data collection method to calculate DDS	Mean DDS (±SD)	% of participants <5 MDD-W	Citation
Nigeria Demographic Health Survey	Urban	8975 women	-	10 (MDD-W)	24-hour dietary recall	4.69±1.81	49.4	Askeer et al. (2023)
Southern Ethiopia	Urban	635 pregnant women	<25-44	10 (MDD-W)	24-hour dietary recall	4.67	46.7	Mesfin et al. (2023)
Amhara region of Ethiopia	Rural	421 women	≤21-39+	10 (MDD-W)	24-hour dietary recall	4.00±0.74	73.2	Alamirew et al. (2023)
*South-east Nigeria	Both	1200 women	15-49	10 (MDD-W)	24-hour dietary recall	5.78±1.16	11.7	Onyeji & Sanusi (2022)
Oromia Region, Ethiopia	Rural	634 women	15-45	10 (MDD-W)	24-hour dietary recall	5.98±1.86	18.1	Merga et al. (2022)
Sagnarigu Municipality of Ghana	Peri-urban	423 pregnant women	18-42	10 (MDD-W)	24-hour dietary recall	6.30±2.2	20.1	Saaka et al. (2021)
Ouagadougou and Bobo-Dioulasso main cities in Burkina Faso	Both	12 754 women	15-49	10 (MDD-W)	24-hour dietary recall	3.80	69.4	Custodio et al. (2020)
Rufiji, Tanzania	Rural	1006 women	18-49	10 (MDD-W)	24-hour dietary recall	3.00	90	Bellows et al. (2020)
Mbarara district, Uganda	Rural	402 women	15-49	10 (MDD-W)	24-hour dietary recall	n/a	29.8	Tamale & Kagoro-Rugunda (2019)
Kayes, Mali	Rural	5046 women	15-49	10 (MDD-W)	24-hour dietary recall	3.82±0.05	73	Adubra et al. (2019)
Southern Senegal	Rural	1926 women	15-45	10 (MDD-W)	24-hour dietary recall	2.90±1.4	n/a	Tine et al. (2018)
*Lusaka Province, Zambia	Urban	714 women	15-49	10 (MDD-W)	24-hour dietary recall	5.80	12.5	Marinda et al. (2018)
Northern Ghana	Rural	400 pregnant women	15-49	10 (MDD-W)	24-hour dietary recall	4.20±1.5	53.9	Saaka et al. (2017)
Laikipia County, Kenya	Urban	254 pregnant women	15-49	9 (FAO)	24-hour dietary recall	6.84±1.46	39.4	Willy et al. (2016)
Ghana	Both	2262 women	15-49	9 (FAO)	24-hour dietary recall	n/a	56.9	Amagusi et al. (2016)

DDS: Dietary Diversity Score; SD: standard deviation; MDD-W: Minimum Dietary Diversity for Women; SANHANES-1:The South African Health and Nutrition Examination Survey

*Note: Children were also included in this study but we focused on the results from adults only.

The hallmarks of a superior quality or healthy diet are those which provide sufficient healthful food; a diversity of food, including plenty of legumes and whole grains, fruits and vegetables, sugar and salt consumed in moderation; using unsaturated fats rather than trans or saturated fats; consuming disease-free (safe) and minimally or unprocessed foods (FAO 2016). Available evidence suggests a relationship between poor dietary diversity and under-nutrition as a low DDS is associated with a deficiency of micronutrients in the diet and is generally a diet dominated by starchy foods, and lack of animal products, vegetables and fruit (Sambo et al. 2022). In their study using data from the 2017 General Household Surveys, Jonah & May (2019) found that more affluent households consume from a greater number of food groups than poorer households and the differences in the vegetables, fruits, meat, and dairy food groups are particularly steep, which leaves poorer households more vulnerable to micronutrient deficiencies and thereby at risk for malnutrition. Poorer populations typically consume a monotonous diet of starchy staple foods, dairy foods, a few fruits and vegetables and little or no animal products, and therefore suffer the most in achieving an adequate dietary diversity, resulting in multiple nutrient deficiencies (Oldewage-Theron & Kruger 2011).

This is consistent with studies in both Africa and South Africa. For example, among 254 pregnant women from Kenya, Willy et al. (2016) found that the most eaten food group was cereals (99.2 %) and foods of animal origin were least eaten (5.5 %). In a study on 421 women from Ethiopia, Alamirew et al. (2023) found that they predominantly consumed starchy staples (100 %), pulses (99.5 %), and other vegetables (89.6 %). Meat, poultry and fish (16.9 %), dark green leafy vegetables, eggs and fruit were least consumed (Alamirew et al. 2023). In Ethiopia, Mesfin et al. (2023) found that participants consumed grains, white roots, tubers, and plantains (87.3 %) and other vegetable food categories (75.5 %), while meat and poultry was the least consumed food group. In Johannesburg, Oldewage-Theron and Kruger (2008) found that many food items consumed were carbohydrate-based. The current study’s 24-hour dietary recall results showed slightly differing results compared to the aforementioned studies as, although the consumption of starchy foods was similar, the consumption of animal products was significantly higher. Most of the participants’ diets consisted of grains, white roots, and tubers (99 %); meat, poultry, and fish (83 %); and other vegetables (61 %). Similarly, responses to the REAP-S questions indicated that 41 % of study participants consumed two or more vegetables a day, confirming that the participants consume vegetables. From the 24-hour dietary recall, it appears that these vegetables were mostly non-vitamin A-rich vegetables as the consumption of vitamin A-rich vegetables and fruit were low (26 %).

The fact that an overwhelming majority of study participants consumed ‘grains, roots, or tubers’ and ‘meat, poultry and fish’ food groups is that these are considered staples in South Africa which consumes 104 kg/capita/year of maize; and 32 kg/capita/year of chicken (Ronquest-Ross et al.

2015). Food consumption data from South Africa between 1994-2012 showed that there was a decrease in the consumption of vegetables and an increase in the consumption of fast-foods and processed meats, sweet and savoury snacks, meat, fats and oils and soft drinks (National Department of Health 2019). These foods are usually cheap and thereby affordable to low-income households and this may have greatly influenced the development of less healthy diets, overweight/obesity and NCDs (Madlala et al. 2022). Thus, our results may also be an indication of the shift in South African diets from more traditional diets high in starchy staples to more westernised diets high in animal products due to the nutrition transition (National Department of Health 2019). Furthermore, in the current study, few participants reported to consuming eggs (17 %), pulses (beans, peas, or lentils) (15 %) and nuts and seeds (12 %) the previous day which was very similar to the findings in other studies in South Africa and Africa (Labadarios et al. 2011; Amagusi et al. 2016; Madlala et al. 2022; Acham et al. 2012; Custodio et al. 2020; Bellows et al. 2017) which may be a further indication of the shift in diets. These foods are nutrient-dense and provides essential nutrients required for reproduction and growth of children. Since the current study is focused on WRA, the following section will focus on women.

In the current study, non-pregnant women had a lower DDS compared to pregnant women (3.8±1.5 vs 4.2±1.4) which may be an indication that pregnant women are more cognisant of ensuring they have a more varied diet (Savard et al. 2020). In the total group, 64 % did not meet the MDD-W and more non-pregnant women did not reach the MDD-W compared to pregnant women (72 % vs 60 %). Meaning that only 28 % of non-pregnant women and 40 % of pregnant women reached the MDD-W. As with the DDS, the non-pregnant women had a lower diet quality score when considering the REAP-S results compared to pregnant women (26.5±3.6 vs. 27.3±3.2). In the current study, it was found that women who did not meet the MDD-W had a significantly higher MUAC than those who met the MDD-W, meaning that meeting the MDD-W may be associated with an improved nutritional status. It was also found that women who consumed the following five food groups (grains, white roots and tubers; dairy; meat, poultry and fish; vitamin A rich fruit and vegetables; and vegetables other than vitamin A rich vegetables) had a significantly smaller MUAC compared to those who did not consume these foods, meaning that these foods may be associated with a healthier nutritional status. In a similar fashion, the REAP-S results indicated that those who consumed ≥2 dairy portions per day had a smaller MUAC and thereby potentially a better nutritional status. On the other hand, those consuming sweets and fried foods had a larger MUAC indicating that regular consumption of these foods may contribute to a poorer nutritional status.

Regarding the consumption of fast-foods, in their study on a nationally illustrative group of participants aged 16+ years (n=3287) from all ethnicities and provinces to measure the popularity of fast-foods and street foods South Africans purchase, Steyn et al (2011) found that a great percentage of the population purchased fast-foods and street foods. They found that the consumption of fast-foods and street foods were influenced by socio-demographic factors such as LSM group and the possession of home appliances. However, regular fast-food consumers had a significantly higher DDS compared to regular street food consumers (4.69 vs. 3.81) (Steyn et al. 2011). Another study among 17-year-olds in the Birth to Twenty cohort in Soweto and Johannesburg (n=655) found that 20 % of the participants ate fast-foods 2-4 times a week and 30 % had it 5-7 times a week (Feely et al. 2009). They hypothesised that fast-foods and street foods may contribute substantially to total dietary intake since many of the items sold are large meals in terms of energy value, particularly foods like a kota which comprises a quarter loaf of white bread and fried chips as the two main ingredients (Feely et al. 2009). Another study on young adults (n=341) at three different shopping malls in Johannesburg found that 28 % of participants had fast-foods 2-3 times a week with the most popular food items being soft drinks, burgers, fried chicken and pizza (van Zyl et al. 2010). In the current study, 76 % of participants reported that they rarely/never eat 4/more meals/week from sit down restaurants or take away outlets, and one reason this could be so high in comparison to the published studies mentioned above is that this study did not consider the impact the informal food environment had on participants' food choices which were based on evidence presented above, and so it may have had a significant impact on participants' dietary choices (Steyn et al. 2011).

5.4 Describing the formal urban food environment in Roodepoort

In the current study, the median distance from the study participants' residential addresses to grocery stores was 337.6 (193.5–594.2) m and to fast-food outlets was 230.5 (141.4–416.6) m. This means that it is as accessible to visit a grocery store or a fast-food outlet and that consumers may choose to visit either when visiting a food outlet. Since this is in an urban area, it is expected that all types of outlets should be close to each other. Our results differed greatly from the national South African study published by Otterbach et al (2021) which found that the median distance to a fast-food chain was 8.7 km and grocery store was 7.6 km, compared to the current study in which both types of outlets are <400m away. One likely reason for the vast difference in distance could be that the current study included all grocery stores and fast-food outlets in the Roodepoort areas whereas the study by Otterbach et al. (2021) included only Big Food retailers (modern food outlets belonging to national or international chains).

There was a total of 190 grocery stores and a total of 423 total fast-food outlets in the study area, which represents an mFREI score of 31 %. Guided by the interpretation of the mRFEI score by Ndlovu et al. (2018), the current study's score of 31% is considered low and indicates a low availability of healthy food stores relative to unhealthy ones and thereby representing an obesogenic food environment. This was similar to a food environment study in Gauteng conducted by Ndlovu et al. (2018) where they reported that fast-food outlets vs. grocery stores (n=1559 vs. n=709), resulting in mFREI score of 33 %, also indicating an obesogenic food environment.

Furthermore, in their study Ndlovu et al. (2018) found that the distribution of food availability followed a social incline, where grocery stores were concentrated in higher socio-economic areas, while fast-food outlets were concentrated in areas with lower- to middle-income areas (Ndlovu et al. 2018). Another study by Battersby & Peyton (2014) in Cape Town reported a similar trend – they found that the dispersal of supermarkets in Cape Town is highly unequal and residents in the highest-income areas had almost 8x as many supermarkets per household as those in the lowest-income areas. Due to Roodepoort being a smaller area and not being an affluent area, a similar trend was not observed in the current study.

In the current study, a moderate positive relationship between grocery stores and fast-food outlets was observed, meaning that where you find a grocery store, you were likely to find a fast-food outlet in its proximity. This is classic of the South African retail landscape in which the popularity of shopping centres that include supermarkets and fast-food chains in the same location (Otterbach et al. 2021). Local supermarkets, fast-food franchises and multinational franchise corporations also share a unique co-existence with informal traders (Otterbach et al. 2021). In South Africa, the main sources of food shopping are a mixture of formal retailers and less formal retailers (Odunitan-Wayas et al. 2021). Formal retailers include supermarkets and fast-food outlets and informal retailers include street vendors, spaza shops, convenience stores, and food/community markets (Odunitan-Wayas et al. 2021). Street vendors characteristically operate from temporary structures in active areas like bus and train stations, industrial or business districts. They typically sell sweets, cold drinks, fruit, vegetables and cooked lunches (Vogel 2018). Spaza shops are small, informal, independently owned convenience shops usually run from a house or a shipping container. They are typically in residential areas and within walking distance from people's homes. They usually sell a limited number of mandatory items such as sugar, condiments, bread, tea, coffee, cleaning materials and toiletries (Vogel 2018). In her study on 288 urban black adults living in Mamelodi, Pretoria, Vogel (2018) found that informal food retail outlets like street vendors and spaza shops were more accessible and were utilised daily in most instances, whereas supermarkets were visited less frequently and preferred for larger, bulk purchases. However, there has been an increase in the number of supermarkets over the last two decades and the main source for food shopping have now become supermarkets, which accounts for >50 % of the total sale of food (Odunitan-Wayas et al. 2021). The supermarket sector in South Africa is highly concentrated with four major supermarket chains (Shoprite Checkers, Pick n Pay, Spar and Woolworths) accounting for over 95 % of formal retail market sales (Otterbach et al. 2021). While supermarkets were originally only found in South Africa's large cities, they have more recently expanded to urban townships and rural areas which makes them more accessible to many low-income consumers (Otterbach et al. 2021). The entry of international food and beverage companies to South Africa and the expansion of the formal food sector, including the increase in the number of fast outlets has led to the increased availability of processed and ultra-processed foods to consumers which are more affordable and acceptable (Beukman 2020). These dietary changes can cause an individual to become overweight or obese which leads to an increase in the incidence of metabolic syndrome and associated NCDs (Beukman 2020). The current study analysed the impact of the formal food environment only on participants from the Roodepoort area, without considering the impact of the informal food environment.

The next section discusses the impact the food environment has on human health and well-being.

5.5 The relationship between diet quality and the formal urban food environment

In the current study, the two groups of women as categorised by the MDD-W (<5 and ≥5 food groups) had similar distances to a grocery store or fast-food outlet (no significant difference in distance to these stores). In addition, there was no correlation between diet quality scores and distances to grocery stores or to fast-food outlets, meaning that the distance to grocery store/fast-food outlets was not related to a participants' nutritional status. However, the mRFEI score was low (31%) indicating a less healthy or obesogenic food environment may be influencing participants' diet quality. These findings are similar to another study conducted in Potchefstroom by Beukman (2020) who sought to investigate whether retail food environments had an influence on the study population's health status (using the BMI measurement) and found no significant results. On the contrary, several other studies conducted in both South Africa and Africa found that food environments had an influence on a population's health status. For example, the study on a South African nationally representative sample (n=3287) by Steyn et al. (2011) suggests that higher income households are more frequent consumers of western fast-food and lower income households are more frequent consumers of local street foods; however, both are energy- and fat-dense and linked with higher consumption of soft drinks, all of which are factors that likely contribute to South Africa's obesity epidemic. Another study on three towns in Kenya, Rischke et al (2015) found that supermarket purchases are significantly associated with the consumption of processed foods. In their study in Lusaka, Zambia, Khonje et al (2020) found that the use of modern food retailers is positively associated with an increased BMI among adults (i.e. an increased likelihood of being overweight and obese). In their study of 550 urban adults living in Kenya, Demmler et al (2017) found that purchasing food in supermarkets contributes to a higher BMI, an increased likelihood of being overweight or obese, higher levels of fasting blood glucose and therefore an increased likelihood of having diabetes and the metabolic syndrome. Thus, these authors found that better supermarket access resulted in dietary shifts away from fresh fruits and vegetables with a move towards processed foods, snacks, and animal products. In their study in Central Province of Kenya, Kimenju et al (2015) found that buying in a supermarket was associated with a significantly higher BMI and a higher probability of overweight. In their study using data from the fifth wave (2017) of the South African National Income Dynamics Study, a nationally representative survey, Otterbach et al (2021) found that a closer proximity and thus improved access to supermarkets and fast-food restaurants increases BMI and the probability of overweight and obesity. This was also found in two recent studies with data from urban Zambia by Khonje et al (2020) and by Khonje and Qaim (2019) who also observed that the use of present-day food retailers shifted a household's diet towards ultra-processed foods as they are more inclined to retail those types of products than traditional markets which are more inclined to trade unprocessed or minimally processed foods.

In the current study, although supermarkets were used as an indicator of a healthy food outlet, evidence from several studies suggest that access to supermarkets does not necessarily lead to healthy food choices, as they increase access to both healthy and less healthy foods (Odunitan-Wayas et al. 2021). In their study in Lusaka, Zambia, Khonje et al (2020) found that modern retailers add to an increased intake of ultra-processed foods and calories, but they also add to an increased intake of protein and micronutrient mainly through the consumption of meat and dairy so that have both a positive and negative effect on population health and well-being. They also found that the use of present-day food retailers upsurges food intakes and thereby calorie intakes, mainly through dairy products, meat and sugar (Khonje et al. 2020). However, the upsurge in the consumption of animal-sourced foods also results in increased consumption of protein and micronutrients like iron, zinc, and vitamin A, which implies that the development of modern retailers has both a positive and negative effect on nutrition simultaneously: it is associated with a reduction in micronutrient deficiencies among adults and a rise in overweight/obesity (Khonje et al. 2020). Similarly, in Kenya, Demmler et al (2018) found that supermarket shopping had significant increases on participant energy consumption from dairy, vegetable oil, processed meat products (sausages etc.), and highly processed foods (bread, pasta, snacks, soft drinks etc.). These shifts toward processed and highly processed foods lead to less healthy diets, with higher sugar, fat, and salt contents, and probably lower amounts of micronutrients and dietary fibre (Demmler et al. 2018). These authors found a positive association between supermarket purchases and BMI but did not identify a significant effect on being overweight or obese (Demmler et al. 2018). Evidence from their study suggests that the supermarket expansion contributes to the nutrition transition (Demmler et al. 2018).

In summary, although no significant association was established between the diet quality scores and the food environment measures, most of the study participants were overweight or obese and living in an obesogenic food environment, indicating that there may have been a relationship but the measuring tools were not sufficiently sensitive. Measuring food environments is a fairly new field of study and it is also complex and labour intensive (Jalbert-Arsenault et al. 2017). Several methods to measure food environments are still being developed and they are constantly evolving (Jalbert-Arsenault et al. 2017).

Still, the food environment may be a powerful tool that we can use to shift consumer’s food choices, and thereby influence their diet quality and overall health. With the growth, expansion and modernisation of both grocery stores and fast-food outlets, consumer access to food will be greatly increased in years to come, and it is therefore vital it ensure more healthful foods are made available to influence consumer dietary choices and protect the health of WRA as well as future generations.

Concluding remarks, recommendations and limitations are presented in Chapter 6.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

This study sought to investigate the association between the formal urban food environment and diet quality of women of reproductive age within the city of Johannesburg.

The first study objective was to determine the diet quality of women of reproductive age within the city of Johannesburg using a REAP-S survey and a 24-hour dietary recall to measure the DDS and classify the score into the MDD-W categories. The mean REAP-S score for all participants was 27.1±3.3, with non-pregnant women having a lower REAP-S score than pregnant women (26.5±3.6 vs. 27.3±3.2). The REAP-S survey results showed that the participants had a moderate diet quality based on the observation of dietary behaviours. There is no cut-off value for the REAP-S score thus to classify the diet quality based on the REAP-S score solely is not possible. However, individual line items in the survey provided insights into the dietary behaviour. For example, some healthy eating habits were reported that: 50 % of participants indicating that they do not skip breakfast; 76 % reported that they rarely/never eat 4 or more meals/week from sit down restaurants or take away outlets; almost half the participants (48 %) reported that they usually/often ate ≥2 fruit/day; and 41 % reported that they usually/often ate ≥2 portions of vegetables/day. On the contrary, some of the unhealthier behaviours reported were that 65 % of participants usually/often add fats to their meals at the time of eating; almost half (42 %) rarely/never use low-fat processed meats instead of regular processed meats; and 45% indicated that they rarely/never consumed ≥2 wholegrains per day. From the DDS results, it was found that the study population had poor dietary diversity (DDS = 4.1±1.4) with 64 % of the study population not meeting the MDD-W (60 % pregnant and 72 % non-pregnant not meeting the MDD-W). The study found a correlation between the two diet quality scores (r = 0.159 p = 0.001) indicating the two measures had similar outcomes of diet quality. The results presented above and as discussed in chapter 5 support the assertion that the first study objective was suitably addressed.

The second study objective was to measure the density of the formal urban food environment in terms of healthy (grocery stores) and less healthy (fast-foods outlets) food retailers using GIS) technology to calculate the mRFEI within the city of Johannesburg; as well as the median distance from participants' residential addresses to food retailers (grocery stores and fast-foods outlets). We found the environment to be an obesogenic food environment indicated by a low mRFEI score (31 %). The median distance from the study participants' residential addresses to grocery stores was 337.6 (193.5–594.2) m and to fast-food outlets was 230.5 (141.4–416.6) m which indicates that it is as accessible to visit a grocery store or a fast-food outlet and that consumers may choose to visit either when visiting a food outlet. The results presented above and as discussed in chapter 5 support the assertion that the second study objective was suitably addressed.

The final study objective was to determine the relationship between diet quality of women of reproductive age and the formal urban food environment in which they reside within the city of Johannesburg. The study found no associations of either diet quality score with the mRFEI score; or either diet quality score and the distance to food retailers (grocery stores and fast-food outlets). However, many participants were overweight with the MUAC results indicating that 30 % may be obese and the BMI results of non-pregnant women indicating that the majority were overweight or obese (73 %). The results presented above and as discussed in chapter 5 support the assertion that the final study objective was suitably addressed.

South Africa is undergoing the 'nutrition transition' (Graham et al. 2018) which was reflected in this study by the higher consumption of animal-based products and the lower consumption of nuts and seeds, pulses and eggs compared to other studies in South Africa. The increase in the number of supermarkets in both urban and rural areas may have impacted food consumption patterns (Claasen et al. 2016); and the fast-food industry is growing at a rapid pace and increasing the availability of less healthy foods (Govender 2017). South Africans are progressively consuming inexpensive, speedy, and big-portioned fast-food items (Govender 2017). The consistent intake of meals from fast-food outlets over time have been connected to adult weight gain, with an amplified danger of obesity and NCD occurrence (Burgoine et al. 2014). Even though this sample reported less frequent food purchases from restaurants or fast-food outlets, it did not take into account the impact of the informal food environment on food choice, although regardless of this, their diets lacked diversity and therefore, by implication, diet quality. The current study found that participants live in an obesogenic food environment, most did not reach the MDD-W and most non-pregnant participants were overweight or obese indicating that although no association was found, the food environment may have a considerable impact on study participant food choices, diet quality and thereby their overall health. The results of this study may be an indication that there may have been a relationship but the measuring tools were not sufficiently sensitive. The health of WRA is important for the future generations' health since evidence shows that nutritional status of women not only during pregnancy, but also prior to pregnancy affects offspring health (Ramakrishnan et al. 2012). It is therefore vital that the influence of the food environment be fully understood and measures by taken to improve the health and well-being of WRA.

6.1 Contribution of the study

The main contribution of the study is that it adds to the body of knowledge surrounding the urban food environment and diet quality of women within Johannesburg. It also aids in highlighting potential intervention points to improve the health status of WRA by providing insights into their food environment which can be used when planning and implementing nutrition or health programmes, strategies or regulations. By measuring the food environment geographically, healthy food access gaps can be acknowledged and nutrition programmes can be progressed. This study also contributed towards establishing a standardised protocol for collecting GIS data to compare different regions and to ensure that data collection is as complete as possible. Due to the complex nature and novelty of collecting GIS data on food outlets and the ever-changing food environment, the collection of this type of data can be quite challenging.

6.2 Limitations of the study

There are a few limitations of this study – the main limitation is that the findings may apply only to a specific area of Johannesburg and therefore cannot be generalised to other communities in South Africa. The study also did not consider the impact of the informal urban food environment, and the food retailers included in the study were only those that could be found online. The study also looked at the food outlets to which participants may have access but did not consider their shopping patterns and behaviours. There is a possibility that adaptations to any validated instrument can influence study results. Collecting dietary data also has its limitations: participants may not recall everything they had eaten the previous day and they may report food intake close to what they consider to be socially desirable or acceptable. The study also had an uneven distribution of pregnant vs. non-pregnant participants which may have skewed the results based on participant food choices while pregnant vs.. non-pregnant. Another limitation is the self-selection bias of participants which occurs when the decision to participate in a study is left entirely up to the participants and they may not be representative of the area's population. Furthermore, both pregnant and non-pregnant women were included in the study which may have resulted in varied outcomes.

6.3 Recommendations

The following recommendations can be made based on the results of this study:

1. Educating the population on the general food-based dietary guidelines and general nutrition education to warrant that they are adequately advised about how healthy or less healthy their food selections may be. The effects of the food environment on nutrition and health can mainly be attributed to shifts in people's food choices (Demmler et al. (2017). For example, in their study in Tshwane, Duvenage et al (2023) observed a higher than mean national DDS (4.99 vs. 4.02) could be justified by the fact that most participants having received nutrition education on the importance of diet quality, highlighting the importance and impact of nutrition education. Although, nutrition knowledge should be assessed.
2. Providing farming education on urban farming techniques. For example, in their study in Tanzania, Bellows et al (2017) found that growing vegetables for home consumption was positively associated with a higher DDS. Eating fruit and vegetable is vital for a balanced and healthy diet (McGuirt et al. 2018). It also decreases the risk of diet-related diseases such as heart disease, high blood pressure and type-2 diabetes (McGuirt et al. 2018).

3. In the development of corporate social responsibility programmes, food retailers (grocery stores and fast-food outlets) can encourage healthier food choices and provide a wider variety of healthy food options for their customers and South Africans at large. There are numerous options for choosing healthier fast-food meals, including the following: whole grain options, healthy vegetarian options, the option to choose water or milk instead of a soft drink, limiting the number of starchy options, not upsizing the menu option and offering other side dishes instead of fried chips (Baloyi et al. 2023).
4. Regulatory policies (health promotion levies), together with town planning that can support a healthier food environment would be beneficial as evidence suggests that supermarkets and their food sales strategies seem to have a direct impact on people's health, not only regarding increasing overweight and obesity but also to nutrition related NCDs (Demmler et al. 2017).
   - For example, regulating the price of healthy and less healthy foods. One key driver of dietary patterns is the price of healthy foods compared to highly processed foods – healthier diets cost almost 70 % more than less healthy alternatives (Balusik et al. 2023). One way to improve diet quality is by ensuring that healthy foods and nutritious diets are offered at a price that is affordable to the poor (Jonah & May 2019). Taxes could also be put on particularly less healthy foods and beverages and subsidies and other types of incentives offered to food retailers to offer particularly healthy products (Khonje et al. 2020).
   - Food policies to endorse healthier dietary behaviours could also involve changes of in-store placements of healthy and less healthy foods, the regulation of advertisement promotions (Otterbach et al. 2021), the regulation of portion and packaging sizes and the improved designs of both voluntary and mandatory health labels (Khonje et al. 2020).

6.4 Suggestions for future research

The current study found that the study participants live in an obesogenic food environment and a significant portion were overweight or obese, indicating that the formal urban food environment may be impacting participant food choices. There is currently limited research in South Africa that links increased numbers of fast-food outlets and supermarkets to nutrition and health outcomes (Otterbach et al. 2021). Thus, a suggestion for future research is to nationally map the food environment and monitor it annually with the health status of the population to monitor what is happening in the food environment space. Another suggestion is to develop a standardised data collection protocol that can be used internationally to assist with accurately collecting GIS data. This will allow for a more accurate comparison between regions over time.

In summary, based on the above study, the food environment is a powerful tool that we can use to shift from an obesogenic to a leptogenic environment and salutogenic behaviours. The introduction of food and health education policies and programmes may prompt consumers to shift their choice of using fast food outlets and are rather encouraged to visit grocery stores that prioritise healthier foods such as fresh produce or to incentivise fresh produce shops like local farmers markets.

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APPENDICES

Appendix 1: Quick screening form at recruitment

CHAMP study
Quick screening form at recruitment

Date: | D | D | M | M | 2 | 0 | 2 | 3 |

Table A: Inclusion criteria *(looking for YES answers)*

	Yes	No
1. Are you able to communicate effectively in English, Afrikaans, Sotho, Xhosa or Zulu?		
2. Are you between the ages of 18 and 49 years?		

If NO to any of the above questions (Table A), do NOT continue. Supply the patient with the Thank You note and a short explanation.

If YES to all the question above, continue to Table B.

Table B: Exclusion criteria *(looking for NO answers)*

	Yes	No	Don't know
1. If you are pregnant, are you carrying more than one baby, such as twins or triplets?			
2. Do you have high blood pressure? a. If pregnant, did you have high blood pressure *before* pregnancy? *(include 102 women who developed high blood pressure during pregnancy after 20 weeks gestation)*			
3. Do you have diabetes?			
4. Do you have high cholesterol?			
5. Are you using any prescribed medication for the above mentioned?			
6. Have you been diagnosed with TB in the past 12 months?			
7. Have you been diagnosed with Hepatitis in the past 12 months?			
8. Have you been diagnosed with cancer or any other serious illness in the past 12 months?			

If YES to any questions in Table B, do NOT continue. Supply the patient with the Thank You note and a short explanation. We need to recruit 102 women with hypertension or pre-eclampsia – see highlighted questions.

If NO or DON'T KNOW to all the questions in Table B, continue to invite her to the study.

Ask: Do you want to take part in the study? YES / NO

If no, reason: ____

Appendix 2: Informed Consent Form

UNISA university of south africa

PARTICIPANT INFORMATION SHEET

Ethics clearance reference number:

Research permission reference number:

April 2020

Cardiovascular, haemostatic and micronutrient status of pregnant women in urban food environments – the CHAMP study

Dear Prospective Participant

My name is Dr Elize Symington. My colleagues and I are doing research in the Department of Life and Consumers Sciences at the University of South Africa (UNISA). We have funding from UNISA and the National Research Foundation. We are inviting you to participate in a study entitled *Cardiovascular, haemostatic and micronutrient status of pregnant women in urban food environments – the CHAMP study.*

WHAT IS THE PURPOSE OF THE STUDY?

We are conducting this research to find out more about women's health, especially regarding heart health, blood clotting and nutritional status as well as foods that you eat. We are interested to know more about pregnant and non-pregnant women's health. This will help us to better understand what measures can be taken to optimise the health of women who may fall pregnant and those who are already pregnant. In this way their babies may be healthier.

WHY AM I BEING INVITED TO PARTICIPATE?

You have been invited because you are attending the antenatal clinic or family planning clinic today, or because you were admitted to Rahima Moosa Mother and Child Hospital.

You have also complied with the following criteria:

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
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- Women of childbearing age (18 to 49 years of age)
- Be able to speak and read a local language

However, you will be excluded if you:

- Are pregnant with more than one baby
- Have been diagnosed with a known lifestyle disease such as diabetes, kidney disease, high cholesterol, high blood pressure (however if you got high blood pressure only with pregnancy, you will be included)
- Have been diagnosed with a known infectious disease such as TB or hepatitis (you will be included if you are either HIV positive or negative)
- Have been diagnosed with a known serious illness such as cancer, lupus or psychosis

We plan to include 335 pregnant women and 335 non-pregnant women.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

Your role would be to answers questions about your living conditions, health and lifestyle behaviour. For more information about your health, we want to get information from your medical file. This study also involves measuring your health such as your blood pressure, heart rate, body weight, height, as well as waist and arm circumference. We also want to measure the health of your arteries by measuring thickening and stiffness of the carotid artery in your neck using probes and ultrasounds. Lastly, the study wants to draw blood to measure your cholesterol, clotting factors, inflammation, oxidative stress profile? and nutrient status. This all should take between 60 and 75 minutes. If you are pregnant, we will also want to look at your baby's medical file a few days after birth.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason. All questionnaires are anonymised by using a provided participant number and not your name.**WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?**

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Yes. After completion of the measurements, your cardiovascular measurement results and anthropometric results will be shared with you and discussed. These types of measurements are typically conducted at clinics, many times at a cost, however, you will receive this at no financial cost. As a participant, you will also contribute to the knowledge of the health of women of childbearing age in Johannesburg.

ARE THEIR ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

Most of the measurements that will be performed won't harm or hurt you in any way, but you might experience the following:

- If you give permission to a blood sample, you might feel uncomfortable or scared. This will only last for a short while. We want to make sure that you are not hurt and therefore the qualified professional will draw the blood from your arm. She will talk to you and explain to you everything that she is going to do.
- You may be concerned that the researchers will be testing your HIV status. The research team will not test your blood for HIV. The clinic nurse may test your blood for HIV as part of routine antenatal care. We do ask you permission that we get the result of this test, which is transferred to your study number, thus it is anonymously used further on.
- During the body measurements you will be asked to remove some of your clothes keeping on only light clothing. This might make you feel uncomfortable or shy. To help you feel less shy and uncomfortable, only females will take these measurements. Also, the area where these measurements will be done will be private and closed off. This means that no one else will be able to see you. Only the person that will take the measurements and someone to help her will be with you.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

Yes. Your name will not be recorded on any sheet with your data. Only your participant number will be used. No one will be able to connect you to the answers you give. If you are pregnant, we will collect your contact details in order to contact you to collect your baby's birth data a few days after birth, however this will not be entered into the dataset but kept separate in a file. You

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will be allocated a participant number and you will be referred to in this way in the data, any publications, or other research reporting methods such as conference proceedings.
All research team members will handle documentation with confidentiality by adhering to the conditions reflected in the signed *confidentiality agreement* forms. Your answers may be reviewed by people responsible for making sure that research is done properly, including the fieldworkers, postgraduate assistants and members of the Research Ethics Review Committee. Still, records that identify you will be available only to people working on the study, unless you give permission for other people to see the records.

In the case of the results being published (research reports, journal articles, or conference proceedings), the data will maintain anonymity since individual data are not reported, but rather the average for the whole group.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cabinet at the UNISA Science Campus in Florida. Electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After 5 years, the hard copies will be shredded and discarded, and the electronic copies be deleted.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

You will not receive payment for taking part of the study.

HAS THE STUDY RECEIVED ETHICS APPROVAL?

This study received written approval from the Health Research Ethics Committee of the College of Agriculture and Environmental Sciences, UNISA. A copy of the approval letter can be obtained from the researcher if you wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings or require any further information, please contact Dr Elize Symington on 011 417 3438 or syminea@unisa.ac.za.

Should you have concerns about the way in which the research has been conducted, you may contact the research ethics chairperson of the CAES Health Research Ethics Committee, Prof MA Antwi on 011-670-9391 or antwima@unisa.ac.za if you have any ethical concerns.

Thank you for taking time to read this information sheet and for participating in this study.
Thank you.

Dr Elize Symington

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CONSENT TO PARTICIPATE IN THIS STUDY

I, ___________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the provide the necessary information asked in the questionnaire, as well as the other health measures indicated in the information sheet.

I have received a signed copy of the informed consent agreement.

Participant Name & Surname.. (please print)

Participant Signature..Date.....................

Researcher's Name & Surname...(please print)

Researcher's signature..Date.....................

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Appendix 3: CHAMP Participant Questionnaire & Data Collection Sheet (TP1)

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CHAMP study

Cardiovascular, haemostatic and micronutrient status of pregnant women in urban food environments

Checklist per participant

Participant nr:		
Pregnant?	Y	N

√		Fieldworker	Comments
Time point 1 at healthcare clinic			
	DATE:		
	Informed Consent Form signed		
	Questionnaire 1 **Section A: Socio-demographic data**		
	Questionnaire 1 **Section B: Medical history**		
	Questionnaire 1 **Section C: Diet history**		
	Questionnaire 1 **Section D: REAP-S**		
	Questionnaire 1 **Section E: Anthropometry**		
	Questionnaire 1 **Section F: Blood pressure**		
	Questionnaire 1 **Section G: CV measurements**		
	Questionnaire 1 **Section H: Blood samples**		
	Gift provided		
	Cash receipt signed		
Time point 2 birth data – ONLY FOR PREGNANT PARTICIPANTS			
	Date Phoned to make appointment:		
	Date for appointment:		
	Questionnaire 2		

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CHAMP study

Cardiovascular, haemostatic and micronutrient status of pregnant women in urban food environments

Participant Questionnaire & Data Collection Sheet (TP1)

Y = Yes
N = No
NA = Not assessed

Participant nr: | | | | **Date:** | 2 | 0 | Y | Y | M | M | D | D | **Fieldworker:** ____________

Hospital card nr: | | | | | | | | |

SECTION A: SOCIO-DEMOGRAPHIC DATA

1. Residential address								
2. Date of birth	Y	Y	Y	Y	M	M	D	D

3. Population group			1	2	3	4	5
			Black	Coloured	Indian	White	Other. Specify:
4. Home language			1	2	3	4	5
			English	Xhosa	Zulu	Sotho	Other. Specify:
5. In which country were you born?	1	2	3	4	5	6	7
	South Africa	Zimbabwe	Lesotho	Swaziland	Botswana	Namibia	Other. Specify:
6. What is your highest formal educational level completed?			1	2	3	4	5
			None	Primary	Std 6-9/ Gr 8-11	Std 10/ Gr 12	Post-school Education
7. What is your marital status?		1	2	3	4	5	6
		Single	Married (civil or traditional)	Divorced/ separated	Widowed	Living together	Other. Specify:

Participant nr: | | | |

8. What is your employment status?

1	2	3	4	5
Unemployed	Self-Employed	Part time Employed	Full-time Employed	Other. Specify:

9. How many people live in your household most days of the week (including children and elderly)?

10. Do any members of the household receive any grants?

1	2	3	4	5	6
None	Child support	Social relief	Disability	Old age pension	Other. Specify

11. To determine your living standards measure, please indicate which of the following you currently have in your household:

		Metropolitan dweller (250 000+)	Y	N	DVD Player / Blu Ray Player
		~~Living in a non-urban area~~	Y	N	Refrigerator or combined fridge/freezer
Y	N	House / Cluster House / Town House	Y	N	Electric Stove
Y	N	Tap water in house / on plot	Y	N	Microwave oven
Y	N	Flush Toilet inside house	Y	N	Deep Freezer - Free Standing
Y	N	Hot running water	Y	N	Washing machine
Y	N	Built in Kitchen Sink	Y	N	Tumble dryer
Y	N	No Domestic Workers or Gardeners	Y	N	Dishwashing Machine
Y	N	Home security service	Y	N	PayTV (M-net / DSTV / TopTV) Subscription
Y	N	3 or more working Cell phones in Household	Y	N	Home Theatre System
Y	N	Zero to One Radio set in Household	Y	N	Vacuum Cleaner
Y	N	Air conditioner (excl. fans)	Y	N	Motor Vehicle
Y	N	Have TV set(s)	Y	N	Computer - Desktop / Laptop
Y	N	Swimming Pool	Y	N	Land line (excl. Cellphone)
Y	N	HiFi/Music centre			

Participant nr: ☐☐☐

SECTION B: MEDICAL HISTORY

Questions based on clinic checklist according to the National Department of Health, *Guidelines for Maternity Care in South Africa*, 2015.

Confirmation of general information from Maternity Case Record/Clinic card	
12. Are you pregnant?	☐ Yes ☐ No If yes, what was first day of your last normal menstrual period (LNMP): 2 0 Y Y M M D D Was a sonar conducted? ☐ Yes ☐ No Data of sonar: 2 0 Y Y M M D D If yes, what is the gestational age from sonar? _____ wks/_____ days If yes, wat is the estimated date of delivery (EDD)? Date: 2 0 Y Y M M D D -- If no, are you using any form of contraception? ☐ Yes ☐ No If you are using contraception, what are you using? ☐ Implant ☐ Injection ☐ Intra-uterine device ☐ Tubal Ligation ☐ Oral ☐ Other Provide names of contraception, if available: ……………………………………………………
13. Are you using any medication?	☐ Yes ☐ No
If YES, please specify:	Name of medication (and obtain from Maternity Case Record): …………………………………………………… ……………………………………………………
14. Have you used any traditional medicine in the **past month**?	☐ Yes ☐ No
If YES, please specify what and what it is used for:	…………………………………………………… ……………………………………………………
15. Have you smoked or used snuff in the past week?	☐ Yes ☐ No
16. Did you smoke or use snuff in the past year?	☐ Yes ☐ No
17. RVD test date: ____/_____/ 2 0 2 _ **Obtain from file** (most recent test)	☐ Reactive (Tested HIV positive) ☐ Non-reactive (Tested HIV negative) ☐ Test declined
18. CD4: ______________________ **Obtain from file**	Therapy: ☐ TEE: tenofovir disoproxil fumarateemtricitabine-efavirenz ☐ TLD: Tenofovir (TDF) + Lamivudine (3TC) + Dolutegravir (DTG) ☐ Other: ________________ *(Also ask HIV neg cases – possible preventative treatment)* For pregnant women only: time of initiation of therapy: ☐ Before pregnancy ☐ During pregnancy

Participant nr: | | | |

19. Blood pressure (mm Hg) **from medical file (first reading)**	________/________ mmHg Date when BP was taken: ____/_____/ 2 0 2 _
20. Antihypertensive treatment **Obtain from file**	☐ Yes ☐ No
21. Proteinuria **Obtain from file**	☐ Yes ☐ No

If yes, type of treatment	**Yes**
Magnesium sulphate	
Aldomet	
Monohydralazine	
Nifedipine	
Dihydralazine (nepresol)	
Labetalol	
Aspirin	

History:	
22. Have you ever been pregnant before (exclude current pregnancy)?	☐ Yes ☐ No
If no, skip to question 30 (General Medical)	
23. Previous stillbirth or neonatal loss? (28 days after birth)	☐ Yes ☐ No
24. History of 3 or more consecutive spontaneous abortions? (miscarriage)	☐ Yes ☐ No
25. History of baby abnormality in previous pregnancy?	☐ Yes ☐ No
26. Last pregnancy: did you have high blood pressure?	☐ Yes ☐ No
27. Previous surgery on reproductive tract (including caesarean section)?	☐ Yes ☐ No

Obstetric & Neonatal history: *(A= alive; ID= infant death; NND= neonatal death; IUD= Intra-uterine death)*

28. How many times have you been pregnant before (excluding current pregnancy)? ....

29. How many times have you given birth to a live baby? ....

General medical: Have you ever been diagnosed with the following?	
30. Diabetes mellitus	☐ Yes ☐ No
31. Hypertension (high blood pressure)	☐ Yes ☐ No
32. Cardiac disease	☐ Yes ☐ No
33. Kidney disease	☐ Yes ☐ No
34. Epilepsy	☐ Yes ☐ No
35. Asthmatic (using medication)	☐ Yes ☐ No
36. Tuberculosis (TB)	☐ Yes ☐ No
37. Thyroid problems	☐ Yes ☐ No
38. Liver disease	☐ Yes ☐ No
39. Cancer	☐ Yes ☐ No
40. Genetic disease, e.g. Sickle cell disease, Hemochromatosis, Thalassaemia	☐ Yes ☐ No
41. Known "substance" use (including heavy alcohol drinking)	☐ Yes ☐ No
42. Any other severe medical disease or condition. Specify:	☐ Yes ☐ No

Participant nr: | | | |

SECTION C: DIET HISTORY

43. What day was yesterday?

Monday	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*	*Sunday*

44. Would you describe the food that you ate yesterday as typical of your usual food intake?

Yes	1	No	0

45. On a scale of 0 to 9, how thirsty are you now? 0 = not thirsty at all to 9 = very, very thirsty

0	1	2	3	4	5	6	7	8	9

46. Have you in the past month eaten non-food items, such as soil or charcoal?

Yes	1	No	0

If yes, what do you consume? (tick all that apply)

		How often?
Soil	1	_____ /day or _____ /week or _____ /month
Charcoal	2	_____ /day or _____ /week or _____ /month
Plastic	3	_____ /day or _____ /week or _____ /month
Grass	4	_____ /day or _____ /week or _____ /month
Clay	5	_____ /day or _____ /week or _____ /month
Ice	6	_____ /day or _____ /week or _____ /month
Other: __________________	7	_____ /day or _____ /week or _____ /month

47. Did you receive any vitamins or minerals at the clinic?

Yes	No

Participant nr: | | | |

Do you use any of the following?

	Name of product (Brand)* Type?	Quantity of capsules/ pills at a time?	How many times/week	When did you start taking these?
48. Vitamins and/or minerals from the **shop**				
49. Vitamins and/or minerals from **clinic**				
50. Other: Specify				

If none of the above, skip to question 52.

51. When do you usually take the supplement?

Just before a meal	During a meal	Just after a meal	In between meals

52. If you are not using the supplements from the clinic, please tell me why not?

____

24 Hour Recall

Now I want to find out about everything you ate or drank yesterday. Please tell me everything you ate from the time you woke up yesterday up to the time you woke up this morning. I will also ask you what time you ate the food, where you were at the time and how the food was prepared. We will then just check if we did not forget anything.

After you woke up yesterday, tell me everything you ate from that time please.

Time	Place	Description of food and preparation method	Code (office)

Participant nr: | | |

Time	Place	Description of food and preparation method	Code (office)

Did you taste any foods during preparation?
Did you snack on anything during the day?

Participant nr: | | | |

SECTION D: REAP-S (Rapid Eating Assessment for Participants – Shortened Version)

CJ Segal-Isaacson, EdD RD, Judy Wylie-Rosett, EdD RD, Kim Gans, PhD, MP

In the average week, how many times a week do you:	Usually/ Often 5-7x/week	Sometimes 2-4x/week	Rarely/ Never 0-1x/week
Office use	1	2	3
1. Skip breakfast?	○	○	○
2. Eat 4 or more meals from sit down restaurants or take away outlets?	○	○	○
Office use	3	2	1
3. Eat 2 or more servings of whole grain products or high fibre starches a day? *Serving = 1 slice 100% whole grain bread; 1 cup whole grain cereal (like oatmeal, Future Life, All bran flakes, Weetbix, high fibre cereals); 3-4 whole grain crackers; ½ cup brown rice or whole wheat pasta or barley or wheat; boiled or baked potatoes (with skin).*	○	○	○
4. Eat 2 or more fruit a day? *Serving = ½ cup or 1 med. fruit or ¾ cup 100% fruit juice.*	○	○	○
5. Eat 2 or more servings of vegetables a day? *Serving = ½ cup vegetables or 1 cup leafy raw vegetables.*	○	○	○
6. Eat or drink 2 or more servings of milk, yoghurt or cheese a day? *Serving = 1 cup milk or yoghurt; 40-60g cheese (1 to 2 matchbox size).*	○	○	○
Office use	1	2	3
7. Eat 3 or more portions of meat, chicken, or fish a day? *One portion = 90g. 90g meat is the size of a deck of cards or ONE of the following: 1 regular hamburger, 1 chicken breast or leg (thigh or drumstick) or 1 pork chop or 3 eggs.*	○	○	○
8. Use regular processed meats instead of low-fat processed meats? *Regular: salami, patties, boerewors, polony, hotdogs, sausages, vienna, frankfurter, Russians, fish fingers, nuggets, canned meat, bacon, biltong, dried wors* *Low-fat: like roast beef, lean ham, low-fat cold cuts*	○	○	○
9. Eat fried foods such as fried chicken, fried fish, French fries (slap chips), vetkoek, samosas or kota	○	○	○
10. Eat regular potato chips (crisps), nacho chips, corn chips, crackers, salted popcorn, nuts or puffs instead of pretzels, low-fat chips, low-fat crackers or air-popped popcorn?	○	○	○
11. Add butter, margarine or oil to bread, potatoes, rice or vegetables?	○	○	○
12. Eat sweets 2 or more times a day? Like cake, cookies, pastries, donuts, muffins, chocolates, scones, biscuits, jam, syrup, condensed milk, frozen treats, custard, jelly and pudding.	○	○	○
13. Drink 440ml or more of regular soft drinks, fruit drink/punch instead of low sugar drinks a day? *Note: 1 can of soft drink = 330ml; buddy = 440ml*	○	○	○

	YES	NO
14. Do you or a family member usually shop for and prepare your own meals rather than eating from sit down restaurants or take away outlets?	○	○
15. Do you usually feel well enough to shop for and prepare your own meals?	○	○

16. On a scale of 1 to 5, how willing are you to make changes in your eating habits in order to be healthier?	1 Not willing	2	3	4	5 Very willing

Participant nr: | | | |

SECTION E: ANTHROPOMETRICAL MEASUREMENTS

FIELDWORKER:	
WEIGHT (kg)	
Recall: pre-pregnancy body weight	_ _ _ . _ _
1st Measurement	_ _ _ . _ _
2nd Measurement	_ _ _ . _ _
3rd *(if needed)*	_ _ _ . _ _
HEIGHT (cm)	
1st measurement	_ _ _ . _ _
2nd measurement	_ _ _ . _ _
3rd *(if needed)**	_ _ _ . _ _

*If difference between 1st and 2nd measurement is more than 2cm, take the 3rd measurement.

MUAC (cm)	
1st Measurement	_ _ . _
2nd Measurement	_ _ . _
3rd *(if needed)#*	_ _ . _

#If difference between 1st and 2nd measurement is more than 1cm, take the 3rd measurement.

WAIST (cm)	*Only non-pregnant women*
1st measurement	_ _ _ . _ _
2nd measurement	_ _ _ . _ _
3rd *(if needed)**	_ _ _ . _ _

*If difference between 1st and 2nd measurement is more than 1cm, take the 3rd measurement.

Participant nr: | | | |

SECTION F: BLOOD PRESSURE

FIELDWORKER:		
Blood pressure	**SBP/DBP**	**HR**
1st Measurement	/	
2nd Measurement	/	
3rd Measurement	/	

Participant nr: | | | |

SECTION G: SPHYGMOCOR MEASUREMENTS

FIELDWORKER:		
Aortic Pressures (Pulse Wave Analysis)	1st Measurement	2nd Measurement
SP		
DP		
PP		
MAP		
AP		
HR		
AIx		
AIx 75		
Brachial Pressures		
SP		
DP		
PPP		
MP		
Central Haemodynamic		
ED (ms)		
ESP (mmHg)		
A T2 (ms)		
Pulse Wave Velocity Assessment		
HR		
PWV (m/s)		
transit time (ms)		
PWV distance (mm)		
Biological age		

Participant nr: | | | |

SECTION H: BLOOD SAMPLES

Fieldworker/Nurse: ____________________

Time of blood sample collection: ________________

Blood sample: *Nr of EDTA tubes (purple)*	
Blood sample: *Nr of serum tubes (yellow)*	
Blood sample: *Nr of heparin tubes (green)*	

Finger prick result on Hb (obtain from medical record): ________________

Appendix 4: Definition of mRFEI Search Terms

Grocery Store Search terms

No.	Search term	Definition
1	Grocery store	A grocery store, grocery shop or simply grocery is a store that primarily retails a general range of food products, which may be fresh or packaged.
2	Grocery shop	A grocery store, grocery shop or simply grocery is a store that primarily retails a general range of food products, which may be fresh or packaged.
3	Convenience store	A convenience store, convenience shop, corner store or corner shop is a small retail business that stocks a range of everyday items such as coffee, groceries, snack foods, confectionery, soft drinks, ice creams, tobacco products, lottery tickets, over-the-counter drugs, toiletries, newspapers and magazines.
4	Convenience shop	A convenience store, convenience shop, corner store or corner shop is a small retail business that stocks a range of everyday items such as coffee, groceries, snack foods, confectionery, soft drinks, ice creams, tobacco products, lottery tickets, over-the-counter drugs, toiletries, newspapers and magazines.
5	Retail food store	Retail food is all food, other than restaurant food, which is purchased by consumers and consumed off-premises.
6	Retail food shop	Retail food is all food, other than restaurant food, which is purchased by consumers and consumed off-premises.
7	Hypermarket	A hypermarket is a big-box store combining a supermarket and a department store. The result is an expansive retail facility carrying a wide range of products under one roof, including full grocery lines and general merchandise
8	Supermarket	A supermarket is a self-service shop offering a wide variety of food, beverages and household products, organized into sections. This kind of store is larger and has a wider selection than earlier grocery stores but is smaller and more limited in the range of merchandise than a hypermarket or big-box market.
9	Minimarket	A store that sells food and sometimes other goods but is not as big as a supermarket.
10	Food mart	A marketplace where groceries are sold.
11	Food store	A store selling primarily food at retail, which store is not primarily engaged in the sale of food for consumption on the premises.
12	Food shop	A store selling primarily food at retail, which store is not primarily engaged in the sale of food for consumption on the premises.
13	Super food store	An extremely large shop that sells food and/or other goods usually for use in the home.
14	Chain food store	A chain store or retail chain is a retail outlet in which several locations share a brand, central management and standardised business practices.
15	Greengrocer	A greengrocer is a person who owns or operates a shop selling primarily fruit and vegetables.

Fast food outlet Search terms

No.	Search term	Definition
1	Fast food outlet	A fast-food restaurant, also known as a quick-service restaurant within the industry, is a specific type of restaurant that serves fast-food cuisine and has minimal table service.
2	Fast food shop	A fast-food restaurant, also known as a quick-service restaurant within the industry, is a specific type of restaurant that serves fast-food cuisine and has minimal table service.
3	Fast food store	A fast-food restaurant, also known as a quick-service restaurant within the industry, is a specific type of restaurant that serves fast-food cuisine and has minimal table service.
4	Self-service restaurant	The serving of oneself (as in a restaurant or gas station) with goods or services to be paid for at a cashier's desk or by using a coin-operated mechanism or a credit or debit card.
5	Quick-service restaurant	A fast-food restaurant, also known as a quick-service restaurant within the industry, is a specific type of restaurant that serves fast-food cuisine and has minimal table service.
6	Take-away food store	Takeaway food shop means premises where the primary function is the sale of solid food that is ready for immediate consumption with the intention that the food will be consumed elsewhere than in those premises
7	Take-out food store	Takeaway food shop means premises where the primary function is the sale of solid food that is ready for immediate consumption with the intention that the food will be consumed elsewhere than in those premises
8	Drive-in restaurant	A drive-in is a facility where one can drive in with an automobile for service. At a drive-in restaurant, for example, customers park their vehicles and are usually served by staff who walk or roller-skate out to take orders and return with food, encouraging diners to remain parked while they eat.
9	Drive-thru restaurant	A drive-in is a facility where one can drive in with an automobile for service. At a drive-in restaurant, for example, customers park their vehicles and are usually served by staff who walk or roller-skate out to take orders and return with food, encouraging diners to remain parked while they eat.
10	Food truck	A food truck is a large, motorized vehicle or trailer, equipped to cook, prepare, serve, and/or sell food.
11	Quick-lunch counter	A lunch counter is an informal café or a counter in a shop where people can buy and eat meals.
12	Cafeteria	A restaurant in which customers serve themselves from a counter and pay before eating.

Appendix 5: Student Ethics Certificate

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UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 07/03/2023

NHREC Registration # : REC-170616-051
REC Reference # : 2022/CAES_HREC/046
Name : Ms K Naidoo
Student #: 67891055

Dear Ms Naidoo

Decision: Ethics Approval Confirmation after First Review from 10/02/2022 to 31/01/2025

Researcher(s): Ms K Naidoo
67891055@mylife.unisa.ac.za; 083-393-7339

Supervisor (s): Dr B Van der Westhuizen
vdwesb1@unisa.ac.za; 011-471-3710

Dr EA Symington
syminea@unisa.ac.za; 011-471-3438

Working title of research:

Investigating and mapping out the urban food environment and diet quality of women of child-bearing age within the city of Johannesburg, South Africa

Qualification: M Consumer Science

Thank you for the submission of your yearly progress report to the Unisa-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is confirmed to continue for the originally approved period, subject to submission of yearly progress reports. **Failure to submit the progress report will lead to withdrawal of the ethics clearance until the report has been submitted.**

Furthermore, the following amendment is approved:

1. Inclusion of pregnant women in the sample.

The researcher is cautioned to adhere to the Unisa protocols for research during Covid-19.

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Due date for next progress report: 28 February 2024

The progress report form can be downloaded from the college ethics webpage: https://www.unisa.ac.za/sites/corporate/default/Colleges/Agriculture-&-Environmental-Sciences/Research/Research-Ethics

*The **low risk application** was originally **reviewed** by the UNISA-CAES Health Research Ethics Committee on 10 February 2022 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.
3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing, accompanied by a progress report.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data require additional ethics clearance.
8. No field work activities may continue after the expiry date. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

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Note:
*The reference number **2022/CAES_HREC/046** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Yours sincerely,

Prof MA Antwi
Chair of UNISA-CAES Health REC
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