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Chronic non-communicable diseases in a black South African population living in a low-resource community

Susanna S Pretorius

A thesis submitted to the Faculty of Health Sciences,

University of the Witwatersrand, Johannesburg

in fulfilment of the requirements for the degree of

Doctor of Philosophy

Johannesburg 2016

DECLARATION

I, Susanna Salomina Pretorius declare that this thesis is my own work. It is being submitted for the degree of Doctor of Philosophy in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree of examination at this or any other university.



Susanna Salomina Pretorius Date: 17 November 2016

I certify that the studies contained in this thesis have the approval of the Human Research Ethics Committee of the University of the Witwatersrand, Johannesburg.

Human Research Ethics Committee protocol number: M080440



Susanna Salomina Pretorius Date: 17 November 2016

DEDICATION

This thesis is dedicated to all the people who never stop believing in me;

To my parents and family, thank you for your guidance, endless support and unconditional love. It motivated me through difficult times, and especially my son Hannes, thank you for your independent, positive spirit, unconditional love and support and for affording me the time to complete this thesis.

But, most of all, I am grateful to God for all his blessings, for watching over me and guiding me along the best pathways for my life always.

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PUBLICATIONS AND PRESENTATIONS

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CHAPTER 3

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Pretorius S, Stewart S, Carrington MJ, Lamont K, Sliwa K, Crowther NJ. Is there an association between sleeping patterns and other environmental factors with obesity and blood pressure in an urban African population? **PLOS One 2015; 10(10): e0131081. DOI: 10.1371/journal.pone.1031081**

CHAPTER 4

Stewart S, Mocumbi AO, Carrington MJ, **Pretorius S**, Burton R, Sliwa K. A not-so-rare form of heart failure in urban black Africans: pathways to right heart failure in the Heart of Soweto Study cohort. **Eur J Heart Fail. 2011: 13:1070-7**

Pretorius S, Sliwa K, Ruf V, Walker KZ, Stewart S. Feeding the emergence of advanced heart disease in Soweto: A nutritional survey of black African patients with heart failure. **Cardiovasc J Afr 2012; 23 (5): 245 – 251**

Pretorius S, Sliwa K. Perspectives and perceptions on the consumption of a healthy diet in Soweto, an urban African community, in South Africa. **SAHeart, 2011; 8 (2): 104-113**

CHAPTER 6

Stewart S, Carrington M, **Pretorius S**, Ogah OS, Blauwet L, Antras-Ferry J, Sliwa K. Elevated risk factors but low burden of heart disease in urban African primary care patients: A fundamental role for primary prevention. **Int J Cardiol 2012; 158(2): 205 – 210**

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Pretorius S, Stewart S, Ruf V, Walker K, Sliwa K. Food choices and their nutritional value in black African patients with heart failure: How affordable is a healthy diet?

Heart Failure 2009 congress, Nice, France. May 2009.

Sandra Pretorius, Simon Stewart, Karen Walker, Nigel Crowther, Tracy Snyman, Karen Sliwa**.**
Vitamin C but not thiamine deficiency in black African patients with heart failure in South Africa: Identifying the need for nutritional intervention in the urban African setting.

SA Heart Congress 2009. Sun City.

Sandra Pretorius, Simon Stewart, Karen Walker, Nigel Crowther, Tracy Snyman, Karen Sliwa**.**
Data from the Heart Failure Management Project at Chris Hani Baragwanath Hospital.

European Heart Congress 2009. Barcelona.

Sandra Pretorius, Simon Stewart, Karen Walker, Nigel Crowther, Tracy Snyman, Karen Sliwa.
Vitamin C but not thiamine deficiency in black African patients with heart failure in South Africa: Identifying the need for nutritional intervention in the urban African setting**.**

Nutrition Congress 2010. Durban

Sandra Pretorius, Simon Stewart, Karen Walker, Nigel Crowther, Tracy Snyman, Karen Sliwa.
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PASCAR, Dakar, 16-20 May 2013.

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STATEMENT OF CONTRIBUTION TO DATA COLLECTION AND ANALYSIS

I declare that I designed and collected all data for the descriptive studies as presented in chapters 3.2, 4.3 and 5, and the review paper as presented in chapter 7. I was part of the Soweto Cardiovascular Research Unit and a team of researchers (Prof Karen Sliwa, Prof Simon Stewart, Dr Melinda Carrington, Dr Kim Lamont) responsible for the collection and management of all data from the Heart of Soweto (HOS) study as presented in chapters 3.1, 4.2 and 6.2. I performed data analysis with the assistance of Prof Simon Stewart and Prof Nigel Crowther. I wrote the manuscripts for the first-author publications and had a major input as a member of the writing team into the co-authored publications emanating from my research. I wrote all the nutritional educational material, dietary guidelines and the culturally adapted recipes for the 'Living with heart failure in Soweto' booklet.

ABSTRACT

Introduction: The African continent, particularly sub-Saharan Africa, is facing a high burden of disease from the human immunodeficiency virus (HIV) pandemic and nutritional deficiencies, while at the same time, facing ever increasing rates of cardiovascular diseases (CVDs). The mortality rates from CVD are almost equal to the death rates from communicable diseases. In Sub-Saharan countries CVD prevention and management faces many barriers. One such difficulty is the shortage of data for the descriptive epidemiology of CVD risk factors. In an attempt to address this shortage of data, we established the Heart of Soweto (HOS) study in one of the largest African urban communities in South Africa. The purpose of this study was to identify and describe some of the factors contributing to the emergence of chronic diseases of lifestyle, such as heart disease, high blood pressure, diabetes and obesity in a black urban African population, within the framework of the HOS study. We also investigated the impact of a dietary intervention on cardiac function in subjects with chronic heart failure (CHF) in this black urban cohort.

Methods: Data was collected as part of the "Heart of Soweto" (HOS) study, which was a prospectively designed registry that recorded data relating to the presentation, investigation and treatment of patients with newly diagnosed cardiovascular disease presenting to Chris Hani Baragwanath Hospital (CHBH), Soweto in 2006. Data collected included socio-demographic profile and all major cardiovascular diagnoses. Heart disease was defined as non-communicable (ND) e.g. coronary artery disease or communicable (CD) e.g. rheumatic heart disease. A survey was also conducted on consecutive patients attending two pre-selected primary care clinics in Soweto (644 and 667 patients from the Mandela Sisulu and Michael Maponya clinics, respectively). Data collected included, ethnicity, duration of residence in Soweto, highest level of education and employment status. Clinical data collected included prior or current diagnoses of diabetes and hypertension and pharmacological therapy related to the treatment of hypertension, as well as smoking status and exposure to second-hand smoking. Weight, height, and waist and hip circumference were measured. Questions were asked regarding the duration of night-time sleep and napping during the day. Descriptive studies were undertaken at the Heart Failure Clinic at CHBH, Soweto to firstly describe the food choices and macro-and micronutrients intake of 50 consecutive patients presenting with heart failure using an interviewer-administered quantitative food frequency questionnaire (QFFQ). Food data were translated into nutrient data using the Medical Research Council (MRC) Food Finder 3, 2007, which is based on South African food composition tables. Secondly we performed a randomized controlled study of a multidisciplinary, community-based, chronic HF management program in Soweto, compared with usual care, at CHBH Heart Failure Clinic located at the Soweto Cardiovascular Research Unit (SOCRU), or at the General Cardiac

Clinic (standard care) in Soweto. In this study 49 consenting, eligible patients were individually randomized on a 1:1 basis to either usual care or to the study intervention and cardiac function was measured before and after the intervention.

Results: Data collected at Chris Hani Baragwanath hospital (CHBH) cardiology clinic from 5328 suspected cases of heart disease, demonstrated that the most prevalent form of heart disease was hypertensive heart failure (22.0%). It was found that those participants who presented with ND (35.0%) were older and had higher BMI and mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) than those with CD (39.0%; all comparisons $p<0.001$). Within this cohort of 5328 de novo cases of heart disease, 2505 (47%) were diagnosed with HF, of which 697 (28%) were diagnosed with right heart failure (RHF). There were more women than men diagnosed with RHF (379 vs. 318 cases), and on an adjusted basis, compared with the remainder of the Heart of Soweto cohort (n = 4631), RHF cases were more likely to be African (adjusted OR 2.33, 95% CI 1.59 – 3.41), with a history of smoking (OR 1.72, 95% CI 1.42 – 2.10), a lower body mass index (OR 0.96, 95% CI 0.94 – 0.97 per kg/m^2) and were less likely to have a family history of heart disease (OR 0.79, 95% CI 0.64 – 0.96).

Data collected at 2 primary health care clinics in Soweto from 862 women (mean age 41 ± 16 years and mean BMI 29.9 ± 9.2 kg/m^2) and 449 men (38 ± 14 years and 24.8 ± 8.3 kg/m^2) indicated that in females, former smokers had a higher BMI ($p<0.001$) than current smokers, while exposure to second hand smoking was associated with a lower BMI ($p<0.001$) in both genders. Longer sleep duration in females was associated with a lower BMI ($p=0.01$). Napping during the day for > 30 minutes in males was related to a lower BMI and waist circumference ($\beta=-0.03$, $p<0.05$ for both) and lower systolic ($\beta=-0.02$, $p<0.05$) and diastolic BP ($\beta=-0.02$, $p<0.05$). Longer night time sleep duration was associated with lower diastolic ($\beta=0.004$, $p<0.01$) and systolic BP ($\beta=0.003$, $p<0.05$) in females. Within this same cohort, obesity was more prevalent in females (41.8%) than males (14.1%; $p<0.001$), 16% (n = 205) had an abnormal 12-lead ECG with more men than women showing a major abnormality (24% vs. 11%; OR 2.63, 95% CI 1.89–3.46). Of 99 cases (7.6%) subject to advanced cardiologic assessment, 29 (2.2%) had newly diagnosed heart disease which included hypertensive heart failure (13 women vs. 2 men, OR 4.51 95% CI 1.00–21.2), coronary artery disease (n = 3), valve disease (n = 3), dilated cardiomyopathy (n = 3) and 2 cases of acute myocarditis.

Nutritional deficiencies were observed in a cohort presenting with HF at the cardiology outpatient clinic, CHBH. In women, food choices likely to negatively impact on heart health included added sugar [consumed by 75%: median daily intake (interquartile range) 16 g (10–20)], sweet drinks [54%: 310 ml (85–400)] and salted snacks [61%: 15 g (2–17)]. Corresponding figures for men were added sugar [74%: 15 g (10–15)], sweet drinks [65%: 439 ml (71–670)] and salted snacks [74%: 15 g (4–22)]. The women's intake of calcium, vitamin C and vitamin E was only 66%, 37% and 40% of the age-specific requirement, respectively. For men, equivalent figures were 66%, 87% and 67%, respectively. Mean sodium intake was 2 372 g/day for men and 1 972 g/day for women, 470 and 294% respectively, of daily recommended intakes (DRI). In men, vitamin C intake was 71 ± 90 (79% of DRI). Similarly, in women vitamin C intake was 66 ± 80 (88% of DRI).

Data collected from our HF management programme study supported the deficient intake of vitamin C in African subjects presenting with heart failure. Thus, plasma vitamin C concentrations (normal range 23 – 85 μmol/L) were markedly deficient in both standard care [6.53 (3.80, 9.22) μmol/L] and managed care [3.65 (1.75, 8.23) μmol/L] groups. In terms of clinical presentation, males were significantly older (49.9 ± 10.9 years; $p<0.005$) than females (37.2 ± 12.8) and at follow-up females had a significantly higher ejection fraction (34.8 ± 9.56 %) than males (29.5 ± 8.27; $p<0.05$) and when the groups were combined, the ejection fraction was significantly higher (32.2 ± 9.27; $p<0.05$) at follow-up compared to baseline (29.9 ± 8.80). We found that heart rate was significantly lower at follow-up (89.9 ± 14.6 beats/min) compared to baseline (93.4 ± 17.2; $p<0.05$) only in the managed care group. Furthermore, if diastolic blood pressure increased over the follow-up period, ejection fraction fell by 5.98% ($p=0.009$) in comparison to cases where diastolic blood pressure remained the same or fell. In addition, thiamine levels at baseline correlated negatively with systolic blood pressure ($r=-0.68$, $p=0.04$) at follow-up.

Conclusion: Non-communicable heart disease and other diseases of lifestyle, such as high blood pressure, obesity and diabetes, are drastically increasing in Sub-Saharan Africa in general and in a black urban African community, such as Soweto, specifically. Soweto can clearly be described as a community in epidemiological and nutrition transition and is facing a double or even triple burden of disease. This is a community that is still being burdened by historically prevalent forms of communicable or infectious diseases juxtaposed against people who have lived their whole lives in Soweto and are increasingly suffering from newer or non-communicable diseases of lifestyle. Women seem to be especially burdened by this increase in non-communicable diseases, with a predominance of women suffering from heart disease and obesity. Certain exacerbating risk factors have been identified from the HOS in this community, namely the gender specific effects of sleep, smoking and other environmental factors on BMI and blood pressure, and the adverse effects of

changing dietary patterns particularly the increased consumption of refined and processed foods, high in sugar, salt and fats and insufficient intakes of fruits and vegetables.

Although there are some limitations to our HF management study, it serves as an indication that targeted, culturally sensitive care, adapted to an urban African population, might contribute to improved patient outcomes. However, prevention should always be our first priority through community-based and gender specific screening and the development and implementation of targeted prevention programs.

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LIST OF ABBREVIATIONS

NCD's	:	non-communicable diseases
WHO	:	World Health Organization
CVD	:	cardiovascular disease
HIV	:	human immunodeficiency syndrome
AIDS	:	acquired immunodeficiency syndrome
LMICs	:	low-to-middle-income countries
DALYs	:	disability-adjusted life years
YLLs	:	years of life lost
YLDs	:	years lived with disabilities
GBD	:	global burden of disease
BMI	:	body mass index
SAFBDG	:	South African food based dietary guidelines
HOS	:	Heart of Soweto
CHBH	:	Chris Hani Baragwanath Hospital
CAD	:	coronary artery disease
ACS	:	acute coronary syndrome
HDLS	:	high-density lipoprotein cholesterol
CRP	:	C-reactive protein
NHANES	:	National Health and Nutrition Examination Survey
USA	:	United States of America
HT	:	hypertension
BP	:	blood pressure
CHF	:	chronic heart failure
HF	:	heart failure
UN	:	United Nations
QFFQ	:	quantitative food frequency questionnaire
SOCRU	:	Soweto Cardiovascular Research Unit
ECG	:	echocardiography
MRC	:	Medical Research Council
NYHA	:	New York Heart Association
SBP	:	systolic blood pressure
DBP	:	diastolic blood pressure

NIDDM	:	non-insulin dependent diabetes mellitus
LVEF	:	left ventricular ejection fraction
COPD	:	chronic obstructive pulmonary disease
RHF	:	right heart failure
PAH	:	pulmonary arterial hypertension
TB	:	tuberculosis
HAART	:	highly active antiretroviral therapy
ICD	:	infectious chronic disease
ICCC	:	Innovative Care for Chronic Conditions
CNCICD	:	comorbid non-communicable and infectious chronic disease

TERMINOLOGY

Cardiovascular disease: Cardiovascular disease refers to conditions that involve narrowed or blocked blood vessels that can lead to a heart attack, chest pain (angina) or stroke.

Non-communicable disease: A non-communicable disease (NCD) is a medical condition or disease that is by definition non-infectious and non-transmissible among people.

Chronic diseases of lifestyle: Poor lifestyle choices, such as smoking, overuse of alcohol, poor diet, lack of physical activity and inadequate relief of chronic stress are key contributors in the development and progression of preventable chronic diseases, including obesity, type 2 diabetes mellitus, hypertension and cardiovascular disease.

Heart disease: Heart conditions, such as those that affect the heart's muscle, valves or rhythm, are considered forms of heart disease.

CHAPTER 1

INTRODUCTION

1.1 Background

Non-communicable diseases (NCD's) are classified as being 'non-infectious' and are the end result of being exposed over many years, to adverse lifestyle and environmental factors, such as diets high in saturated fat, sugars and salt, inactivity, increased levels of stress, smoking, as well as exposure to environmental smoke and pollution and too much or too little sleep [1]. It manifests in the long-term as cardiovascular disease, diabetes, cancer and chronic respiratory disease and these four are also often referred to as the principle NCD's because of their high mortality rates and because they are preventable through the modification of four major risk factors, namely; tobacco use, lack of exercise, unhealthy food choices and alcohol abuse [1]. Other NCD's that should also be mentioned as they share the same risk factors are mental disorders, oral disease, eye disease, renal disease and muscular-skeletal conditions [1,2].

The major underlying socio-economic, cultural, political and environmental determinants of NCDs are globalization, urbanisation and an ageing population. It has however, been noted that these diseases are observed in younger age groups in Sub-Saharan Africa than in the developed world, and that it affects people across the economic spectrum [3]. Together with industrialisation, urbanisation and economic growth, there has been a shift in terms of disease patterns globally and more people are currently dying of chronic diseases of lifestyle than before [4,5,6]. In the year 2008, 58% of all deaths reported worldwide were due to chronic diseases and the burden caused by these diseases is ever increasing in low-income and middle-income countries [2]. This shift has become known as 'the epidemiological transition' and outlines the changes seen in disease patterns and population distribution in relation to changes in mortality and morbidity and provides a useful framework to describe these changes due to demographic and socio-economic developments [5,7]. It consisted, up to now, of four phases; the first phase was called the "Age of Pestilence and Famine" during which period, mortality rates were very high due to infectious diseases, with a variable life expectancy and life span. The second phase, became known as the "Age of Receding Pandemics" with a decrease in epidemics and a decline in mortality rates due to an increase in economic posterity. During this phase the people could also expect to live up to 50 years of age instead of 30 years of age and population numbers increased, in the third phase, however an increase in degenerative and human-made diseases were being experienced and therefore became known as the "Age of Degenerative and Man-Made

Diseases" where the causes for morbidity and mortality were mostly from non-communicable diseases, such as heart disease, hypertension and diabetes instead of infectious diseases. Then a fourth phase was entered, characterised by a delay in degenerative diseases [8,9]. The theory of epidemiological transition is useful when trying to understand the relationship between disease patterns and morbidity and mortality levels in a population, but should perhaps not be used to provide a definitive prediction [7].

It is postulated, that a new phase, the fifth phase of the epidemiologic transition, namely an increase in obesity and inactivity has been entered, and that this global increase in obesity is threatening to annihilate the progress made in the treatment of chronic diseases of lifestyle [4]. It has become a well-known fact, widely described in the literature, that obesity levels have reached alarming levels globally. Previously this trend was mostly seen in developed countries, but this is no longer the case as the prevalence of obesity levels in less-developed countries has in some instances started to overtake those seen in developed countries in adults as well as children. Especially alarming, is the overall increase seen in non-communicable diseases in developing countries and its association with obesity [4,10,11]. Thus, the prevalence of obesity amongst children aged 7 to 17 living in urban areas in China is more than 20% and 1 in every 5 adults in China is overweight [4]. Obesity prevalence data from South Africa indicates that up to 60% of women are overweight or obese [12,13,14].

1.2 An evolving epidemic of CVD in low and middle-income countries

According to the World Health Organisation (WHO), the African continent and subsequently sub-Saharan Africa can be expected to experience the largest increase in age-standardised death rates due to cardiovascular disease (CVD), diabetes, respiratory disease and cancer [15]. These countries are facing a double burden of disease as they are still burdened by poverty-related diseases, high injury rates, as well as the human immunodeficiency virus or acquired immunodeficiency syndrome (HIV/AIDS) pandemic and nutritional deficiencies, while at the same time, facing ever increasing rates of chronic diseases of lifestyle, such as CVD, hypertension and diabetes [16,17].

The impact of chronic diseases on mortality and morbidity in low-to middle-income countries (LMICs)b is high, accounting for about 60% of global deaths in these countries, and the burden of

chronic diseases is expected to increase by 27% in Africa and sub-Saharan Africa over the next 10 years [5,18]. It has been observed that in adults, the overall age-standardised death rates from chronic diseases are higher in low-income, developing countries, than in high income countries [19,20].

To help us describe and quantify the extent and impact of the problem and guide us in redressing it, a useful tool to measure the health of populations that combines information on death and non-fatal outcomes, namely 'Disability-adjusted life years' (DALYs) has been developed [21]. It is the sum of, and quantifies both premature mortality, as Years of Life Lost (YLLs) and morbidity, as the Years Lived with Disability (YLDs) within a population. Thus, DALY = YLL + YLD (GBD 2010). Health intervention programs should therefore be aimed at reducing the number of DALY's in a population through the promotion of a healthier and longer life for everyone.

It was reported by the Global Burden of Disease Study of 2010 (GBD 2010) that in South Africa, the three major causes of DALYs were HIV/AIDS, diarrheal diseases and interpersonal violence, and the three major risk factors that contribute to disease burden in South Africa, are alcohol use, increased body mass index (BMI) and increased blood pressure [22]. Adding to this is the fact that in South Africa CVD poses a major public health problem across all population groups and according to Vorster et al (2007), in 2000 it contributed 23, 41, 31 and 52 % respectively to the total age-standardised death rates in the African, white, coloured and Indian population groups [23].

A growing concern is the fact that in developing countries, such as in South Africa, CVD is occurring in younger individuals than in the developed countries and as the epidemic advances, the poor is affected the most in both developed and developing countries and especially the communities with low socio-economic status living in urban areas [13,24,25].

Although the burden of diseases affecting the cardiovascular system (CVD), such as heart disease, is stabilizing in high-income countries, in LMIC such as South Africa, it continues to rise [26]. With scarce health-care resources, LMIC are typically ill-equipped to cope with these new health challenges; particularly when already over-burdened by illness related to malnourishment and infection (such as HIV-AIDS) [26,27]. There is little scope to tackle new forms of heart disease arising from changing risk behaviours due to profound social and economic changes (so-called

"epidemiological transition"). Contemporary studies demonstrate high levels of non-infectious causes of heart disease in Sub-Saharan Africa particularly in urban communities like Soweto [13,26]. Data from the HOS reported low levels of coronary artery disease (CAD), with HIV-related cardiomyopathy and pericardial disease being the most common diagnosis in HIV- positive cases with the potential therefore to curtail at least one of the devastating consequences of HIV-AIDS [26].

Chronic diseases of lifestyle can be prevented and managed to a large extent. However, the prevention and eradication of chronic diseases requires a multi-sector approach, which should involve a broad range of government sectors, industry, as well as international organisations. Even though some public health and clinical interventions have been formulated, the development, implementation and action plans consistent with WHO recommendations, are slow in many developing countries including South Africa [28].

1.3 The Heart of Soweto Study – why it exists

It can therefore be said, that the contemporary balance between historically prevalent and emerging forms of chronic disease, and heart disease, in Sub-Saharan Africa has shifted [26] and will have a profound impact on future generation, as reflected in the sharp increase of non-communicable disease vs. communicable/infectious disease states, with more cases of "lifestyle"-related heart disease due to high blood pressure, smoking, obesity and poor dietary patterns emerging than ever before [29]. Elevated blood pressure is particularly deadly given that it remains a largely silent condition that results in often irreversible and deadly heart failure and stroke [30].

The causes and devastating effects of an epidemic of chronic diseases of lifestyle have been well documented in developed countries. However, little data is available from developing countries, such as South Africa, on the added negative impact of chronic diseases of lifestyle together with malnourishment and infectious diseases. This is especially true for vulnerable populations, like black South Africans, in whom risk factors were seldom found and who were consequently not targeted for health promotion and prevention strategies.

Poverty and high levels of household food insecurity can be the greatest barriers for the majority of people (especially those in rural and urban informal areas) to the application of many of the Food Based Dietary Guidelines (FBDGs). The 1999 South African National Food Consumption Survey indicated that where household income was less than R12,000 per annum, few foods were found in the house (maize, salt, white sugar, tea, fat/oils, white rice and white bread were most common) and micronutrient intakes were frequently low [31]. The relationship between a household's food security status and its purchasing power is far from static; it changes over time. All other factors remaining constant, changes in income alter the quantity and quality of foods purchased and consumed. Therefore, food choices should be evaluated in the context of total lifestyle and living circumstances. In South Africa, socio-economic circumstances have a major influence on food choices and dietary patterns [29].

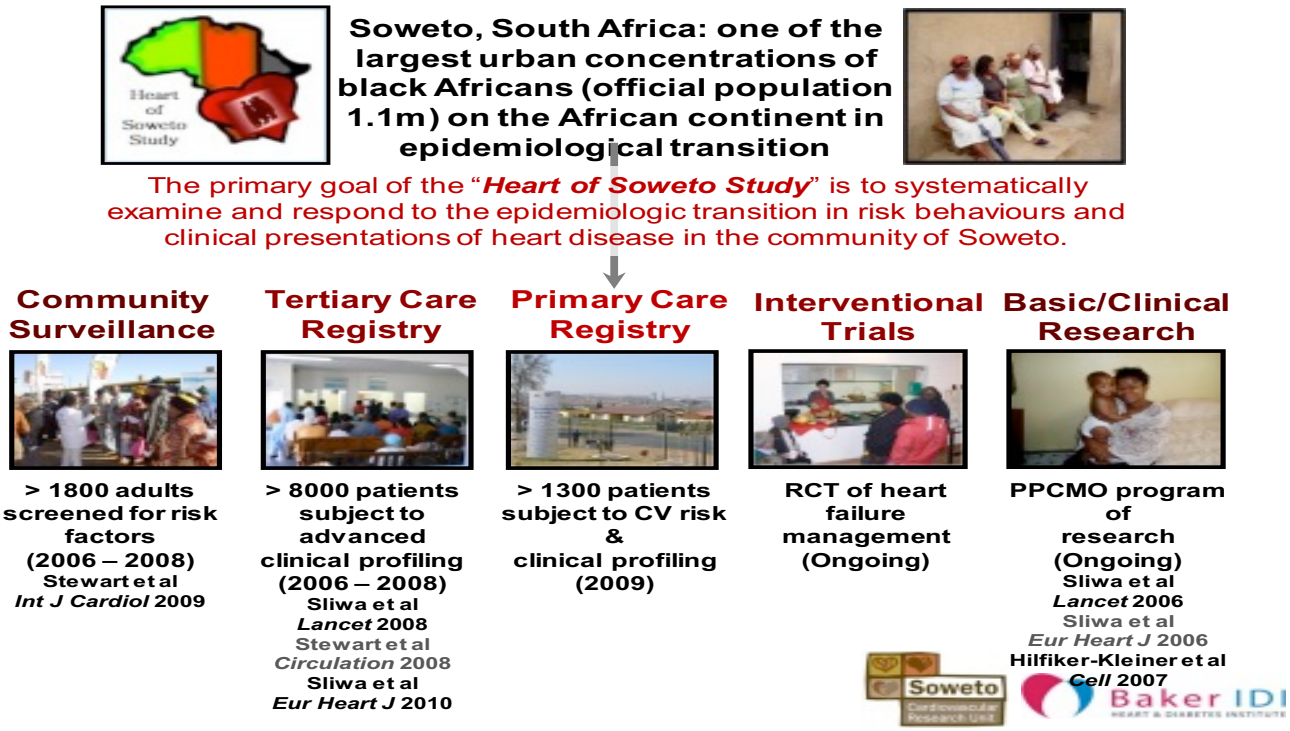
In Sub-Saharan countries CVD prevention and management faces many barriers. Such difficulties include a shortage of data for the descriptive epidemiology of risk factors and case presentation, inadequate or poor infrastructure, shortage of health care providers, weak capacity for policy development, limited public knowledge of risk factors, non-compliance to long-term therapy, poor drug procurement policies as well as ineffective resource.

To try and address this shortage of data, the Heart of Soweto study (HOS) was established in one of the largest African urban communities in South Africa.

1.3.1 The Heart of Soweto Study

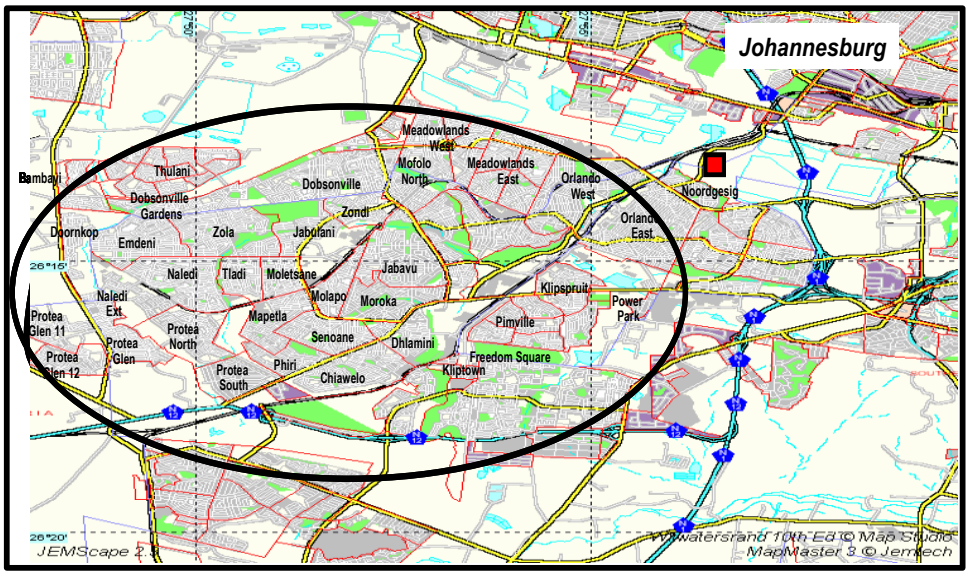
The principle aim of the HOS was to describe, monitor and act on the emerging burden of CVD and heart disease in urban African communities by investigating the full clinical spectrum of cardiovascular related disorders, especially heart disease and other chronic diseases of lifestyle, such as high blood pressure and diabetes mellitus in patients attending the outpatient cardiology clinic at Chris Hani Baragwaneth hospital (CHBH), a tertiary-care centre, as well as the broader community of Soweto (see figure 1.1) [13].

Figure 1.1: The Heart of Soweto Study: A schematic depiction [13]



As shown in figure 1.2, Soweto is a densely populated urban area of the city of Johannesburg in Gauteng, South Africa bordering the city's mining belt. Soweto is derived as the abbreviation: South Western Townships. Soweto possesses a catchment area of 1.1 million people with 12 primary health care clinics and one major hospital at the time of the study [11]. It is an area demarcated by high levels of rural migration, informal settlements and poverty, as well as modern shopping centres and luxurious houses, therefore a population ideally suited for the study of the emergence, progression and effects of the epidemiological transition theory [11].

Figure 1.2 Soweto [11]



Foundational research from the HOS, as well as health awareness and screening programs suggest that "epidemiological transition" has indeed broadened the spectrum of advanced forms of heart disease in one of Africa's largest urban concentrations of Africans [13,32]. Health awareness and screening days were performed in Soweto, from 2006 – 2007, and consisted of a self-reported medical history, clinical assessment, measurement of tobacco consumption and sleep duration, as well as the assessment of BMI, blood pressure and random blood glucose and total cholesterol levels. Data from the screening days reported a high prevalence of related risk for CVD in this population group [14]. According to Stewart et al, 2008, poor socio-economic circumstances and an increase in non-communicable heart disease pose a major threat in a low-resource community like Soweto, especially in younger individuals and women [32].

Following on from the highly successful screening and awareness days in the Soweto community and after having examined participants in a tertiary care hospital outpatient clinic, we came to realise just how important the role of the primary health care clinics are in the assessment of chronic diseases risk factors and the proactive implementation of prevention programs. We therefore extended our research into the primary health care setting, as depicted in Figure 1.1 and described in chapter 6 [11].

1.3.2 Framing and operationalizing the research problem

Data from the HOS study has shown an emerging trend of developing CVD and the underlying risk factors in a population that previously showed low prevalence for non-communicable diseases [13]. To investigate and describe the propelling force behind this trend, one needs to look at the population-wide changes in demographics, social, environmental, education and economic changes, and the consequent changes in lifestyle [11].

The causes and devastating effects of an epidemic of cardiovascular disease and its end result, chronic heart failure have been well documented in developed countries. However, little data is available from developing countries, such as South Africa, on the added negative impact of cardiovascular disease together with malnourishment and infectious diseases. This is especially true for vulnerable populations, like black South Africans, in whom CVD risk factors were seldom found and who were consequently not targeted for health promotion and prevention strategies [15].

Through the analysis of baseline information on food choices, dietary patterns and nutrient intake of patients with chronic heart failure (CHF) living in an urban African area, specific, culturally sensitive and economically viable dietary recommendations and intervention strategies can be developed and implemented for the prevention of risk factors underlying the development of chronic diseases, of which CHF is often the end-result. It is postulated that these targeted intervention programs could potentially improve patient understanding and compliance with treatment, including adherence to dietary guidelines, and facilitate behavioural changes. Improved compliance should improve the health of the individual and result in fewer admissions to hospital with a resultant saving of cost for both the patient as well as health services. Furthermore, improved awareness and understanding regarding risk factors for chronic diseases of lifestyle, will aid the individual in taking control of their own health. If nutrition education and promotion could be better understood and recognised to be inclusive of behaviour change, then it will be viewed as a necessary component within intervention programmes, cardiac rehabilitation and self-management programmes [33].

In addition to monitoring risk factors at baseline or community level, data from the HOS clearly indicated the need and importance of people accessing primary health care for cardiovascular risk

assessment and the implementation of pro-active prevention and management programmes, in trying to reduce chronic non-communicable diseases in an urban low-resource community like Soweto [34].

1.4 Profiling risk factors for chronic non-communicable diseases

It is the cumulative effect of an unhealthy lifestyle and the resultant risk factors, over a prolonged period of time, which contributes to the burden of chronic diseases [1]. Risk factors can be classified as 'modifiable', such as personal and community influences, living and working conditions and socio-cultural, which, to a certain extent, can be controlled and/or changed by an individual, and on the other hand, 'non-modifiable' factors, which are beyond an individual's control, such as age, sex and genetics [15].

Data from the HOS shows that the effects of the epidemiologic transition and its consequences can clearly be seen in an African urban area, such as Soweto, where historically prevalent forms of communicable diseases (rheumatic and infectious forms of heart disease) are now being superseded by non-communicable (newer) forms of disease, such as high blood pressure, atrial fibrillation, coronary artery disease (CAD) and acute coronary syndromes (ACS), which are all precursors of chronic heart failure [11, 35]. Different population groups face different distributions of risk factors, and in South Africa, the three major risk factors recognised as contributing to the chronic disease burden, are alcohol abuse, increased BMI and increased blood pressure, but not elevated cholesterol levels [5]. South Africa, and in particular low-resource communities such as Soweto are suffering from a double or even triple burden of disease; a) historically prevalent communicable or infectious diseases, b) newer forms of NCDs (especially heart disease) c) infectious diseases such as HIV / AIDS and tuberculosis [11]. However, when throwing a spotlight on this phenomenon of older and newer forms of heart disease being simultaneously present in the HOS cohort, interesting new data emerged not previously reported on in an African urbanised low-resource population. Dyslipidaemia has previously been reported as not common in sub-Saharan Africa, but this might be changing, as higher lipid levels have been observed in women from the HOS cohort due to the much higher incidence of obesity observed in the women (50%) than in the men (26%) [15]. Lyons et al, 2014 also reported significant decreases in high-density lipoprotein cholesterol (HDLC) levels in participants presenting with communicable or infectious diseases, especially in the women with elevated C-reactive protein

(CRP). This can be expected as a consequence of infection, however as 50% of women in this cohort have been reported as having significantly higher BMI its needs to be taken into account that obesity in itself can cause a low-grade inflammatory response, as described in chapter 3.1 [15]. These results therefore highlight once again the need for targeted interventions as risk factors contributing to the ever-increasing burden of chronic diseases and cardiovascular disease in particular are multifactorial [15].

1.4.1 Obesity

Obesity has been identified as one of the major risk factors for developing chronic diseases of lifestyle, such as type 2 diabetes, hypertension, dyslipidemia, sleep apnea, gall bladder disease, osteoarthritis and lower back pain, and adversely affects a person's health and quality of life [17,18]. Overweight and/or obesity is the end result when energy intake is more than energy output, to such an extent that the excess energy is stored and fat cells becomes either enlarged or increase in number [18]. It is usually described in terms of BMI, which is the ratio of weight measured in kilograms (kg) to the square of height measured in metres (m). The BMI classification used to define obesity is as follows; underweight (BMI less than 18.5), normal weight (BMI 18.5 – 24.9), overweight (BMI 25 – 29.9), obesity (BMI > 30) or being morbidly obese (BMI > 35) [19]. Evidence-based research is increasingly supporting the notion that obesity is a heterogeneous condition, which can be explained to a large extent through individual differences in regional body fat distribution, and in particular by visceral adipose tissue or liver fat accumulation. It is therefore, also useful to measure other indicators, such as waist circumference in conjunction with BMI, as an elevated waist circumference is indicative of increased abdominal fat levels, as well as triglyceride levels. Elevated waist circumference together with elevated triglyceride levels is a strong predictor of excess visceral adiposity [20].

According to prevalence data from the National Health and Nutrition Examination Survey (NHANES) USA, in 2011 – 2014, the prevalence of obesity was just over 36% and was higher in women (38.3%) than in men (34.3%) [21]. Prevalence data from South Africa indicates that overweight and obesity are on the rise, with 56% of black African females older then 18 years of age, being either overweight or obese when compared to 29% of males [36]. This high prevalence of obesity and associated diseases of lifestyle is now also experienced in developing countries and across the African continent, with

prevalences of 42% to 50.1% being reported for urban African populations in South Africa [11,20]. Data collected in the Soweto community as part of the HOS, showed that of the 1691 Sowetans screened for cardiovascular risk factors, 43% were obese with a higher prevalence in women (55%) than men (23%) [14], and the prevalence of obesity in the HOS clinical registry was 50% for women and 26% for men [15].

Contributors to obesity might be, (a) socio-cultural factors, as it can be an important contributor to the forming of people's perceptions and behaviour, e.g. men and women might have inaccurate perceptions of their body weight, and no more so than in South Africa, where it has been shown that being overweight in certain black South African communities, is associated with well-being, beauty, affluence and a negative HIV/AIDS status, and being overweight is not considered to be a health problem [11], (b) educational status, where a link has been established between low educational status and an increased BMI in black African women [11], (c) increased levels of stress, which contribute to weight gain [11,17], (d) increased energy dense diets high in fat and refined carbohydrates due to the nutrition transition and urbanisation, with the resultant shifts in dietary patterns and composition, which can lead to an increased BMI [29], (e) decreased physical activity, where people tend to make use of public transport instead of walking or cycling long distances as they did when living in rural areas [11,37], (f) genetic factors, where studies have shown approximately 40-70% of the variation in BMI is due to genetic factors [38].

1.4.2 High blood pressure

Globally, high blood pressure can be classified as another major risk factor for cardiovascular disease, stroke, left ventricular hypertrophy and renal disease [24,30]. Data from the HOS, as well as previously reported African and African-American studies have also established that hypertension (HT) is an important antecedent for heart failure [30, 39]. It has been postulated by various studies undertaken in South Africa and especially studies looking at the effects of migration from rural to urban areas on the health of a population, that urbanisation as such may be positively associated with high blood pressure [11, 40]. With urbanisation people are exchanging a simpler more traditional lifestyle for one characterised by a diet higher in fat, salt and refined sugar, higher consumption of convenience and processed foods, limited intake of fruits and vegetables and opting for a more

sedentary way of life, spending more time in front of the television and computer and making use of either public transport or their own vehicle instead of walking [29].

Consistent with data that emerged from other sub-Saharan countries during the period from 1987 – 2004 that showed a prevalence of high blood pressure from 13% in rural areas to 48% in urban areas, the HOS found that of the more than 1600 black Africans screened in Soweto, 33% was hypertensive [30, 41,42]. Key findings from the HOS, is the differences in disease patterns according to the origin of the participants; women that were born in Soweto presented with non-communicable forms of disease at an older age, while participants who migrated to Soweto presented with historically prevalent communicable forms of disease, such as rheumatic heart disease [24]. Women from this cohort were also more likely to report a family history of heart disease, were more likely to be obese and to have a history of high blood pressure, while more men smoked and the men who did present with high blood pressure had higher BP than the women [24]. Another noteworthy finding was that in the HOS cohort, hypertensive heart disease occurred in younger individuals as opposed to findings in high-income countries [30].

Social trends in Soweto therefore, seems to contribute to potential pathways in the development of HT, with women more likely to be obese and men more likely to smoke, exacerbated by other modifiable risk factors found in both sexes [30]. It can therefore, safely be said that a targeted approach has become necessary, focusing on anti-smoking campaigns targeting men and healthy diet and physical activity programs targeted especially at women, as well as addressing the misconceptions surrounding weight loss and infectious disease (especially HIV) [30, 43].

1.4.3 Sleep duration

Population-based studies looking at the possible association between sleep and health are becoming increasingly more important, as more and more evidence is emerging that sleep is playing an essential role in the overall health and well-being of individuals, especially for energy conservation, brain programming, infection control and mental wellness and might be an important indicator for health outcomes [44,45]. With increasing industrialisation and globalization sleeping patterns of individuals are changing as people are becoming less dependent on daylight hours, working longer hours and

spending more time on commuting to and from their place of work [46]. A report from the National Health Interview Survey done in the USA indicates that between 1985 and 2004 the percentage of Americans sleeping less than six hours per day, increased by approximately 5 – 6 % [47].

Observational studies have shown an association between sleep deprivation, where individuals are constantly sleeping ≤5-6 hours per day, and increased prevalence of obesity, as well as the development of metabolic and cardiovascular diseases and breast cancer [47]. In addition, certain studies have shown that people sleeping >8-9 hours per day, as well as taking naps during the day, may be at increased risk of developing diabetes, CVD and have an increased risk of stroke [45,48,49]. Evidence of an association between self-reported short sleep duration and poor quality of sleep with a higher prevalence of increased blood pressure has also been reported by a few cross-sectional studies. However, some of these studies also found high blood pressure amongst people reporting long sleep duration and a significant association in women but not men [47].

Therefore, studies investigating the influence of sleep habits and duration of sleep on the overall health and well-being of people, suggest that sleep duration, either too short or too long is a strong risk factor for the development of chronic diseases of lifestyle. However, it is less obvious to the general public that sleep duration is a modifiable risk factor for chronic diseases. Creating public awareness around sleep habits should therefore form part of all health intervention strategies. Unfortunately, no study of sleep duration during the day or the night and its relationship with CVD has been performed in any African populations.

1.4.4 Other risk factors

Other less emphasized risk factors, but not less important, which are contributing to a hostile cardiovascular environment are diet and a lack of physical activity, smoking as well as second-hand smoking, an ageing society, HIV and its therapy, air pollution, rural to urban migration, psychosocial and economic stressors and climate change [5]. Although physical inactivity is being recognised as a major risk factor in the morbidity and mortality from NCDs, globally, data on the extent and impact of cardiovascular fitness and physical inactivity in South Africa, as well as sub-Saharan Africa is

sparse [50]. Physical activity results from SANHANES-1 (2013), indicated that 27.9% of males and 45.2% of females in South Africa were unfit [36].

However, prevalence, trends over time and geographic and individual variations of CVD cannot be fully explained by all the known adult risk factors of lifestyle, which led to the hypothesis that maternal, fetal and infant malnutrition influence the risk of CVD through adult responses to environmental and dietary changes [48]. Evidence of an association between early malnutrition and susceptibility to HT, abnormal lipid metabolism, altered endocrine and immune functions, insulin resistance and the resultant increased risk for obesity, CVD and type 2 diabetes has been established in recent years, but needs further investigation [48].

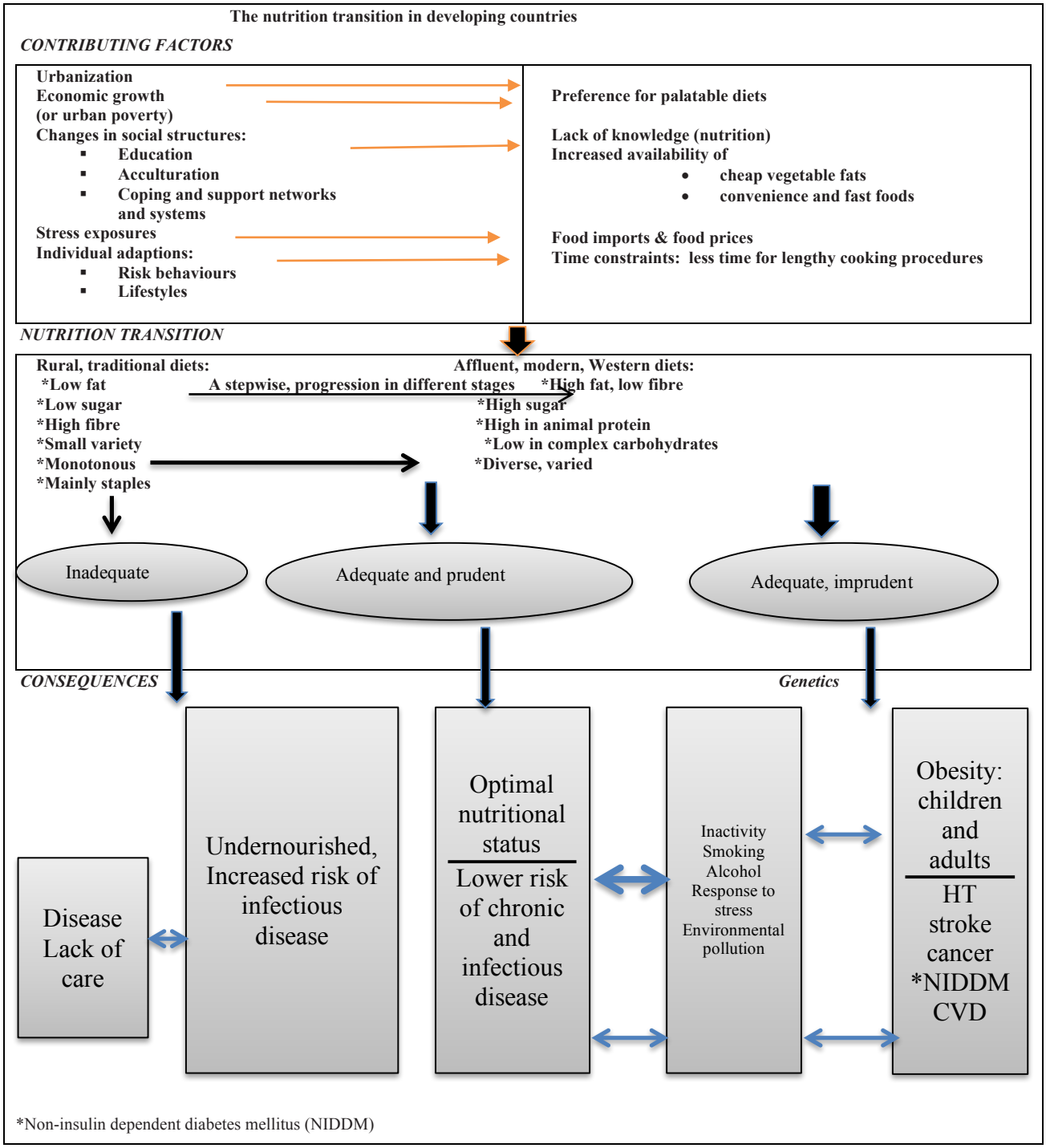
When people are exposed to the typical Western diet, regardless of fetal and childhood circumstances, their risk for NCD will be increased. It has also been shown that under-nutrition in adults, especially African men may lead to increased plasma fibrinogen [48], which is a major risk factor for high blood pressure, stroke and myocardial infarction (MI).

1.5 Nutrition transition: A reality in Soweto?

Globally, but especially in developing countries, major changes in dietary patterns and lifestyle can be seen. This has become known as the nutrition transition and different countries are in different stages on this continuum, with the expectation that population groups in the higher socio-economic brackets will carry the highest risk for developing chronic diseases of lifestyle (see fig 1.3) [47]. Indications are, however that as the nutrition transition progresses in developing countries, the burden is shifting to the lower socio-economic sectors and the poorest [11].

Many public health issues and social challenges can be traced back to dietary patterns and nutritional intake of populations. In order therefore, to develop appropriate and relevant policies, strategies and intervention programs, it is necessary to understand the contributing factors to, and consequences of, the nutrition transition on communities and individuals [51].

Figure 1.3: A schematic depiction of the contributing factors and consequences of the nutrition transition in developing countries (adapted from Vorster HH et al, 1999) [51]



Urbanization is changing the face of social and environmental landscapes worldwide and continues to increase. According to *Patel et al*, the proportion of the world's population living in urban areas, has

already exceeded the 50% mark in the year 2008, and will continue to rise [51]. This is due to the migration of people from rural to urban areas in search of employment, as well as natural urban demographic growth. Rapid, unplanned and unsustainable patterns of urban development are making developing cities focal points for many emerging environmental and health hazards, as people arriving in these urban areas often find themselves having to live in informal settlements with poor sanitation, no clean running water, limited mobility, limited access to healthcare and food supplies and a change in dietary patterns and food choices [51]. This may either lead to under-nutrition due to lack of sufficient food and nutrients or the availability of different, but poor quality diets and the resultant over-nutrition [29,37]. Data from the THUSA (Transition and Health during Urbanization of South-Africans) study has indeed confirmed these adverse changes in dietary patterns due to the nutrition transition through comparison of the diets of rural and urban Africans [52]. These changes include a decreased intake of unrefined starches, dietary fibre and plant protein sources such as legumes and an increased intake of animal protein, saturated fatty acids and total fat, as well as increased consumption of energy-dense snack foods, cold drinks and foods with added sugar, salt and fats [52].

With urbanisation, people also have more access to modern mass media and are being targeted more by marketing campaigns, have better transportation systems and easy access to large modern supermarkets that are dominated by multinational corporations [51]. One of the main driving forces for people moving to urban areas, and especially a large urban area such as Soweto, South Africa, is to gain employment. This increase in income, does not necessarily lead to healthy food and lifestyle choices, but to an increase in the consumption of sweetened and processed foods and decreased levels of activity, as people do more sedentary type jobs and their mode of transport changes from active to more passive forms, e.g. instead of walking, taking a taxi or bus to work [29,43].

As urban populations grow, the quality of local ecosystems and the urban environment will play an increasingly important role in public health with respect to issues ranging from solid waste disposal, provision of safe water and sanitation, and injury prevention, to the interface between urban wealth on the one hand and poverty on the other, environment and health [51, 53]. There is a double challenge for governments, as the poor need to be protected, while at the same time global markets need to be strengthened to create wealth. Increased wealth leads to increased health and is associated with better

quality of life and higher life expectancy. Therefore, to promote healthier food and lifestyle choices, policies are needed to promote healthier economic development [53].

There is a strong link between the nutrition transition and globalisation and the following mechanisms have been suggested in recent literature; urbanisation, government policies governing the production, trade, distribution and marketing of foodstuffs, global and local advertising and promotion of food, foreign direct investments, global sourcing of food, retail restructuring and the development of easily accessible shopping centres and supermarkets, but also global and local food insecurity [53].

The effect of globalisation on the supply of food, can either be positive or negative in the sense that it may alleviate under-nutrition by stimulating economic growth and supplying more affordable and varied foods, but on the other hand, it may lead to inequality and exclusion by making the supply of healthy and affordable foods only available to the higher income brackets [28]. A global increase in the consumption of more-energy-dense, sweeter foodstuffs and processed foods is being documented. These shifts in dietary patterns seem to be country and population specific, e.g in the higher-income countries, such as the USA, increased portion sizes, intake of convenience foods, snacking and increased consumption of calorically sweetened beverages form part of the changes in diet [54]. While in the lower-income countries less data are available, but there seems to be an increased intake of processed and take-away foods [11,54].

1.5.1 Dietary consumption in a low-resource African urban population: perspectives and perceptions

Within South Africa, as in other developing countries that are undergoing a nutrition transition, the intake of foods high in fats, sugars and salt is increased and the intake of unrefined cereals, fruits and vegetables remain inadequate [11,53]. These changes in dietary patterns and the resultant poor quality of these diets have been linked to the increase in chronic diseases of lifestyle and are especially affecting the poor [11]. A case in point is South Africa, where studies have shown that in African populations living in urban areas, urbanisation and the nutrition transition have had a profound impact on the increase seen in CVD risk factors [38,52].

The South African population is made up of many different ethnic and cultural groups, each with its own way of preparing foods and food choices. It is however, the black African population who is currently undergoing a rapid process of urbanization. The diets of rural Africans tend to be higher in carbohydrates (>65% E), lower in fat (< 25% E), lower in sugar (<10% E), and have a higher fibre content, corresponding to the more traditional way of eating, than black African populations living in urban areas who are now consuming about 30% of their energy as fat. The ratio of plant to animal protein intake has also changed with animal protein and therefore more saturated fat being consumed with urbanization [51]. It has also been reported that the consumption of fruit and vegetables by black urban African populations tends to be infrequent and in small amounts, usually around 2 small portions per day or sometimes just over weekends, with women generally consuming more fruit and vegetables than men [54]. Calcium intake in both rural and urban black Africans tends to be low, which may contribute to an increased prevalence of high blood pressure. Micronutrient deficiencies may contribute to the development of NCD's through various metabolic processes, e.g. fruit and vegetables contain cardio-protective nutrients, such as potassium, which is indicated in lowering blood pressure, vitamin C with its antioxidant activities and folate for the reduction of homocysteine levels, as well as soluble fibre that assist in the lowering of cholesterol [54].

There are many factors that affect food choices and methods of food preparation and these include general nutrition knowledge, beliefs regarding the development of obesity and dietary behaviour and practices [36]. Sufficient knowledge around what constitutes a healthy diet can positively influence beliefs and healthier food choices, but may vary according to socio-economic circumstances and exposure to education interventions, and can be influenced by cultural beliefs and norms around overweight and obesity [36]. An association has been shown between a lack of knowledge as to healthy food choices, time constraints and perceptions of what is convenient in terms of meal preparation, acceptable portion sizes and BMI. Thus, food choices are influenced by availability and affordability on the one hand and the abundance of fast food outlets and vendors that sell high fat, energy dense food on the other hand [36].

Insufficient information on food choices, and macro- and micro-nutrient intake is available for the population of Soweto and especially for people suffering with chronic heart failure (CHF), which

clearly indicates the need for an analysis of dietary intake in African subjects living in urban environments, with a special emphasis on those with CHF.

1.6 Heart Failure Management

In the last 10-15 years, advanced heart disease and the end-result, heart failure (HF), has emerged as a major health problem worldwide, as well as in low-income populations, with data from Europe suggesting that about 3-4% of the general population have left ventricular systolic dysfunction and 5-6 % of the elderly population [55]. Data from the HOS study showed that during the period from 2006 - 2008, of the 5328 de novo cases captured with heart disease, 2505 (47%) of these cases presented with chronic heart failure. Ominously, in addition to the "traditional" causes of HF in Africa, such as 'idiopathic dilated cardiomyopathy', 'rheumatic fever', 'HIV-related cardiomyopathy', 'peripartum cardiomyopathy' and 'hypertensive heart failure', "lifestyle" factors, including hypertension, obesity, dyslipidaemia and type 2 diabetes mellitus (particularly in women), appear to have expanded the pathways to, and burden of, HF in this community [56].

HF is associated with shorter life expectancy, greater morbidity and impaired quality of life than most common diseases [18]. About 30% of people die within 3 months of diagnosis of HF, with an annual mortality of 10% thereafter, and those with severe HF have an annual mortality of >50% [18]. The economic impact of advanced heart disease on the government, as well as the individual is huge, with an estimated $5,501 spent for every hospital diagnosis of HF and about $1,742 for monthly care [18]. In the UK, the annual cost of taking care of people with HF exceeds 1 billion pounds [57]. Most of the published data and current knowledge on HF are based on studies in Europe and America. There is a paucity of studies on HF management in sub-Saharan Africa, including the contributing effect of lifestyle and food choices on the development and management of heart disease and other chronic diseases of lifestyle in low-resource urban African communities.

In an effort to address this, a HF management program was developed and implemented at the HF clinic at CHBH as part of the HOS. The aim was to assess the efficacy of such a program in the treatment of heart failure patients and to improve outcomes in these patients, as described in chapter five.

1.7 The role of integrated prevention in tackling the epidemic of NCDs

As always, prevention is better than cure! Fortunately, there is still time to avert a future generational crisis due to lifestyle (non-communicable) forms of CVD (predominantly heart disease) whilst addressing current issues related to poor maternal and early childhood health and advanced risk factors in older individuals [58].

Evidence-based data on how to prevent NCDs is obtained from individuals, as well as populations. Data from individuals assist in identifying specific risk factors contributing to NCDs and therefore, provide specific indicators for disease prevention, but on its own does not provide sufficient information on the efficacy of these prevention strategies at the population level [59]. The Alma Ata Declaration states that for disease management to be effective, intervention strategies should include; policy actions to promote healthy choices, preventative actions and education to encourage personal and behavioural changes and rehabilitative programs for the prevention of complications [16].

Prevention programs should include both primary and secondary prevention and might seem fairly obvious and straightforward initially, but can face a number of challenges when implemented in low-resource communities. Approaches include public health or community-based strategies targeting risk factor awareness and prevention, which can be relatively cost effective, but require extensive training and educational programs as well as additional regional and national government policies, e.g. taxation on tobacco and alcohol and legislation on smoking [5].

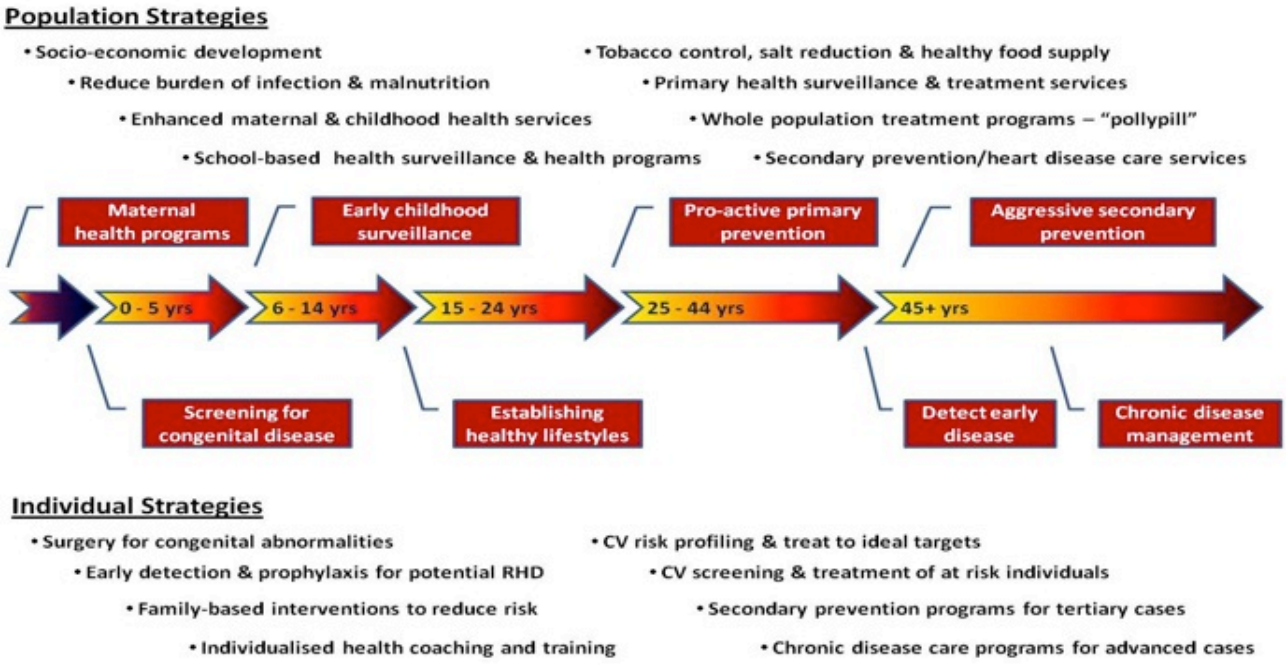
There is a need to implement cost-effective primary and secondary prevention strategies in low to middle-income countries. The key to achieving sustainable and productive health outcomes within a resource-poor environment lies in:

- properly understanding and documenting the problem (i.e. risk profile and spectrum of chronic diseases of lifestyle within the local population)
- developing and implementing health promotion strategies to deal with anticipated health risks
- adopting fundamental, low-cost treatment strategies
- building clinical and research capacity

- and to continuously evaluate the impact of intervention strategies in the community

Following from the HOS study, we have mapped-out an integrated strategy to systematically apply effective prevention in urban communities within sub-Saharan Africa as shown in Figure 1.4 [24].

Figure 1.4: An integrated approach to effective prevention of CVD in sub-Saharan Africa (adapted from Stewart S et al, 2011) [24]



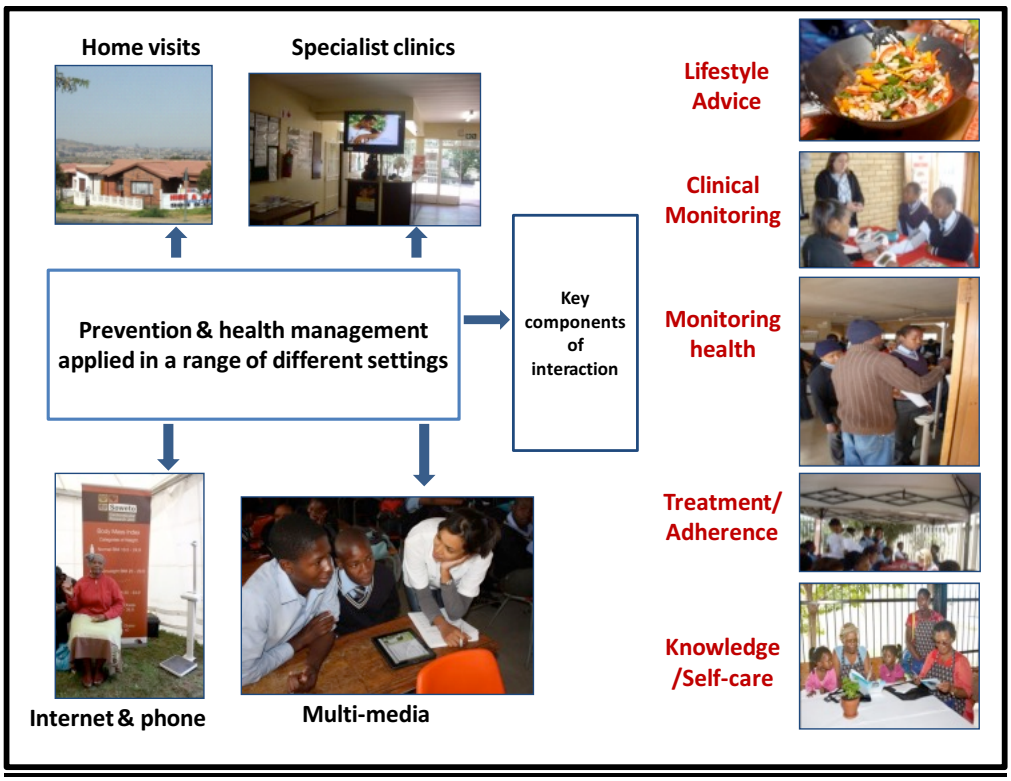
1.7.1 Community-based strategies in tackling chronic diseases

Caring for persons suffering from chronic diseases are usually the responsibility of families and community members and even more so in rural communities without the necessary healthcare infrastructures and services. But, it is seldom a smooth process between implementing health policies and services on the one side and patients and their families on the other side [25]. Community-based strategies to alleviate the burden of NCDs usually include; policies on healthy nutrition, the control and regulation of tobacco and alcohol products, educational programs, i.e. dietary guidelines to

educate the public on healthy eating and the importance of physical activity and health service management [3,16]. It is however, of the utmost importance to include communities when developing and implementing intervention programmes, as they play a crucial role in shaping lifestyle decisions driving chronic diseases, diffusing health messages from healthcare professionals to all individuals in the community and shaping perceptions and practices of whether or not members of a community will make use of medical services and adherence to advice and intervention strategies [25].

Integrated community-based intervention programmes should be as comprehensive as possible and should include a variety of targeted activities to produce a synergistic effect. It should form part of the core training of all health care professionals. The community approach in chronic disease prevention has a high degree of generalizability, cost-effectiveness due to the use of mass communication methods, ability to diffuse information successfully through use of community networks and multi-media, and potential for influencing environmental, regulatory and institutional policies that shape health.

Figure 1.5: Direct and indirect means of communicating with a community



1.7.2 National and international strategies for tackling chronic disease

Global recognition of the crippling burden of chronic diseases of lifestyle is emerging by international health agencies and national governments. In 2005, the WHO advocated that chronic diseases in developing countries should be prevented through changes in priority setting and the reallocation of resources in its publication "Preventing chronic disease: a vital investment" [28]. And in September 2011 a United Nations (UN) high-level meeting on NCDs took place, which provided a unique opportunity to mobilise a worldwide movement for the prevention of premature death and disability from NCDs, especially heart disease, diabetes, stroke, cancer and chronic respiratory disease. Following this call, the Lancet NCD Action Group and the NCD Alliance put forward a plan of action identifying five priority areas to address this eminent crisis, namely leadership by all role-players, preventative action, targeted treatment, national and international co-operation, monitoring and evaluation and accountability. It also includes the five major areas of intervention, namely smoking and tobacco control, reduction of salt intake, increased physical activity, following a healthy diet, and reduced alcohol consumption [60].

1.8 Theoretical framework

Within a social-ecological perspective the assumption is made that multiple facets of physical and social environment as well as personal attributes, including behaviour patterns, influence health and health behaviours [12, 23, 48].

Risk factors contributing to the development of chronic diseases of lifestyle, awareness around these risk factors for the prevention and management of chronic diseases, accessibility to health care and the accessibility and affordability of food can be examined within this framework, as it is suited to examining both individual and environmental determinants of behaviour. It also increases the relevance of findings to health promotion efforts.

Within the framework of the HOS study all of these contributing factors to the emergence of chronic diseases of lifestyle in a black urban African population were examined and described in order to

develop awareness and prevention programs from primary to tertiary level. The focus of this thesis is, therefore, a) on the emerging chronic disease component of this quadruple burden of disease in urban Africans in Soweto, as urbanisation and the nutrition transition in South Africa are accompanied by an increase in CVD risk factors, particularly obesity, in African populations, b) the relationship of these environmental factors (education, employment, exercise, smoking, sleeping patterns) with obesity in an urban population of African subjects, as environmental factors other than food intake and urbanisation are also known to affect the prevalence of obesity and c) to describe food intake in this African urban population and the role of urbanisation on dietary patterns and its association with the development and progression of chronic diseases of lifestyle, and d) to describe and evaluate the feasibility of targeted intervention strategies in an urban African low-resource community such as Soweto.

1.9 Aim and objectives of the thesis

The burden of NCD's in low- and middle-income countries is increasing despite continuous calls to action. There are various reasons for this;

- Limited applied health research around the development and prevention of NCD's
- Research, policy development and action plans are being performed on some NCD's but not others and therefore for some NCDs we have sufficient information to be able to initiate interventions whilst at the other end of the scale we have NCDs for which we know very little [25].

Therefore, the primary aim of this thesis is:

- To examine and describe contributing factors to the emergence of chronic diseases of lifestyle, most particularly heart disease but also hypertension, diabetes and obesity in a black urban African population, within the framework of the HOS study, and to analyse dietary intake in HF patients and hence develop a heart failure management programme for use in a low-resource setting.

The objectives set out in this thesis are therefore:

- To perform chronic diseases of lifestyle risk profiling in an urban African community looking at socio-economic, education and sleep pattern data from the HOS
- To measure the prevalence and risk factors for communicable and non-communicable heart disease and right heart failure in *de novo* suspected heart disease patients
- To measure the prevalence of CVD risk factors and heart disease in subjects attending primary care clinics in Soweto
- To describe dietary habits and potential nutritional deficiencies in black African patients diagnosed with CHF
- To compare a standard care with a managed care heart failure management programme in a low resource setting

1.10 Description of the research papers contained within this thesis

Data from the HOS study, as well as from several studies undertaken in black African populations in South Africa, were used to describe the unique epidemiological and nutrition transition found in South Africa, specifically in a black urban African population living in Soweto, contextualised within a broader global picture (Chapter 1).

Chapter 3 contains 2 research papers. The purpose of this chapter was to describe the risk factors for communicable (e.g. rheumatic heart disease) and non-communicable (e.g. coronary artery disease) heart disease in patients attending the Cardiology Unit of CHBH in Soweto (publication 3.1) and to describe the prevalence and correlates of common CVD risk factors i.e. obesity, high glucose and high blood pressure in 1311 consecutive patients attending two primary health care clinics in Soweto (publication 3.2).

In Chapter 4 there are 3 research papers that cover the topics of right heart failure and dietary intake in subjects with HF. In the first paper (publication 4.1) the same group of patients as described in publication 3.1 were analysed for the presence of right heart failure and risk factors identified. Poor dietary intake is a risk factor for HF and therefore in the following paper (publication 4.2) dietary

intake in 50 consecutively consenting HF patients attending the cardiac clinic in CHBH were surveyed using validated quantitative food frequency questionnaires (QFFQ). Food intakes, translated into nutrient data were compared to recommended values. The last paper in this chapter (publication 4.3) continued with the topic of dietary intake and compared the monetary cost of a healthy diet to that of the normal dietary intake observed in residents of Soweto.

In Chapter 5 the researcher initiated a randomized controlled study of a multidisciplinary, community-based, chronic heart failure management program in Soweto, compared against usual care (Chapter 5). This study emphasised the impact of dietary intake on the management of HF and measured blood vitamin C and thiamine levels at the initiation of the 2 interventions.

Using the same cohort of subjects as described in paper 3.2, those with a confirmed diagnosis, or with clinical symptoms of underlying heart disease were identified, and underwent advanced cardiac profiling (Chapter 6). The prevalence of heart disease within this population and the presence of associated risk factors were analysed.

Within the final chapter, each of the studies that were undertaken was carefully evaluated and the lessons learned from each of the studies were examined and described (Chapter 7).

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CHAPTER 2

METHODOLOGY OVERVIEW

2.1 Epidemiological studies and publications

All the studies contained in this thesis were conducted in Soweto at CHBH, Department of Cardiology and two primary health care clinics, Michael Maponya clinic and Walter Sisulu clinic and were all performed in adherence to the Declaration of Helsinki. Ethical clearance for all studies was granted by the Human Research Ethics Committee of the University of the Witwatersrand.

Data for the following epidemiological studies, were systematically collected:

A) *At tertiary care level*, as part of the HOS study, which was a prospectively designed registry that recorded epidemiologic data relating to the presentation, investigation and treatment of 1593 patients with newly diagnosed cardiovascular disease presenting to CHBH between January 1, 2006 and December 31, 2006
B) *At primary care level*, as part of the primary care survey in Soweto (644 and 667 patients from Mandela Sisulu, Orlando West and Michael Maponya, Pimville primary health care clinics in Soweto, respectively) on consecutive patients attending these clinics

2.1.1 First author publications

I was responsible for the design of the study protocols, the data collection as a registered dietician and researcher, as well as for the preparation of the following manuscripts for publication, of which I am first author:

a) "Feeding the emergence of advance heart disease in Soweto: A nutritional survey of black African patients with heart failure" (chapter 4)

With regards to the following publication, which carried on from the HOS, we undertook a survey at primary health care level in order to describe the burden of diseases and possible underlying risk factors seen at primary health care clinics in a low-resource environment within Soweto. I was responsible for setting up the survey at the primary health care clinics, obtaining permission from City

of Johannesburg, City Health Department, Primary Health Care, the supervision of data collection by the research nurses and research assistants, as well as the preparation of the manuscript for publication:

b) "Is there an association between sleeping patterns and other environmental factors with obesity and blood pressure in an urban African population?" (Chapter 3.2)

I was responsible for the content, as well as for the preparation of the following review articles for publication:

c) "Perspectives and perceptions on the consumption of a healthy diet in Soweto, an urban African community in South Africa" (Chapter 4.3)
d) "Lessons learned from the HOS and future directions" (Chapter 7.1)

2.1.2 Co-author publications

I am co-author on the following publications on which, as a PhD student, dietician and researcher in the Soweto Cardiovascular Research unit (SOCRU) and the HOS, I was involved in the design of the studies and questionnaires, as well as the data collection and management of the data and the preparation of the manuscripts for publication:

a) "Standing at the crossroads between new and historically prevalent heart disease: effects of migration and socio-economic factors in the Heart of Soweto cohort study" (chapter 3.1)
b) "A not-so-rare form of heart failure in urban black Africans: pathways to right heart failure in the Heart of Soweto Study cohort" (chapter 4.1)
c) "Elevated risk factors but low burden of heart disease in urban African primary care patients: a fundamental role for primary prevention" (Chapter 6.1)

2.2 Research methods used in this thesis

The methods used in this thesis are described in detail in each of the following results chapters and where appropriate (e.g. questionnaires), the attached appendices.

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CHAPTER 3

CHRONIC DISEASES OF LIFESTYLE RISK PROFILING IN A BLACK URBAN POPULATION

3.1 Introduction

It has been established that the burden of NCD is rapidly increasing in low-to middle-income countries (LMIC) with resultant adverse social, economic and health outcomes [1]. However, the causes and consequences of an epidemic of chronic diseases of lifestyle, such as heart disease, high blood pressure, diabetes, cancer and chronic obstructive pulmonary disease (COPD) have been well documented in developed countries, but less so in LMICs where NCDs are emerging as a threat alongside malnourishment and infectious diseases, especially in vulnerable and previously disadvantaged populations [2].

As described earlier, South Africa is still undergoing an epidemiological and nutrition transition. It is a country with great diversity, extending from highly industrialised cities with an advanced economy and an urbanised lifestyle to the more rural areas with more traditional lifestyles [2]. A natural phenomenon globally and also in South Africa is a process of migration, influenced substantially by climate changes and food security, whereby people move from rural to urban areas in search of employment, better education, access to healthcare and better lifestyles [3].

In order to better construct healthcare systems and policies we need to understand the underlying factors contributing to this emerging epidemic of NCDs, and to monitor where the population of South Africa lies on the epidemiological transition pathway. Therefore, we used data from the HOS to expand our understanding of the factors contributing to NCDs in an urban black African population living in Soweto. High numbers of people are migrating to Soweto from rural areas looking for employment and seeking a better life, but unfortunately end up not always finding an improvement in socio-economic circumstances or health. Soweto is characterised by people living in extreme poverty at the one end of the socio-economic scale and those with access to luxury housing and state-of-the art shopping centres at the other end of this scale. This environment is ideally suited for the examination of the epidemiological transition and its effects on specific NCDs, in this case heart disease. Therefore, we used data collected from patients presenting with suspected heart disease at Chris Hani Baragwanath Hospital in Soweto in an effort to examine and describe the effects these changing urban environments and the resultant socio-economic circumstances might have on heart health outcomes (publication 3.1). Furthermore, we hypothesized that the urban environment may be

associated with poorer sleep quality and greater exposure to cigarette smoke and we therefore investigated the relationship of these factors with obesity and high blood pressure in an urban African population. This was done by collecting data from 1311 consecutive patients attending two primary health care clinics in Soweto (publication 3.2).

Publication 3.1: Standing at the crossroads between new and historically prevalent heart disease: effects of migration and socio-economic factors in the HOS cohort study (Statement of originality document: Please see Appendix C) [4].

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Standing at the crossroads between new and historically prevalent heart disease: effects of migration and socio-economic factors in the Heart of Soweto cohort study

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Aims Migration, urbanization, and change in socio-economic factors have potentially profound effects on heart disease in low-to-middle income countries.

Methods and results Chris Hani Baragwanath Hospital in Soweto, South Africa, provides health care to >1 million Africans. We systematically captured data from all *de novo* presentations of suspected heart disease (focusing on 'new' vs. historically prevalent forms) during 2006–2008. There were 3168 female (52 ± 18 years) vs. 2160 male (53 ± 17 years) cases. Overall, 999 (19%) presented with uncomplicated hypertension ($n = 988$) or type II diabetes, 1862 cases (35%) 'new' heart disease (1146 and 581 cases of hypertensive heart failure and coronary artery disease), and 2092 cases (39%) of historically prevalent heart disease (including 724 with primary valve disease and 502 idiopathic dilated cardiomyopathies). Level of education and non-communicable risk factors were important correlates of advanced disease. The rate of historically prevalent cases was higher in those aged 20–49 years (19–60 cases/100 000 population/annum) whilst being higher for "new" heart disease in those aged >50 years (155–343 cases/population/annum). Historically prevalent heart disease cases were younger [adjusted odds ratio (OR) 0.98, 95% 0.97–0.99 per year], more likely to be African (OR 4.59, 95% 2.76–7.60) while being less likely to originate from Soweto (OR 0.87, 95% 0.75–1.00) and be female (OR 0.67, 95% 0.49–0.92).

Conclusion Dynamic socio-economic and lifestyle factors characteristic of epidemiological transition appear to have positioned the urban, mainly African community of Soweto at the crossroads between historically prevalent and 'new' forms of heart disease.

Keywords Africa • Cardiovascular disease • Heart disease • Spectrum of disease • Epidemiological transition

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Introduction

Although the burden of cardiovascular disease (CVD) states, such as heart disease, is stabilizing in high-income countries, in low-to-middle-income countries (LMIC) it continues to rise.[1] With scarce health-care resources, LMIC are typically ill-equipped to cope with new challenges[2] when already over-burdened by illness related to malnourishment and infection.[3] There is little scope to tackle new prototypes of heart disease arising from changing risk behaviours due to epidemiological transition.[4] Contemporary studies demonstrate high levels of non-communicable antecedents of heart disease (except dyslipidaemia) in Sub-Saharan Africa; particularly urban communities.[5–7] Preliminary data from

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the Heart of Soweto Study[8] suggest that epidemiological transition has broadened the spectrum of advanced forms of heart disease in one of Africa's largest urban concentrations of Africans. We found a high burden of complex cases in young individuals and women (a pattern rarely seen in high-income countries).[9]

The contemporary balance between historically prevalent and emergent (new) forms of heart disease in Sub-Saharan Africa is unknown. This tension between the 'old and the new' is largely reflected in the balance between communicable vs. non-communicable disease states.[10] Historically, rheumatic heart disease (RHD),[11] the dilated cardiomyopathies (CMO),[12] pulmonary heart disease, arrhythmias, and infectious forms of heart disease are predominant in Sub-Saharan Africa.[13] With high levels of rural migration and extreme poverty counterbalanced by sufficient consumer demand for new, state-of-the-art shopping precincts, Soweto is an ideal community to study epidemiological transition. We postulated that in Soweto (>1 million people of African descent) the balance between largely communicable (historically prevalent) vs. non-communicable (newer) forms of heart disease[14] has irrevocably changed. Specifically, we hypothesized that (i) the burden of new forms of heart disease is equal to historically prevalent forms, (ii) socio-demographic gradients exist in case presentations and, (iii) lifestyle risk factors are both common and contribute to more advanced presentations in those with historically prevalent heart disease.

Methods

Study setting and design

As described previously,[9] the 3500-bed Chris Hani Baragwanath Hospital (case load of >125 000 inpatients per annum) services the tertiary care needs of Soweto and surrounding communities. With no other major facilities and limited private health care, it represents a key barometer of the overall health of Soweto. All cases of suspected heart disease are referred to the Cardiology Unit for advanced diagnostic testing and gold-standard treatments. A prospective clinical registry of all *de novo* presentations was established in 2006 as part of the Heart of Soweto Study; Sub-Saharan Africa's largest and most detailed study of advanced forms of heart disease to date.

Participants

During 2006–2008, we captured data on 6006 *de novo* presentations to the Cardiology Unit. Excluding those 678 cases (11%) found not to have significant disease or risk, the remainder ($n = 5328$) were referred on the following basis:

- emergency presentation ($n = 401$, 7.6% of total case-load);
- external referral from local primary care clinics for advanced assessment and definitive treatment ($n = 367$, 6.8%);
- internal referral of a patient as a current hospital inpatient ($n = 1992$, 37.4%);
- referral from another outpatient department ($n = 2568$, 48.2%).

The study was approved by the University of the Witwatersrand Ethics Committee and conforms to the principles outlined in the Declaration of Helsinki.

Study data

A complete list of study data captured by the registry, comprising basic socio-demographic (including self-reported years of education, origin and history of any form of CVD) and advanced clinical profiling, has been described previously.[9,11,15] Those of African descent were typically of Zulu or Xhosa origin. Migrants were defined as individuals who were not born in Soweto with a differential of >10 years between calculated age and reported years of living in the area. Anthropometric measurements were available for calculation of body mass index (BMI—kg/m^2) in 3844 (72%) ambulatory cases, and renal function assessed in 4348 (82%) cases. Despite echocardiography being performed in every case (according to gold-standard criteria[16]), not all values were quantified (e.g. due to poor visualization); left ventricular ejection fraction (LVEF) was recorded in 4597 cases (86%). Similarly, 12-lead ECG (blinded Minnesota coding[17]) was available in 4782 (90%) cases. We also adhered to the STROBE guidelines for this type of study.[18]

Data classification and analyses

All data and diagnoses were independently reviewed and adjudicated (consensus approach) by K.S. and S.S. using European Society of Cardiology guidelines.[19] For these analyses, we prospectively classified cases into six clinical groups (using the primary diagnosis)—see *Table 1*.

Table 1

Study classification	Primary diagnoses	General characteristics	Communicable component
Hypertension/type II diabetes (*without evidence of established heart disease or another form of CVD*)	Hypertension	Increasingly prevalent risk factor in urban communities, primary diagnosis only when no evidence of cardiac dysfunction	None/strongly linked to lifestyle risk factors
	Type II diabetes	Low prevalence relative to other LMIC	
Historically prevalent heart disease	RHD and other valve disorders, non-ischaemic CMOs, pericardial disease, and pulmonary heart disease[10]	Historically, the main (reported) contributors to heart disease in Sub-Saharan Africa	Streptococcal infection, tuberculosis, other pulmonary infections, and now HIV infection
New/non-communicable heart disease	Hypertensive heart failure (HF) and (atherosclerotic) coronary artery disease (CAD)	Hypertensive HF is a well-described phenomenon in Sub-Saharan Africa but in historically low numbers	Strongly linked to lifestyle risk factors.

Continued

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Table 1 *Continued*

Study classification	Primary diagnoses	General characteristics	Communicable component
Congenital heart disease	Congenital heart disease (including septal defects) and cardiac trauma	Relatively rare	None
Other heart disease (*other than those listed above*)	Miscellaneous diagnoses including cardiac trauma or cases without a definitive diagnosis	Relatively rare	None/undetermined
Other CVD (*no evidence of underlying heart disease*)	Peripheral arterial and cerebrovascular disease	Haemorrhagic stroke is a common form of CVD (particularly in rural regions). Increasing contribution from modifiable risk factors	Almost exclusively linked to lifestyle risk factors

Study data were documented on standardized forms and entered into a database (Microsoft Access) at the Soweto Cardiovascular Research Unit. Data were then verified and transferred to SPSS Statistics 17.0 for independent analyses at Baker IDI. Normally distributed continuous data are presented as the mean ± standard deviation and non-Gaussian distributed variables as the median plus inter-quartile range. Categorical data are presented as percentages with 95% confidence intervals (CIs) presented where appropriate. For patient group comparisons, we initially used χ^2 analysis with calculation of odds ratios (ORs) and 95% CI (where appropriate) for discrete variables, Student's *t*-test and analysis of variance for normally distributed continuous variables. Multiple logistic regression analyses (entry model) were performed on demographic and baseline risk factor profile (all variables listed in *Table 3*) to derive adjusted ORs for the risk of presenting with historically prevalent vs. 'new' forms of heart disease. Mantel–Haenszel tests were also performed to examine the interaction between gender, age (age-groups), and type of case presentation. In order to address the third hypothesis amongst those with historically prevalent heart disease, the risk of presenting with more advanced heart disease (as evidenced by secondary valve disease and/or left ventricular systolic dysfunction) was assessed. Rate of case presentations per annum was calculated on an age- and sex-specific basis using contemporary Census data[20] for the Baragwanath Hospital catchment area. Significance was accepted at the level of 0.05 (two-sided).

Results

Study cohort

Table 2 shows the broad socio-demographic and clinical profile of this cohort comparing men to women (60% of the cohort) and African (87%) vs. other ethnicities. The latter comprised 292 Caucasian (5.5%), 219 Indian (4.1%), and 191 (3.6%) of mixed descent. There were proportionately more African women (54% of total) than men (33%). Although more men smoked tobacco, their mean BMI was markedly lower than women ($P < 0.0001$ for both comparisons). Men were also more likely to present with left ventricular systolic dysfunction (OR 1.71, 95% CI 1.50–1.95; $P < 0.001$) but numerically more women [1418 (45%) vs. 975 (45%)] presented with any form of HF. In addition to being collectively younger, the overall risk factor profile of Africans (less family history, less smokers, and lower cholesterol levels) was more favourable than other ethnicities ($P < 0.001$ for all sex-based comparisons).

Figure 1 shows the spectrum of 5328 *de novo* cases highlighting key differentials according to sex, ethnicity, and level of education in the pre-specified clinical groupings. The two largest groups were historically prevalent heart disease (39% of the total cohort) comprising 60% women and 93% Africans, and 'new' forms of heart disease (35%) comprising 56% women and 79% Africans ($P <$ 0.001 for both comparisons). A similar proportion of men and women were diagnosed with a non-heart disease form of CVD including 87 cases of stroke/cerebrovascular disease (46 co-morbid cases of stroke were identified) and 57 cases of peripheral arterial disease (28 co-morbid cases). A further 999 cases, predominantly those with uncomplicated hypertension (primary diagnosis with no evidence of end-organ damage, $n = 988$) and 11 cases of type II diabetes (315 co-morbid cases—not shown), had a major risk factor without established heart disease. The proportion of cases with <6 years (low) education ranged from 29% (other forms of CVD) to 48% ('new' heart disease).

Historically prevalent vs. 'new' forms of heart disease

The proportion of historically prevalent (1.8 ± 0.9 diagnoses overall) and new forms of heart disease cases (2.4 ± 0.8 diagnoses) was evenly poised. *Table 3* demonstrates a number of socio-demographic and modifiable risk factors were potentially important in determining the type of presentation. On an adjusted basis, historically prevalent heart disease cases were more likely to be younger, African and be male. Conversely, they were less likely to originate from Soweto in addition to having a positive family history of CVD, elevated total cholesterol level, hypertension, and/or be obese.

We specifically examined age and sex trends according to whether an individual originated from Soweto or had 'migrated' to the area in the most prevalent racial group in the cohort—those of African descent ($n = 3308$). As shown in *Figure 2* there were marked differences in the pattern of presentation on this basis. Overall, there were more cases of historically prevalent than new heart disease up to 49 years for women and 59 years for men, before this pattern reversed in older age groups. For female Sowetans, new heart disease case presentations continuously increased across all age groups compared with historically prevalent cases

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Table 2 Demographic and clinical presentation ($n = 5328$)

	All ($n = 5328$)	Men ($n = 2160$)	Women ($n = 3168$)	African ($n = 4626$)	Other ($n = 702$)
Socio-demographic profile					
Mean age (years)	52.0 ± 17.4	52.8 ± 16.5	51.5 ± 17.9	51.5 ± 17.7	56.7 ± 14.1
African descent	4626 (87%)	1763 (82%)	2863 (90%)	4626 (100%)	—
Female	3168 (60%)	—	3168 (100%)	2863 (62%)	305 (43%)
<6 years education	2264 (43%)	933 (43%)	1331 (42%)	2018 (44%)	246 (35%)
Originally from Soweto	2835 (53%)	1079 (50%)	1756 (55%)	2807 (61%)	28 (4.0%)
Mean years living in Soweto	39.4 ± 17.9	38.2 ± 17.7	39.2 ± 18.1	38.8 ± 18.0	38.6 ± 15.8
Risk factor profile					
Family history of CVD	2157 (41%)	727 (34%)	1430 (45%)	1800 (39%)	357 (51%)
Total cholesterol (mmol/L)	4.2 ± 1.3	4.1 ± 1.3	4.4 ± 1.3	4.2 ± 1.3	4.8 ± 1.3
History of smoking (%)	2425 (46%)	1454 (67%)	971 (31%)	2000 (43%)	425 (61%)
Body mass index (kg/m^2)	28.2 ± 7.3	25.7 ± 6.0	29.8 ± 7.6	28.2 ± 7.2	28.0 ± 7.5
Clinical presentation					
NYHA II, III, or IV	3645 (68%)	1371 (63%)	2274 (72%)	3214 (69%)	431 (61%)
Systolic blood pressure (mmHg)	132 ± 27	132 ± 28	133 ± 27	133 ± 27	132 ± 26
Diastolic blood pressure (mmHg)	76 ± 15	76 ± 16	75 ± 16	76 ± 15	74 ± 14
Angina pectoris/chest pain	626 (12%)	241 (11%)	385 (12%)	505 (11%)	121 (17%)
Peripheral oedema	1702 (32%)	648 (30%)	1054 (33%)	1579 (34%)	123 (18%)
Mean LVEF (%)	54.4 ± 16.4	51.7 ± 16.7	56.3 ± 15.8	54.2 ± 16.5	55.8 ± 14.7
LV systolic dysfunction	1189 (26%)	592 (32%)	597 (22%)	1074 (26%)	115 (21%)
Diastolic dysfunction	759 (17%)	290 (16%)	469 (17%)	676 (16%)	83 (15%)
Primary diagnosis (%)					
Hypertensive heart failure	1146 (22)	414 (19)	732 (23)	1050 (23)	96 (14)
Hypertension	988 (19)	343 (16)	645 (20)	854 (19)	134 (19)
Valve disease	724 (14)	233 (11)	491 (16)	660 (14)	64 (9.1)
Coronary artery disease	581 (11)	342 (16)	239 (7.5)	271 (5.9)	310 (44)
Idiopathic dilated CMO	502 (9.4)	268 (12)	234 (7.4)	470 (10)	32 (4.6)
RHF/pulmonary hypertension	345 (6.5)	160 (7.4)	185 (5.8)	311 (6.7)	34 (4.8)
HIV-related heart disease	518 (9.7)	197 (9.1)	321 (10)	500 (11)	18 (2.6)

NYHA, New York Heart Association Class; LVEF, left ventricular ejection fraction; LV systolic dysfunction, LVEF <45%; CMO, cardiomyopathy; RHF, right heart failure; Diastolic dysfunction, based on E/A ratio and deceleration time according to generally accepted criteria.[16]

which peaked in 30–39 year olds and then declined slowly thereafter. Alternatively, for male Sowetans, new heart disease cases peaked between 50–69 years and then decreased thereafter while historically prevalent cases peaked in 50–59 year age group before decreasing. This pattern was very similar for male migrant Africans. For female migrants however, new heart disease case presentations peaked in 50–59 year olds before declining compared with historically prevalent cases which decreased across all age groups. Although there was no interaction between age, sex, and presentation in 'migrants', there was a borderline association in native Sowetans ($P = 0.059$); the probability of a women aged 20–29 years presenting with historically prevalent heart disease being 1.25-fold greater, but 0.67-fold less likely in the 70+ years age group relative to age-matched males.

Figure 3 shows the estimated rate of case presentations per 100 000 within the hospital's catchment area (estimated at 1.45 million people aged ≥20 years) according to historically prevalent vs. 'new' heart disease. Case presentation in the former was higher in those aged up to 49 years (rising from 19 to 60 cases/100 000 per annum), rising to a peak in those aged >60 years (211 cases/100 000 per annum). Case presentation with predominantly hypertensive HF and CAD was extremely low in those aged 20 to 39 years before rising dramatically thereafter to 343 cases/100 000 per annum in the oldest age group. Overall, the estimated rate of case presentation of historically prevalent vs. 'new' heart disease in adults living within the hospital's catchment area was 45 and 42 cases/100 000 per annum, respectively.

Impact of modifiable risk factors in historically prevalent heart disease

Although modifiable/lifestyle risk factors were not abundant in those with historically prevalent heart disease ($n = 2092$), multivariate analyses indicated they may (along with socio-economic factors) still play an important role in determining the acuity of presentation. Secondary valve dysfunction in the setting of a

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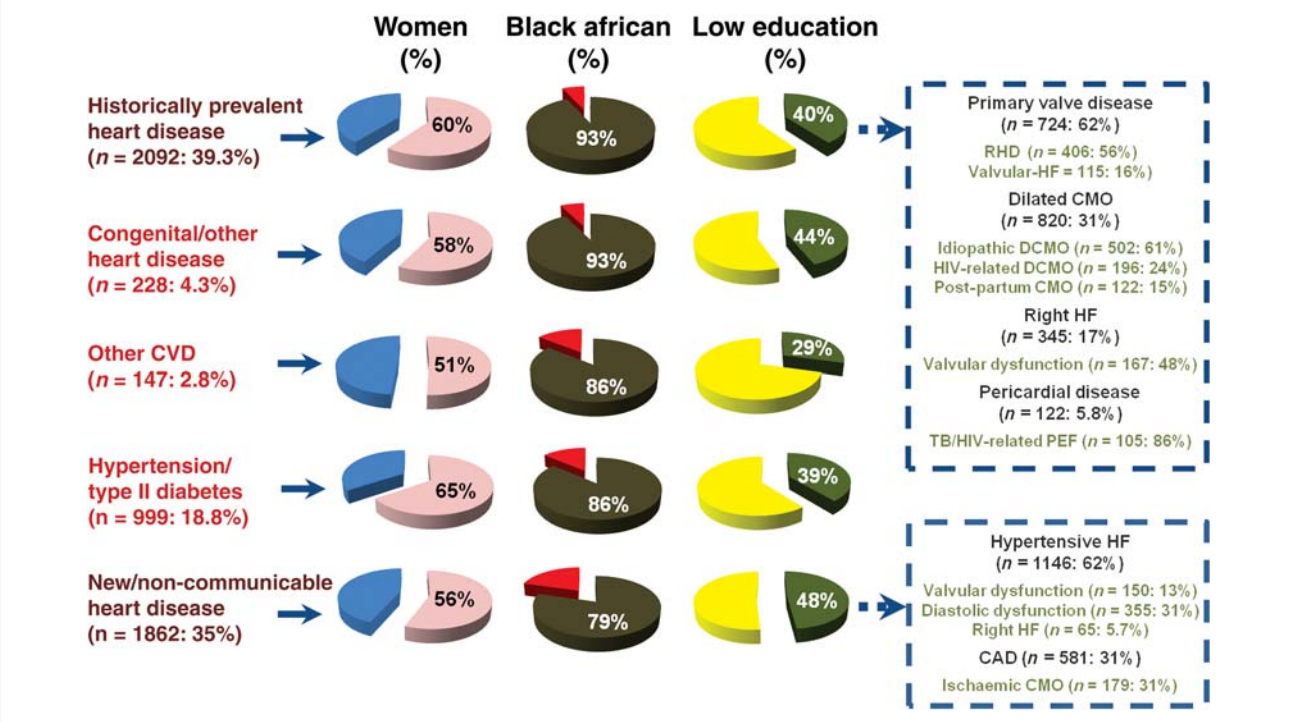

Figure 1 Spectrum of *de novo* case presentations ($n = 5328$).

Table 3 Socio-demographic and risk factor profile according to historically prevalent vs. 'new' heart disease ($n = 3954$)

	Prevalent heart disease ($n = 2092$)		New heart disease ($n = 1862$)		Adjusted odds ratio for prevalent disease
	Men	Women	Men	Women	All cases
Socio-demographic profile (%)					
Mean age in years	49.9 ± 17.2	45.8 ± 18.2	57.3 ± 13.9	59.4 ± 14.3	OR 0.98; 95% CI 0.97–0.99 ($P = 0.001$)
African descent ($n = 3426$)	749 (90)	1197 (95)	591 (73)	889 (85)	OR 4.59; 95% CI 2.76–7.60 ($P = 0.0001$)
Female ($n = 2307$)	—	1260 (100)	—	1047 (100)	OR 0.67; 95% CI 0.49–0.92 ($P < 0.012$)
<6 years education ($n = 1740$)	353 (42)	485 (38)	376 (46)	526 (50)	0.427
Originally from Soweto ($n = 2093$)	307 (37)	429 (34)	952 (51)	416 (40)	OR 0.87; 95% CI 0.75–1.00 ($P < 0.045$)
Years living in Soweto	36.7 ± 17.2	34.9 ± 18.1	41.7 ± 17.5	43.8 ± 17.2	0.624
Risk factor profile (%)					
Family history of CVD ($n = 1591$)	239 (29)	506 (41)	846 (45)	846 (45)	OR 0.75; 95% CI 0.57–1.01 ($P = 0.054$)
Total cholesterol level (>5.0 mmol/L) ($n = 385$)	40 (15)	63 (18)	119 (28)	201 (37)	OR 0.51; 95% CI 0.37–0.72 ($P < 0.0001$)
Hypertension ($n = 2106$)	234 (28)	377 (24)	596 (73)	899 (86)	OR 0.15; 95% CI 0.11–0.21 ($P < 0.0001$)
History of smoking ($n = 1858$)	576 (69)	372 (30)	562 (69)	348 (33)	0.516
Type II diabetes ($n = 220$)	24 (2.9)	32 (2.5)	68 (8.3)	96 (9.2)	0.672
Obese (BMI >30 kg/m^2 ($n = 939$)	75 (13)	284 (30)	163 (28)	437 (55)	OR 0.61; 95% CI 0.45–0.82 ($P = 0.001$)

dilated CMO was more common in men (adjusted OR 1.35, 95% CI 1.01–1.79; $P = 0.041$), those originating from Soweto (OR 1.34, 95% CI 1.03–1.74; $P = 0.030$), those with a smoking history (OR 1.74, 95% CI 1.31–2.29; $P < 0.001$), and increased BMI (OR 1.02, 95% CI 1.00–1.04 per kg/m^2; $P = 0.032$). Similarly, those presenting with associated LV systolic dysfunction were also more likely to originate from Soweto (adjusted OR 1.49, 95% CI 0.97–2.27; $P = 0.069$), have <6 years education (OR 1.57, 95% CI 1.12–2.20; $P = 0.009$) and a lower total serum cholesterol level (adjusted OR 0.80, 95% CI 0.70–0.92; $P = 0.032$). There was also a gradient in total cholesterol levels according to educational experience; 3.6 ± 1.4, 3.7 ± 1.3, and 4.2 ± 1.5 mmol/L in

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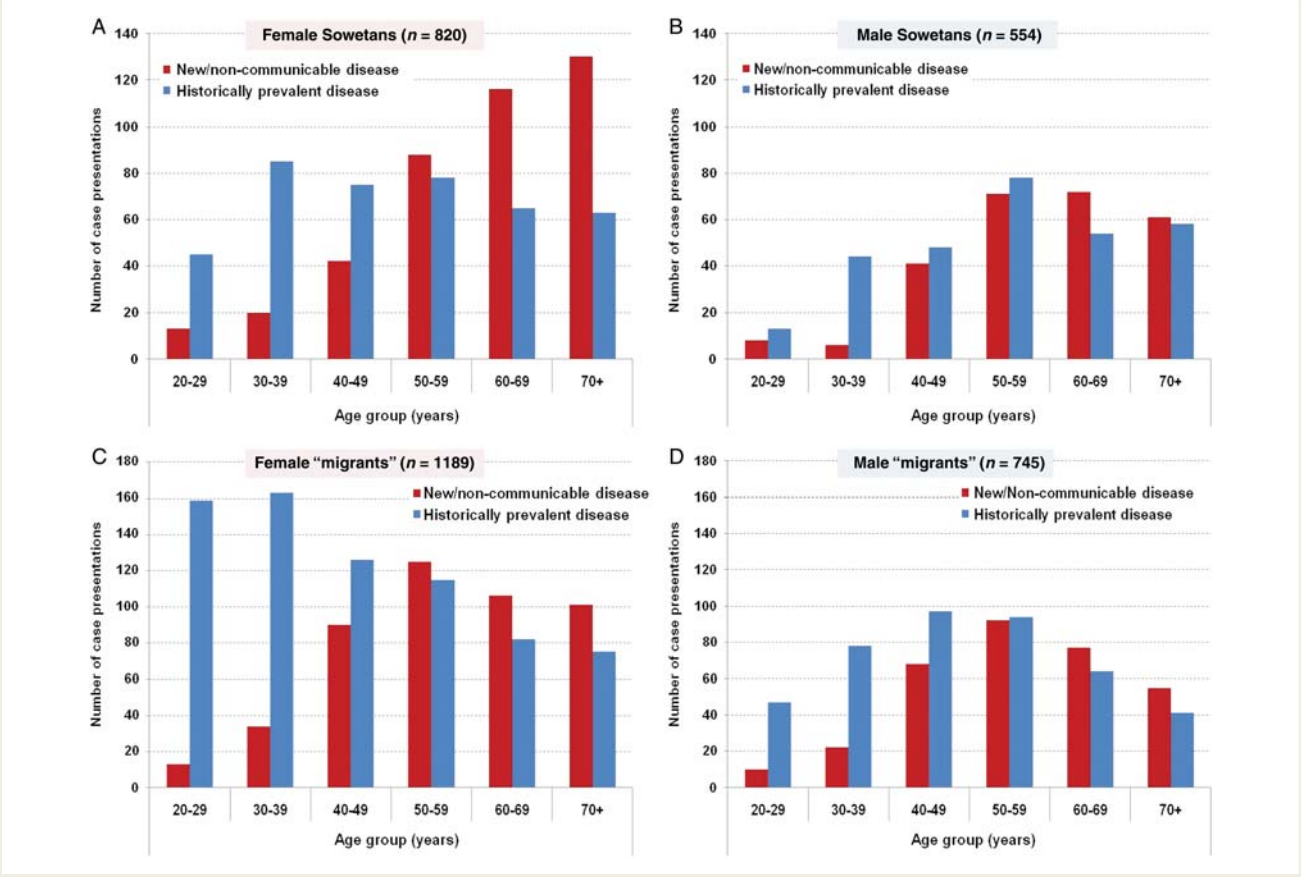

Figure 2 Pattern of 'new' and historically prevalent heart disease in Sowetan vs. 'migrant' Africans ($n = 3308$).

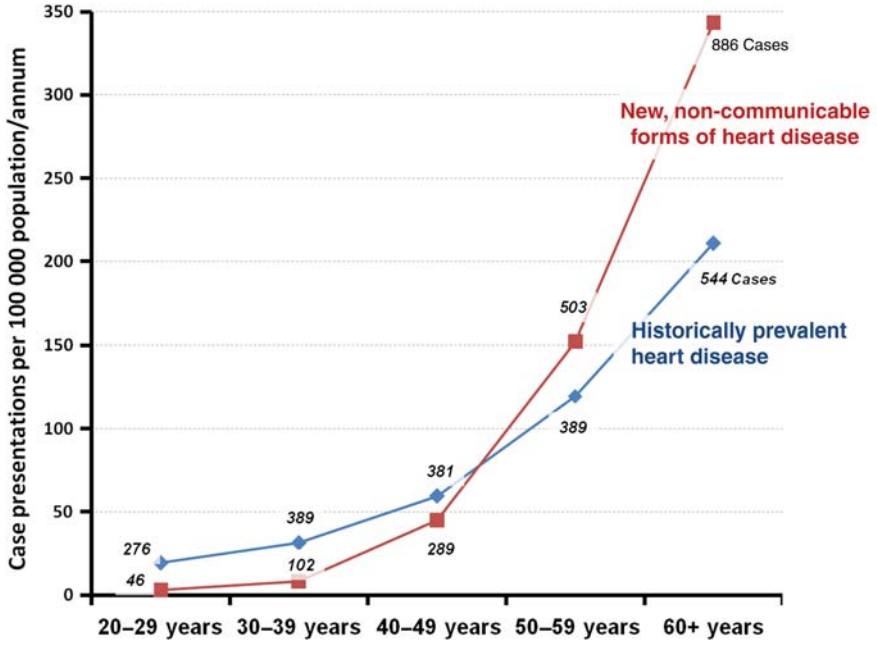

Figure 3 Rate of case presentation of historically prevalent vs. new forms of heart disease according to age group in all racial groups ($n = 3805$).

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those with <6, 6–10 years and >10 years education, respectively ($P < 0.0001$).

Discussion

We present data from Sub-Saharan Africa's largest and most comprehensive cohort study of advanced forms of heart disease.[21,22] As a likely barometer for other Sub-Saharan communities in epidemiological transition,[21,22] the mostly African residents of Soweto are subject to dynamic and complex factors. This includes economic development, erosion of traditional lifestyles, rural migration, and global influences likely to adversely impact the health of vulnerable communities. A growing local appetite for products historically absent from the region (e.g. processed foods) will almost inevitably 'feed' new forms of disease. As a consequence of high levels of risk but poor awareness of healthy lifestyle choices, it appears that Soweto already stands at the crossroads between historically prevalent and newer forms of heart disease due to epidemiological transition. In particular, older African women (particularly those originating from Soweto) appear to be the greatest contributors to this phenomenon.

Specifically, we captured clinical data from 5328 *de novo* cases of hypertension and heart disease (the latter comprising almost 4000 cases). Contrary to contemporary reports,[13] the single most prevalent form of heart disease was hypertensive HF (>1100 cases). When combined with 581 cases of CAD (47% of whom were African), the ratio of these 'new' vs. historically prevalent forms of heart disease was almost 1:1 (both numerically and population rate of presentation). Significantly, we also found a large pool of hypertensive cases at high risk of developing advanced heart disease.[23] Ominously, these data suggest that if South Africa continues to improve life expectancy through positive socio-economic changes and tackling of the HIV epidemic, the number of older adults (particularly women) paradoxically affected by non-communicable forms of heart disease will soon surpass the number of relatively younger adults affected by historically more prevalent disease states.

With the notable exception of hospital-based studies focusing on a single condition such as HF,[24] we are unaware of comparable reports from the region. When compared with the population-based studies across the spectrum of CVD,[25–26] this study highlights a significant gap in our knowledge about advanced forms of heart disease in the region requiring more research capacity as the burden rises.[14] Unfortunately, research funding is almost exclusively directed to towards combating communicable disease in Sub-Saharan Africa.[27] There is potential for a rise in heart disease linked directly to HIV and anti-retroviral therapy[28] (including CAD in individuals without significant atherosclerosis[29] and HIV-related CMO). However, the greatest threat appears to emanate from a complex set of socio-economic circumstances and the rise of non-communicable heart disease. In contrast to high-income countries, the most striking features of these data are the relatively young age of affected individuals and the predominance of women. However, there were clearly identifiable and predictable differences in the pattern of clinical presentations according to socio-demographic profile. It is interesting to note the expected pattern of increasing non-communicable heart disease with advancing age overall but with a significant contribution from older African women (most notably Sowetans) and, by weight of numbers, migrants. Significantly, the prevalence of lifestyle risk factors (excepting dyslipidaemia and diabetes) was still relatively high in those with historically prevalent heart disease. As hypothesized, this influenced the acuity of such cases. Although there was a notable difference in the absolute proportion (93 vs. 79%) and adjusted risk of Africans presenting with historically prevalent vs. 'new' heart disease, it is important to note that almost 500 individuals of African descent per annum still presented with the latter.

It is important to consider if a predicted rise in non-communicable forms of heart disease is justified. Many studies have now documented a rise in life style risk factors in Sub-Saharan Africa.[6,22] Consistent with epidemiological transition, urban regions, where traditional lifestyles associated with a near historical absence of atherosclerotic disease, are being replaced by that typically seen in high-income countries (particularly obese women) are affected most. The predominance of uncomplicated hypertension and hypertensive HF confirms bleak predictions of a wave of such cases in urban Sub-Saharan Africa.[30] The estimated rate of case presentations of non-communicable heart disease in the region (by its very nature a very conservative indicator) of 42 cases/100 000 population per annum is not inconsistent with the WHO estimate of an age-adjusted mortality rate of 389 deaths per 100 000 population/annum in South Africa.[31]

These data highlight many complex and challenging health issues for Soweto and beyond. In addition to revisiting strategies to combat 'old' problems such as RHD,[9] we need to better understand the nexus between heart disease and HIV infection and likely trends within a population that now has high levels of both underlying infection/inflammation and modifiable risk factors. Fundamentally, these data reconfirm the urgent need to establish cost-effective (region-specific) primary prevention strategies and secondary prevention programmes[32] with early disease detection and chronic disease programmes being an obvious priority.[2] At the same time, there is a need to better understand the underlying dynamics and drivers of epidemiological transition in different communities. Consequently, we are now focusing on the primary care burden and management of heart disease in Soweto[33] and the Heart of Africa Study examining heart disease throughout Sub-Saharan Africa.

This study has a number of limitations. A small proportion of potential cases (<10%) were not captured by our registry without evidence of systematic bias in case selection. Despite the central importance of Baragwanath Hospital to managing advanced forms of heart disease in Soweto, it does not reflect the full spectrum of disease (from minor to fatal events) in the community. Impending results from the Heart of Soweto Primary Care Registry (involving >1000 cases) will be important in this context. Moreover, unlike a recent study in Maputo, Mozambique we did not specifically focus on capturing cerebrovascular disease.[34] Although we systematically applied echocardiography and 12-lead ECG, clinical data were obtained according to the nature of the presentation. We also acknowledge the often arbitrary nature of case classifications given the complexity of case presentations and our decision to designate historically prevalent vs.

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new heart disease based on previous reports. Estimate rates of case presentations (like those of the WHO) are complicated by a lack of reliable population data for a dynamic region with large numbers of migrants and itinerant households. By necessity, we also did not collect detailed socio-economic data (e.g. household income). Finally, it is possible that our systematic approach to screening has revealed previously hidden levels of non-communicable heart disease.

Our unique data suggest that Soweto, like other urban regions in Sub-Saharan Africa where modifiable risk factors such as hypertension and obesity are becoming the norm, sits at the crossroads between historically prevalent and 'new' forms of heart disease. If current trends continue, it appears inevitable there will be more patients with non-communicable than communicable heart disease in the near future. The worst case scenario is a sustained burden of complex cases involving predominantly young African women in whom modifiable risk factors alter the natural history of already prevalent disease and an ever increasing burden of relatively older cases with advanced forms of non-communicable heart disease. Clearly, specific primary and secondary prevention strategies will need to be developed to facilitate earlier detection and optimal management of such cases within a resource-poor healthcare environment. As such, appropriate funding to combat the evolving burden of heart disease in these vulnerable communities is urgently required.

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Conflict of interest: All authors had full access to all the data in the study. The corresponding author had final responsibility for the decision to submit the report for publication. There is no conflict of interest for any of the authors of this manuscript.

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3.1.2 Communicable versus non-communicable diseases

Our data suggested that the epidemiological transition is broadening the spectrum of advanced forms of heart disease in this urban community and that Soweto stands juxtaposed between the old and the new, with infectious forms of heart disease still present, while newer non-communicable forms of heart disease, due to socio-economic and lifestyle factors, rapidly on the increase [4]. It highlights the fact that the population of Soweto faces many complex and challenging health issues, that we must move beyond strategies to prevent just infectious diseases, and that we need to better understand the connections between NCDs and infectious diseases within a population that now has high levels of both [4].

With these data we have reconfirmed an urgent need to establish appropriate and cost effective primary and secondary prevention strategies and programmes and to better understand the underlying drivers of the epidemiological transition in these communities. We therefore, extended our research into the primary care setting and the broader community of Soweto in order to assess and describe risk factors contributing to the development of chronic diseases of lifestyle, with the aim of utilising this information to assist with the development of proactive prevention and management programmes to reduce or prevent NCDs in urban communities [5].

It is clearly of the utmost importance to reduce the risk factors contributing to chronic diseases of lifestyle to improve the health of a population and ultimately a country. But in order to do so, we need to better understand as many of the mechanisms contributing to this increased risk as possible [7]. As mentioned previously, poor diet and limited physical activity play an important role, but it is imperative to look beyond the known risk factors. Less well examined in this population, and a potentially important and modifiable contributing risk factor, is sleep duration. We therefore, wanted to establish whether an association exist between sleep duration, as well as exposure to second-hand smoking and these risk factors in publication 3.2.

Publication 3.2: Is there an association between sleeping patterns and other environmental factors with obesity and blood pressure in an urban African population? (Statement of originality document: Please see Appendix C) [6].

PLOS | ONE

RESEARCH ARTICLE

Is There an Association between Sleeping Patterns and Other Environmental Factors with Obesity and Blood Pressure in an Urban African Population?

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Abstract

Beyond changing dietary patterns, there is a paucity of data to fully explain the high prevalence of obesity and hypertension in urban African populations. The aim of this study was to determine whether other environmental factors (including sleep duration, smoking and physical activity) are related to body anthropometry and blood pressure (BP). Data were collected on 1311 subjects, attending two primary health care clinics in Soweto, South Africa. Questionnaires were used to obtain data on education, employment, exercise, smoking and sleep duration. Anthropometric and BP measurements were taken. Subjects comprised 862 women (mean age 41 ± 16 years and mean BMI 29.9 ± 9.2 kg/m^2) and 449 men (38 ± 14 years and 24.8 ± 8.3 kg/m^2). In females, ANOVA showed that former smokers had a higher BMI ($p<0.001$) than current smokers, while exposure to second hand smoking was associated with a lower BMI ($p<0.001$) in both genders. Regression analyses demonstrated that longer sleep duration was associated with a lower BMI ($p<0.05$) in older females only, and not in males, whilst in males napping during the day for > 30 minutes was related to a lower BMI ($\beta = -0.04$, $p<0.01$) and waist circumference ($\beta = -0.03$, $p<0.001$). Within males, napping for >30 minutes/day was related to lower systolic ($\beta = -0.02$, $p<0.05$) and lower diastolic BP ($\beta = -0.02$, $p = 0.05$). Longer night time sleep duration was associated with higher diastolic ($\beta = 0.005$, $p<0.01$) and systolic BP ($\beta = 0.003$, $p<0.05$) in females. No health benefits were noted for physical activity. These data suggest that environmental factors rarely collected in African populations are related, in gender-specific ways, to body anthropometry and blood pressure. Further research is required to fully elucidate these associations and how they might be translated into public health programs to combat high levels of obesity and hypertension.

Competing Interests: The authors have declared that no competing interests exist.

Introduction

Previous studies performed in an urban African population living in Soweto, South Africa have shown prevalences for obesity of 42–50% in women [1,2]. Income inequalities in South Africa, as in the rest of Africa, has resulted in populations migrating from rural to urban areas, leading to changes in lifestyle and a higher prevalence of obesity, which has become, due to its associated diseases, a major public health concern [2,3]. The increasing prevalence of obesity and its comorbid diseases require a better understanding of the contributing factors that predispose individuals to gain weight. This is necessary to plan intervention strategies and thus improve public health [4].

An association between weight gain, obesity and sleep duration has consistently been demonstrated in recent research. It has been shown that sleep duration can have important effects on health and that both short (<7 hours sleep a night) or long sleep duration (≥ 9 hours sleep a night) may represent a risk marker for poorer health outcomes rather than a causal risk factor for diseases [5]. Several studies have reported a relationship between sleep duration and chronic diseases, such as heart disease, diabetes and obesity [6,7,8]. Longer sleep has been associated with unemployment, low education levels, low income, alcohol consumption, depression, low physical activity levels, pregnancy and ethnicity. Short sleep duration is associated with weight gain and obesity, diabetes mellitus, cardiovascular disease, psychiatric illness, performance deficits, as well as higher levels of schooling and income, longer working hours and being single [4,8,9].

The prevalence of obesity within a population is also known to be associated with social factors such as urbanisation [10,11], education and socio-economic status (SES) [12]. Meta-analyses of the relevant literature have shown that in developed countries a negative relationship exists between SES and obesity while this moves to a positive relationship in low income nations [12,13]. Studies have also indicated that smoking cessation leads to increases in body weight [14]. Smoking and obesity are leading causes of morbidity and mortality worldwide and are associated with increased risk of cancers, high blood pressure, ischaemic heart disease and diabetes [15]. The relationship between smoking and obesity is complex. The fact that smokers have a lower body mass index (BMI) than non-smokers can be explained by the effect of nicotine, which increases energy expenditure and reduces appetite [15,16]. Furthermore, smoking cessation is frequently followed by weight gain [14,15]. However, studies indicate that heavy smokers have a higher BMI than light smokers (8–10 cigarettes per day) [15,16]. It is therefore important that variables, such as smoking history should also be quantified when analysing risk factors for obesity in different population groups.

Studies linking sleep duration and smoking status to obesity and related metabolic diseases have largely been restricted to populations in developed countries, with very little data available from African nations. The social determinants of obesity have also been under studied in these countries. Developing nations in Africa have a rising prevalence of obesity, particularly in urban, female populations [17,18]. Therefore, the aim of the current study was to assess the relationship of social factors, smoking status and sleep duration with measures of obesity in an urban African population resident in the Johannesburg-Soweto conurbation.

Methods

Study setting

The overall goal of the Heart of Soweto study (HOS) was to systematically examine and respond to the epidemiologic transition in risk behaviours and clinical presentations of heart disease in an urban African community in Soweto, South Africa [19]. In order to assess chronic

diseases of lifestyle, such as heart disease, diabetes, high blood pressure and obesity, and to plan appropriate intervention strategies, we extended our research into the Soweto community and primary health care setting [1]. Consistent with the HOS clinical registry [19] data were systematically collected on consecutive patients attending two pre-selected primary care clinics from a total of 12 clinics in Soweto (644 and 667 patients from Mandela Sisulu, Orlando West and Michael Maponya, Pimville primary health care clinics in Soweto, respectively). These two primary health care clinics were chosen as they are situated in two diverse socio-economic locations in Soweto. The study was undertaken over a 6 month period and involving 50 discrete days of screening (commencing June 2006) [20].

Participants

Each primary care clinic typically manages more than 300 patients per day with wide-ranging health issues. A study team comprising an experienced cardiac nurse, ECG technician and co-ordinator invited consecutive consenting patients aged over 16 years who presented to the primary care clinic to be screened. All patients were reviewed by a primary health care nurse prior to assessment. A target of assessing approximately 25 consecutive patients each screening day was maintained during the study period [20].

Study data collection

Each participant was subject to a standardised program of assessment as follows (information was collected from patients using a questionnaire that was used in a previous study within this population group) [20]: 1. Self-reported cultural and socio-demographic profile including ethnic origin (African, European, Indian or mixed ancestry), duration of residence in Soweto, highest level of education (none, junior school only, high school without graduating, graduated from high school, tertiary education) and whether currently employed; 2. Risk factor profiling, including smoking status. 3. Anthropometric profile including height and weight with calculation of BMI. Weight was measured with a calibrated Seca 767 electronic scale (Lifemax, Johannesburg, South Africa) that weighs up to 200 kg and height was measured with a Seca 220 telescopic measuring rod according to acceptable standardised methods [21]. The WHO guidelines were used to classify individuals as obese (BMI of 30 or more) [9]. Waist and hip circumference were measured with a standardised measuring tape calibrated in cm. All participants were weighed and measured with their clothes on, but without their shoes; 4. Blood pressure was measured on the right arm by a registered nurse, using the Omron automatic digital blood pressure monitor (Omron M10-IT BPM-Digital, Johannesburg, South Africa). The subject was seated upright and relaxed with his/her right arm supported at heart level. Subjects were instructed to refrain from eating, smoking, ingesting caffeine or exercise/physical activity such as climbing the stairs in the 30 minutes prior to the measurement. HT was diagnosed i.e. subjects with BPs of 140/90 according to South African Hypertension Society guidelines and/or those who were being treated for HT [1,22]; 5. Medical history and management including prior or current diagnoses of diabetes and hypertension and pharmacological therapy related to the treatment of hypertension; 6. Self-reported sleep duration was assessed by asking participants the following questions: "During your longest or nocturnal sleep period, what time do you normally go to bed?" and "During your longest or nocturnal sleep period, what time do you normally wake up?"; 7. Self-reported napping was assessed by asking participants the following questions: "Do you usually take a nap, yes or no?" and "If yes, total nap duration in minutes?". 8. Smoke exposure was measured by asking participants the following questions: "During the past 12 months, have you been regularly (at least once per week) exposed to other

people's tobacco smoke and what has been your typical exposure? ("Exposed" is defined as a minimum of 5 consecutive minutes, during which you inhale other people's smoke).

Statistical Analysis

All statistical analyses were performed using Statistica version 12 SP2 (StatSoft, Tulsa, OK, USA). Normally distributed continuous data are presented as the mean ± standard deviation. Data that was not normally distributed are presented as the median (interquartile range (IQR)) and these variables were log transformed to normality before being analysed using parametric statistical tests.

Means for continuous variables were compared between 2 groups using Students t test, whilst trends across 3 or more groups were assessed using ANOVA with the Tukey HSD post hoc test used for the comparison of paired means. Percentage values were compared across groups using the χ^2 test. Multiple linear regression models were developed to identify the determinants of anthropometric and metabolic variables. The independent variables included in the initial regression models were chosen based on previous statistical analyses and biological plausibility. The independent variables included in the models for BMI were: age, education level, employment status, smoking status, exposure to tobacco smoke, night time sleep duration, day time nap duration, walking distance per day, diabetes, hypertension and treatment type, HIV and TB status. The regression models for waist included all above variables plus BMI. The regression models for systolic and diastolic blood pressures included the same independent variables as for the BMI models but included BMI and waist but excluded hypertension. The same variables were included in the regression models for males and females. Only the independent variables that had $p \leq 0.05$ are reported in the results.

The linearity of all continuous variables was analysed by the observation of scatter plots of observed versus predicted values and residuals versus predicted values. These showed that all continuous variables were linear with the exception of sleep duration. This variable was therefore used in all regression models as either a continuous variable or as a categorical variable. The categorical variable was generated by creating dummy variables for quartiles, with the lowest quartile as the reference.

Outliers were identified by observation of normal probability plots used in combination with lower and upper cut points defined as: lower quartile boundary–(1.5 X IQR) and upper quartile boundary + (1.5 X IQR), respectively. A number of data points that fell above the upper cut point for BMI were observed. Removal of these from the dataset during statistical analysis had minimal effects on the outputs.

Ethics Statement

The Chairman of the human Research Ethics Committee (Medical) of the University of the Witwatersrand has reviewed and approved the request to continue with the Heart of Soweto Study and extending the collection of data into primary health care clinics in Soweto, protocol number, M050550.

As with the 'Heart of Soweto Registry', of which data from the first 4162 cases has been published in 'The Lancet' (2008) [19], every patient in the survey was assigned a unique identifying code (nine digits), and all documentation were labelled accordingly to maintain anonymity.

All participating patients provided verbal consent to become part of the survey, as this was in line with registries at the University of the Witwatersrand at the time, as approved by the ethics committee. Only patients who gave verbal consent were recruited into the survey and a registration form was then completed for those patients who consented.

Results

Characteristics of Study Population

A total of 1311 adult subjects were interviewed, comprising 862 women (66% of the study group) and 449 men and of whom 1294 classified themselves as black African. As summarised in Table 1 females were approximately 3.5 years older than males and had a nearly 3-fold higher prevalence of obesity and had median waist and hip circumferences that were 9.0 and 12.0 cm greater than for males ($p<0.001$ for all comparisons). Sleep duration ($p<0.01$) was 0.30 hours higher in females. Nearly 4-times as many men as women were current smokers ($p<0.001$) and the frequency of the exposure to second hand cigarette smoke was 8.2% higher in men ($p<0.01$). The level of unemployment was 12.0% higher in males than females ($p<0.001$). No gender differences were noted for either diastolic or systolic blood pressure levels however, the prevalence of hypertension was 12.5% higher in females than males ($p<0.001$), and within the total cohort 52.5% of hypertensive subjects were receiving therapy for hypertension. The anti-hypertensive agents being used and their frequency of use within the hypertensive subjects were: thiazide diuretics (48.1%), ACE inhibitors (22.9%), nifedipine (17.8%), beta blockers (3.2%), furosemide (2.4%) and spironolactone (0.48%). Within the hypertensive subjects, 61.5% were receiving 2 or more anti-hypertensive agents.

Anthropometric effects of sleep, smoking, education, employment, exercise, HIV and TB

Table 2 shows that sleeping during the day (napping) was associated with a lower BMI in males but this effect was not significant in females. In both genders, current smokers had lower BMIs

Table 1. Comparison of male and female subjects.

Variables	Males	Females	Combined
Age (years)	37.6 ± 14.0	41.1 ± 16.4***	39.9 ± 15.7
BMI	22.9 (20.5, 26.7)	28.3 (23.5, 34.7)***	26.1 (22.1, 32.4)
Obesity (%)	14.1	41.8***	32.4
Waist (cm)	83.0 (76.0, 92.0)	92.0 (81.0, 103)***	89.0 (78.0, 100)
Hip (cm)	98.0 (91.0, 105)	110 (100, 121)***	105 (96.0, 117)
Diastolic bp (mmHg)	81.3 (74.0, 91.0)	83.0 (74.3, 93.0)	82.7 (74.3, 92.3)
Systolic bp (mmHg)	128 (117, 142)	129 (116, 145)	129 (117, 144)
Hypertension (%)	39.9	52.5***	48.2
Sleep duration (hours)	8.55 ± 1.78	8.85 ± 1.67**	8.75 ± 1.72
Sleep in the day (%)	28.3	29.6	29.2
Current smoker (%)	36.2	9.62***	18.6
Smoke exposed (%)	80.6	72.4**	75.2
High school graduates (%)	45.5	41.5	42.9
Employed (%)	37.8	25.8***	29.8
Walk > 2km/day (%)	75.7	71.8	73.1
HIV-positive (%)	5.69	6.68	6.35
TB-positive (%)	2.96	2.46	2.63

Age and sleep duration are expressed as mean ± SD, whilst BMI, waist, hip, diastolic and systolic blood pressure are given as median (interquartile range) and the remaining variables are expressed as percentages

**p<0.01

***p<0.001 versus males.

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Table 2. BMI values in different population sub-groups for each gender.

Variables		Males			Females		
		BMI	β-value (%)	n	BMI	β-value (%)	n
Sleep in the day	***No***	23.2 (21.0, 26.9)	-	296	28.6 (23.5, 35.0)	-	569
	Yes	22.4 (19.9, 25.3)*	-2.49±1.17	116	27.2 (23.1, 33.6)	-1.58±0.92	237
Smoking status	***Current***	21.9 (19.6, 24.1)	-	157	24.9 (21.5, 29.7)	-	82
	Former	22.3 (20.5, 25.4)	1.45±1.77	46	30.7 (25.2, 36.3)***	7.81±2.25	40
	Never	24.2 (21.5, 27.7)***	5.34±1.10	226	28.6 (23.6, 34.7)***	5.76±1.36	711
Smoke exposed	***No***	24.5 (21.3, 30.6)	-	79	30.7 (26.1, 36.3)	-	225
	Yes	22.8 (20.3, 26.1)***	-4.86±1.33	347	27.2 (22.8, 33.3)***	-4.36±4.79	607
High school graduate	***No***	23.3 (21.2, 27.3)	-	232	29.8 (24.8, 36.0)	-	485
	Yes	22.2 (20.1, 26.2)*	-2.00±1.05	195	26.3 (22.2, 32.0)***	-4.46±0.82	341
Employed	***No***	23.2 (21.0, 27.0)	-	242	28.3 (23.7, 35.0)	-	591
	Yes	22.5 920.6, 26.0)	-1.55±1.14	149	28.6 (23.6, 34.4)	0.05±0.96	207
Walk > 2km/day	***No***	23.5 (21.1, 27.6)	-	101	30.0 (23.1, 35.0)	-	233
	Yes	22.8 (20.3, 26.2)	-1.84±1.23	319	27.7 (23.6, 34.4)	-1.43±0.91	593
HIV status	***Negative***	22.8 (20.5, 26.5)	-	407	28.6 (23.6, 35.0)	-	777
	Positive	24.7 (20.3, 29.9)*	5.48±2.26	24	25.5 (22.8, 30.7)*	-4.46±1.61	57
TB status	***Negative***	22.9 (20.6, 26.6)	-	418	28.4 (23.5, 34.7)	-	813
	Positive	20.8 (19.0, 28.6)	4.74±3.04	13	24.8 (21.9, 27.3)**	-7.45±2.60	21

Data is expressed as median (interquartile range)

*p≤0.05

**p<0.01

***p<0.001

BMI was logged; β-values (effect sizes) were multiplied by 100 to give percentage values (± SD) and were generated from regression models with "No" or "Negative" coded as 0 and "Yes" or "Positive" coded as 1 and for smoking status, "Former" and "Never" were both compared against"Current".

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than those who never smoked, whilst in females former smokers had a significantly higher BMI than current smokers. Exposure to second hand cigarette smoke was associated with a significantly lower BMI in both genders. Subjects who graduated from high school had lower BMIs than those who did not graduate, and this effect was significant in males and females. Neither employment status nor walking more than 2 km per day had a significant effect on BMI in either gender. Within females but not males, HIV and TB positivity were both associated with a significantly lower BMI than that observed in subjects without these infections.

Waist circumference was also analysed across the same exposure groups as depicted in Table 2. Smoking status, smoke exposure, education and HIV status all had the same effects on waist circumference (data not shown) as those observed for BMI (see Table 2). In males, sleep during the day had a similar effect on waist circumference as for BMI, whilst in females BMI was not significantly affected (see Table 2) but waist circumference was lower in those who slept during the day (90.0 [78.0, 102] vs. 92.0 [82.0, 104]; $p<0.05$). In males but not females, subjects who were employed had a lower waist circumference than those not employed (82.0 [75.5, 90.0] vs. 84.0 [76.0, 94.0]; $p<0.05$). Walking more than 2 km per day was associated with a lower waist circumference in females (91.0 [80.0, 102] vs. 95.0 [81.0, 108]; $p<0.05$), but not males. In females who were TB-positive, both BMI and waist circumference were significantly lower than in uninfected subjects whilst in males BMI was not affected (see Table 2) but waist circumference was lower in TB-positive compared to TB-negative men (74.0 [69.0, 80.0] vs. 83.0 [76.0, 92.0]; $p<0.05$).

Effect of smoke exposure on BMI and waist circumference

The data in S1 Fig shows that in males (ANOVA, $p<0.001$) and females (ANOVA, $p<0.001$) BMI falls with increasing exposure to second hand cigarette smoke. The analysis in these 2 groups includes subjects who are current, former and non-smokers. If the comparison is only performed in non-smokers, the effect is still statistically significant (ANOVA, $p<0.001$) with the highest BMI (29.3 [25.0, 35.3]) observed in subjects not exposed to environmental tobacco smoke, and the lowest BMI (25.5 [21.7, 31.8]) in subjects exposed to tobacco smoke $>$ 3 times/day. Similar trends were observed for waist circumference in males ($p<0.05$), females ($p<0.001$), and non-smokers ($p<0.001$).

Determinants of BMI and waist circumference in males and females

The results of linear multiple regression models for the identification of the determinants of body anthropometry and blood pressure are shown in Table 3. Age is shown to correlate positively and strongly ($p<0.001$) with all the dependent variables, with the exception of waist circumference in females.

Subjects who smoke have a BMI that is 4.0% lower in females and 3% lower in males than those who do not smoke. Furthermore, subjects who are environmentally exposed to tobacco smoke have a BMI that is 2.0% lower in both males and females than those who are not exposed, but this association was significant only in females ($p = 0.03$; $p = 0.14$ in males). In males, subjects who sleep during the day for more than 30 minutes have a BMI that is 4.0% lower than those who do not sleep in the day. In model 2 for females, a negative but non-significant association ($\beta = -0.004$; $p = 0.14$) was observed between sleep duration and BMI, whereas in a univariate analysis a significant association was observed ($\beta = -0.007$; $p = 0.005$). When age was removed from the multivariable model (model 2 in Table 3) the association between BMI and sleep duration became significant ($\beta = -0.005$; $p = 0.04$). Further analysis demonstrated that in a multivariable regression model for BMI that included age, sleep duration and an interaction term (age X sleep duration), the interaction term was negative and significant ($\beta = -0.0003$; $p = 0.02$), This interaction was confirmed by running univariate regression models for females above and below the median age (40 years). In the model for females below age 40, no significant association between BMI and sleep duration was noted ($\beta = -0.0003$; $p = 0.93$), but a significant relationship was noted in females with age above the median ($\beta = -0.008$; $p = 0.02$). These relationships are depicted in S2 Fig, where BMI falls significantly across quartiles of sleep duration in females with age $\geq$ 40 years (ANOVA, $p<0.05$) but not in females $<$ 40 years (ANOVA, $p = 0.88$). No such interaction was observed for male subjects. In males receiving treatment for hypertension BMI is 4.0% higher than hypertensive males who are not receiving therapy. In females without hypertension, BMI is 2.0% lower than in hypertensive females not receiving therapy.

Males who smoke have a waist circumference that is 1.0% lower than those who do not smoke. Male subjects who sleep for more than 30 minutes during the day have a waist circumference that is 3.0% lower than those who do not sleep in the day. Diabetic male subjects have a waist circumference that is 5.0% higher than non-diabetic subjects. Males who have HIV or TB infections have a waist circumference that is 4.0% or 6.0% lower respectively, than non-infected subjects. In non-hypertensive females, waist circumference is 2.0% lower than in hypertensive females not receiving therapy.

The data in Table 2 showed that waist circumference was lower in females who walked more than 2km per day compared to those who did not. However this relationship was not observed in the multiple regression analysis depicted in model 4 of Table 3 suggesting that the significant effect of exercise observed in Table 2 is the result of confounding.

Table 3. Multiple regression models for BMI, waist circumference and blood pressure in male and female subjects.

Model no. & gender	Dependent variable	Independent variables with unstandardized B (p-value)	Whole model R^2 (p-value)
		Age 0.001 (0.02)	0.13 (<0.001)
		Smoking -0.03 (0.008)	
1—male	BMI	Nap >30 mins -0.04 (0.006)	
		Treated HT 0.04 (0.02)	
		Age 0.002(<0.001)	
		Smoking -0.04 (0.004)	0.17 (<0.001)
2—female	BMI	Smoke exposure -0.02 (0.03)	
		Non-hypertensive -0.02 (0.04)	
		Age 0.001 (<0.001)	
		BMI 0.27(<0.001)	
		Smoking -0.01 (0.03)	
3—male	Waist	Nap >30 mins -0.03 (<0.001)	0.38 (<0.001)
		Diabetes 0.05 (0.01)	
		HIV -0.04 (0.005)	
		TB -0.06 (0.01)	
4—female	Waist	BMI 0.42 (<0.001)	0.48 (<0.001)
		Age 0.001 (<0.001)	
5- male	Systolic bp	Waist 0.18 (0.002)	0.16 (<0.001)
		Nap >30 mins -0.02 (0.01)	
		Age 0.001 (<0.001)	
6—female	Systolic bp	Waist 0.19 (<0.001)	
		Sleep duration 0.003 (0.03)	0.22 (<0.001)
		Age 0.001 (<0.001)	
		Waist 0.14 (0.03)	
7—male	Diastolic bp	Nap >30 mins -0.02 (0.05)	0.11 (<0.001)
		Age 0.0008 (<0.001)	
		Waist 0.21 (<0.001)	
		Education -0.01 (0.03)	
8—female	Diastolic bp	Nap>30 mins -0.02 (0.05)	0.16 (<0.001)
		Sleep duration 0.005 (0.002)	
		Walking 0.01 (0.05)	

The variables BMI, waist, systolic and diastolic blood pressure are all logged. Variable coding: Smoking, smoke exposure and employment–yes = 1, no = 0; TB and HIV–positive = 1, negative = 0; education—graduated from high school = 1, did not graduate = 0; walking—walk > 2km/day = 1, < 2km/day = 0; napping during the day was coded using dummy variables with subjects who did not nap used as the reference group and compared with subjects who napped $\leq$ 30 minutes/day and subjects who napped > 30 minutes/day; hypertension (HT) was coded using dummy variables with non-treated hypertensives used as the reference group and compared with non-hypertensives and treated hypertensives

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Determinants of blood pressure in males and females

Systolic and diastolic blood pressure correlate significantly with waist circumference in both genders (Table 3). Within females, diastolic blood pressure is 1.0% lower in subjects who graduated from high school when compared to those who did not graduate. Diastolic blood pressure in females is 1.0% higher in those who walk more than 2 km per day when compared to those who walk less than this distance. In males, systolic and diastolic blood pressure are both 2.0% lower in those who sleep for more than 30 minutes during the day and diastolic blood pressure is also 2.0% lower in females who sleep more than 30 minutes in the day when compared to subjects who do not sleep in the day. Systolic blood pressure is 0.30% lower and

diastolic 0.50% lower for every extra hour of night time sleep in female subjects. Due to the non-linearity of the relationship between sleep duration and blood pressure, sleep duration was divided into quartiles and dummy variables generated with the first quartile used as the reference. This was done only for the female subjects. These dummy variables were then included in models 6 and 8 as replacements for the continuous sleep duration variable. The median blood pressure levels were also calculated for each sleep duration quartile. Diastolic blood pressure rose from 81.8 (73.0, 91.0) in quartile 1 to 85.0 (75.7, 92.3) in quartile 2, 82.7 (75.3, 95.3) in quartile 3 and 83.0 (75.0, 93.3) mmHg in quartile 4 ($p<0.05$ for each of the top 3 quartiles versus quartile 1). This trend was repeated for systolic blood pressure. The replacement of the continuous sleep duration variable with a categorical variable did not affect the outputs of the other independent variables for either the diastolic or systolic regression models. An interaction term of age X sleep duration was also generated but showed no significant relationship with either systolic or diastolic blood pressure in the female subjects.

Discussion

This study confirms previous reports demonstrating a much higher prevalence of obesity in urban dwelling African women versus men [1,2]. The results showing that sleep duration in females and napping during the day in males is associated with both lower BMI and lower blood pressure is the first such data from an African study. Furthermore, this cross sectional study is the first to show that in an African population there is a negative relationship between smoking and BMI and is also the first to demonstrate that environmental tobacco smoke exposure is related to a lower body adiposity.

Female subjects in this cohort had a much higher prevalence of obesity, with 41.8% of females being obese compared to 14.1% of males. Females also had significantly higher waist and hip circumferences when compared to males. These results confirm data from previous studies performed in Soweto, showing that urban African females have a very high prevalence of obesity [1,2]. The much higher prevalence of obesity in females than males is characteristic of African populations [17,18], the reason for which is largely unknown.

The present study is the first to confirm the strong inverse effect of smoking on levels of obesity in an indigenous African population. Thus, BMI was higher in non-smokers when compared to those who currently smoke. Studies have previously shown that smoking may increase energy expenditure and reduce appetite [9,16]. Furthermore, it is known that weight gain occurs after people stop smoking and this is confirmed in the present study where subjects who have ceased smoking had higher BMIs than those who still smoke, especially amongst females [14–16]. Our data also demonstrates that male and female subjects that have been exposed to second hand cigarette smoke have a lower BMI than non-exposed subjects. This effect was stronger in females and was almost as strong as that observed for primary smokers. It was also seen in those individuals who are not smokers themselves. Previous studies have shown that passive smoke exposure during pregnancy or in infancy increase the risk of obesity in childhood [21,23] whilst the current study is the first to demonstrate that environmental tobacco smoke exposure in adults is associated with a lower BMI. Our observation from the present study suggest that national smoking intervention programmes must not only take cognisance of the effects of smoking cessation on weight gain in the primary smokers but also in the passive smokers. The prevalence of active smoking in African nations is high, particularly in males [24] and therefore it is possible that successful intervention programmes may have large effects on the prevalence of obesity in these countries. These observations are however, not aimed at policy change as we cannot draw sufficient conclusions from our cross-sectional study.

In the current study a negative relationship was observed between night time sleep duration and BMI in female subjects. A number of other studies have shown that inadequate sleep is associated with overweight and obesity [25–27]. It has been suggested that sleep restriction may lead to obesity via changes in the appetite regulating hormones leptin and ghrelin [28]. Thus, laboratory studies shows that with short sleep duration, leptin levels, a satiety signal, were reduced, while levels of ghrelin, an appetite stimulant, were increased. Furthermore studies have shown that short sleep duration does lead to increased caloric intake [29,30], and increased consumption of foods high in fat and refined carbohydrates has been observed after sleep restriction [4,9]. The relationship between BMI and sleep duration in females was only observed in older subjects. No other studies have shown a modifying effect of age on the relationship between sleep and BMI, and previous investigations have shown that the negative relationship between sleep duration and obesity risk is observed in both children and adults [31]. Therefore, this finding may be unique to our population however, more studies across different ethnic groups are required to confirm this observation.

The present study also demonstrated that female subjects with longer sleep duration had higher systolic and diastolic blood pressures. The relationship between sleep duration and blood pressure is complex, with studies showing a 'U' shaped association [32]. A 'U' shaped relationship was not observed in the present study, with both systolic and diastolic blood pressure in females initially increasing with longer sleep duration and then falling. The relationship between sleep duration and blood pressure also changes according to age group and gender with females aged 18–44 years and $\geq$ 65 years demonstrating a greater risk of hypertension at a sleep duration of $<$ 6 hours, whilst females aged 45–65 years demonstrated the highest risk of hypertension at a sleep duration of $\geq$ 10 hours [32]. No interaction was observed in the current study between age, sleep duration and BMI in the female subjects. The reasons why blood pressure increases at high levels of sleep duration is not fully understood.

In males, no association was observed between sleep duration and BMI however, males who slept during the day had a lower BMI and a lower waist circumference than those who did not nap in the day. A previous study has also shown that sleep in the daytime (siesta) is associated with a lower BMI [33]. It has also been demonstrated that napping for 1 hour or longer is associated with an increased risk of cardiac events [34] whilst napping for 30 minutes or less has some health benefits [35]. However, the current study clearly shows that napping for 30 minutes or more reduces blood pressure in males and females. The reason for these contradictory results may be that the study showing an increased risk of cardiac events with longer nap duration used an older population (45–75 years) than used in the present study, and also used subjects of European descent [34].

Multiple regression analysis demonstrated that the effect sizes for the associations of sleep duration with BMI and blood pressure were comparatively weak (β values between 0.003 and 0.005), whilst the effects of napping during the day were considerably stronger (β values between 0.02 and 0.03). It is also interesting to note that night time sleep duration only had significant associations in females, whilst napping in the day time had more associations in males (with BMI, waist, systolic and diastolic blood pressure) than females (diastolic blood pressure). Furthermore, napping correlated negatively with blood pressure in males and females but night time sleep duration correlated positively in females. These associations do not prove causality and may be moderated by other unmeasured variables. Therefore, more in depth studies are required to investigate the differential effects of day and night time sleeping patterns on BMI and blood pressure in the different genders and to map out the possible causal relationships between these variables.

A higher level of education in female subjects was related to lower diastolic blood pressures. No such relationship was observed in men. A differential relationship of education with

components of the metabolic syndrome across the genders has been observed in other investigations [36–38], but its causes are not known.

HIV and TB infection are both commonly associated with weight loss. Using regression analyses the current study demonstrates a strong relationship in males only of both HIV and TB infection with a low waist circumference. The reason for the differential effects of HIV or TB infection in males and females on waist circumference is not known. However, interpretation of these data is difficult because the treatment status and duration of infection for individuals was not recorded.

The present study demonstrated that male subjects treated for hypertension had a higher BMI than hypertensive males not receiving therapy. A total of 6 different pharmacological agents were being used in this population for treating hypertension, and 61.5% of hypertensive subjects were receiving 2 or more different therapies. Therefore, it was not possible to determine which specific anti-hypertensive agent was associated with the higher BMI. However, the most common agents being used were thiazide diuretics and it has been shown that hydrochlorothiazide is associated with increased levels of visceral fat [39]. Furthermore, a large proportion of hypertensive subjects were also using nifedipine, which is associated with fluid retention [40]. Further studies are required to determine why these effects on BMI were only seen in male subjects, and which anti-hypertensive agents were responsible for the association with weight gain.

Limitations of this study are that this was a cross sectional study and therefore true causation cannot be ascertained. Also, all sleep data were self-reported as per similar studies [4–6,8], and quality of sleep was not objectively assessed. A further limitation of this study is that smoking and environmental tobacco smoke exposure were not assessed via physical measurements e.g. from serum cotinine levels. Additionally, there are other variables that were not measured in this study and which may explain some of the observed associations. Thus, income was not ascertained and neither was alcohol intake or dietary consumption. Also, the number of male subjects was lower than the number of female subjects and therefore the absence of associations in males may be due to a lack of statistical power.

Data from this study suggests that sufficient sleep duration should be recommended as part of a healthy lifestyle, but more cohort studies are required to determine whether excessive sleep duration is a biological risk factor for high blood pressure and cardiovascular disease. The positive effects of daytime napping observed in the current study need to be confirmed in a larger study and more intensive investigations performed on vascular function and body fat distribution. The positive effect of anti-hypertensive agents on body weight is concerning, particulalrly in this population which has a high prevalence of hypertension. This requires further investigation to determine which specific agents are responsible and whether they have detrimental metabolic effects in this population, as has been observed with thiazide diuretics in other populations [40]. The development of comprehensive and culturally acceptable smoking-cessation interventions also requires the inclusion of weight management programmes. The dangers of environmental tobacco smoke exposure must be emphasised but further studies are required to determine the exact effects of this on body fat mass and whether avoiding passive smoke exposure can lead to weight gain.

Supporting Information

S1 Dataset. Socio-demographic data collected from primary care patients (a total of 1311 adult subjects, 862 women and 449 men) attending two pre-selected primary care clinics in Soweto, South Africa.
(XLSX)

S1 Fig. The effect of environmental tobacco smoke exposure on BMI in males (n = 424; grey filled bars) and females (n = 829; open bars). The data is given as median with inter-quartile range; $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$ versus none; $^{+}p<0.05$ versus 1–6 times/week. (TIF)

S2 Fig. The effect of night time sleep duration on BMI in females < 40 years-of-age (n = 414; light grey filled bars) and females ≥ 40 years-of-age (n = 409; dark grey filled bars). The data is given as median with inter-quartile range; $^{*}p<0.05$ versus <8 hours. (TIF)

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Author Contributions

Conceived and designed the experiments: SP SS MC KS. Performed the experiments: SP SS MC KS. Analyzed the data: NC SS. Contributed reagents/materials/analysis tools: SS KS NC. Wrote the paper: SP SS MC KL KS NC.

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3.2.2 Conclusion

Results from the HOS primary care data, as published in paper 3.2 [6] therefore indicate that certain environmental factors, such as smoking and exposure to second-hand smoke and lifestyle habits, such as sleep duration and napping, may have an effect, in gender-specific ways, on BMI and blood pressure, as illustrated in supplementary figures S1 and S1 (Appendix D) and also reported by other studies [7,8].

Sleep duration is a dynamic phenomenon, with short- and long-term fluctuations, in part, due to aspects of our daily lives (e.g. working hours, travelling time and family obligations). This is confounded by socio-economic position, where especially socio-economically disadvantaged groups are more vulnerable and therefore, more likely to be adversely effected by physical and mental health [8]. Furthermore, while there are a number of reported external factors that can adversely affect sleep duration, it does appear that long sleep duration tends to be uncommon among healthy adults, and therefore, likely to be an indicator of poor physical and mental health status [7].

While there are certain limitations to the data collected on sleep duration and sleeping habits, it does provide a clear indication that further detailed investigations are necessary and that education on sleeping habits should be included when planning intervention programs for the prevention of chronic diseases.

Another interesting finding that emerged out of the analysis of our data as described in 3.2, is the association found between the exposure to second hand smoking and lower BMI in both genders. While associations between second hand smoke and increased morbidity and mortality in non-smoking adults and children has been established, especially in relation to an increased risk of heart disease, COPD and certain types of cancer [9], this is a novel finding and should be investigated further. An extension of this study would be to investigate the possible relationship of air pollution and the effects of climate change on the physical, socio-economic and psychological health of populations [10].

Human beings are very dependent on the environment they live in, and even more so people living in low- and middle-income countries with poor socio-economic status [10]. Climate change was recently described in the *Lancet 2009* as the biggest global health threat of the 21st century [11]. With climate change, agriculture production, food prices and infrastructures will change, leading to decreases in the amount and the quality of food produced [10, 12]. Possibly the four most crucial factors for a household's food security as described by the United Nations Organization for Food and Agriculture (FAO) are; access to food and food availability, stability of supply and the degree to which food is nutritious and safe for human consumption [13].

Changes in weather (drought or floods), food insecurity and unemployment are some of the factors that influence people to move from rural to urban areas in search of a better life [14]. As described earlier, one of the main drivers of the epidemiological and nutrition transition is migration from rural to urban areas with the resultant changes in people's lifestyles, diets, food choices and dietary patterns, which can contribute substantially to the development of chronic diseases of lifestyle, particularly heart failure, as will be described further in Chapter 4 of this thesis.

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CHAPTER 4

HEART FAILURE IN AN URBAN AFRICAN POPULATION: PATHWAYS TO HEART FAILURE IN THE HEART OF SOWETO STUDY COHORT

4.1 Introduction

As demographics of a country change and the epidemiological transition progresses from communicable to non-communicable diseases, it can be expected that CVD might become a major public health concern in low- and middle-income countries [1]. Urban Africans living in Soweto, South Africa represent such a population in transition. The clinical endpoint of many cardiovascular disorders is HF, which signifies the inability of the heart to oxygenate tissue at the rate required to meet oxidative needs [2]. A recent review from Callender et al (2014) reported that in low- to middle-income countries HF poses a major burden to public health and healthcare services, and contributed on average around 2.2% to hospital admissions, with the mean age of patients being 63 years, which is more than a 10 years younger than reported from studies in high income countries, affecting more men than women [1].

4.2 Heart failure in urban black Africans: pathways to right heart failure

The major risk factors for CHF reported are highly variable and multiple causes are often attributed to individual cases of HF [1]. The leading causes of HF are reported as hypertension, left ventricular hypertrophy, atherosclerosis and diabetes and patients affected by CHF are frequently re-hospitalised, have a poor quality of life and high mortality rates [3]. CHF is a common and very important healthcare issue in both general practice and hospital settings. For patients suffering from CHF, it is a disabling and deadly condition. CHF is among the most common reasons for unplanned hospital admissions, and mortality from the condition is comparable to or worse than most of the common malignancies. CHF is also a very costly disease, representing a large and growing drain on healthcare resources [4,5]. Creating awareness on the causes and pathways of CHF might assist patients in making the appropriate lifestyle changes to reduce risk or manage symptoms, as well as improve their adherence to treatment regimens [5].

We therefore, endeavoured to examine and describe the characteristics and pathways to right heart failure (RHF) from data captured from 5328 patients presenting with heart disease at the outpatient cardiac clinic at CHBH, Soweto, South Africa, from 2006 to 2008, as part of the HOS clinical registry. As described in publication 4.1, we found RHF to be a common condition in this patient

cohort, attributable to a range of causes and which, to a large extent, could be prevented by emphasizing the importance of prevention or at least providing early effective treatments for RHF in this urban African population [6], as well as creating awareness of the possible negative effects of unhealthy food choices in this population, as described in publication 4.2 [6].

Publication 4.1: A not-so-rare form of heart failure in urban black Africans: pathways to right heart failure in the HOS cohort (Statement of originality document: Please see Appendix C) [6].

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A not-so-rare form of heart failure in urban black Africans: pathways to right heart failure in the Heart of Soweto Study cohort

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Aims Preliminary data suggest that right heart failure (RHF) may be more common in urban Africans than first suspected. We examined the characteristics and pathways to RHF in the Heart of Soweto cohort.

Methods and results A clinical registry captured data from 5328 *de novo* presentations of heart disease to the Cardiology Unit, Chris Hani Baragwanath Hospital in Soweto, South Africa during 2006–08. Of 2505 cases of HF (47% of total cohort), 697 (28%) were diagnosed with RHF (50% primary diagnosis). Despite more females than males (379 vs. 318 cases), proportionately more men presented with RHF [15 vs. 12% of cases; odds ratios (OR) 1.27, 95% confidence intervals (CI) 1.08–1.49] and Africans predominated overall ($n = 642$, 92%). Apart from concurrent left-sided heart disease (213 cases, 31%) there were many pathways to RHF including chronic lung disease (179 cases, 26% including COPD and tuberculosis) and 141 cases (20%) of pulmonary arterial hypertension (PAH). On an adjusted basis, women were almost two-fold more likely to present with PAH (OR 1.72, 95% CI 1.17–2.55; $P = 0.006$) while those with low levels of education (OR 0.69, 95% CI 0.47–1.01; $P = 0.054$) and originating from Soweto (OR 0.64, 95% CI 0.42–0.96; $P = 0.029$) were less likely to present with PAH compared with the rest of the cohort.

Conclusion These data suggest cases of RHF and related PAH are relatively common among urban Africans presenting with *de novo* heart disease.

Keywords Right heart failure • Pulmonary arterial hypertension • Africa

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Introduction

In contrast to the findings of the European Heart Failure Survey II, whereby only 3.2% of a cohort of patients registered with the syndrome heart failure (HF) had a component of right heart failure (RHF),[1] we have previously noted surprisingly high levels of RHF in the Heart of Soweto Study cohort.[2] In the first year of capturing data on all presentations of heart disease (pre-established and *de novo*) to the Chris Hani Baragwanath Hospital, we found that one in five of all cases of HF involved a component of RHF.[3] Potential reasons for high levels of RHF in Soweto are many and varied, and may mirror those found in other populations in economic transition such as post-war Northern England.[4] As reported from the international BOLD Study, South Africa has a particularly high prevalence of COPD[5] that develops across all ages in townships such as Soweto for a range of reasons. This includes exposure to pulmonary irritants from at-risk occupations such as mining, direct and passive smoking, urban pollution, and indoor pollution from domestic (solid fuel) heaters. It also includes endemic levels of a broad range of antecedent diseases, most notably tuberculosis and human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS) that remain poorly detected and controlled.[6] In children, lack of adequate paediatric services to deal with congenital heart disease that lead to

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pulmonary arterial hypertension (PAH) is commonly seen[7] and there is also a high incidence of aggressive forms of rheumatic heart disease (RHD) which includes a strong component of RHF.[8,9] High altitude (Johannesburg is ~1000 m above sea level) may also be a contributory factor. Greater levels of PAH, when compared with reports from high-income countries,[10,11] are less easy to explain.

Using 3-year data from the Heart of Soweto Study cohort documenting the characteristics of *de novo* presentations of heart disease to a tertiary hospital in the predominantly African community of Soweto, South Africa, we specifically examined the nature of RHF presentations in this cohort.

Methods

Study setting and design

Descriptions of the purpose and methods of the Heart of Soweto Study, the largest and most comprehensive study of emergent heart disease in sub-Saharan Africa, have been described in detail in previous reports.[1,2] Data derived from this study cohort represent an important (but not exclusive) barometer of heart disease in urban communities in sub-Saharan Africa. The data described in this report are derived from the 3500-bed Chris Hani Baragwanath Hospital (case load of >125 000 in-patients) servicing the tertiary care needs of Soweto (population of 1.1 million) and surrounding communities. All cases of suspected heart disease were referred to the hospital's Cardiology Unit for advanced diagnostic testing and gold-standard treatments. A prospective clinical registry of all *de novo* presentations of the same collected data was implemented during the period 2006–08.

Study cohort

We captured data on 5328 cases of *de novo* heart disease being managed by the Cardiology Unit during the 3-year study period. The majority of cases were either current inpatients at the Baragwanath Hospital ($n = 1992$, 37.4%) or referred by another outpatient department ($n = 2568$, 48.2%) including a respiratory clinic for patients diagnosed with chronic lung disease (where respiratory diagnoses were made). The study was approved by the University of the Witwatersrand Ethics Committee and conforms to the principles outlined in the Declaration of Helsinki.

Study data

A complete list of study data captured by the registry, comprising basic socio-demographic (including years of education and determining if a person was born in Soweto) and advanced clinical profiling, has been described previously.[2] Echocardiography (according to gold-standard criteria[12]) and 12-lead electrocardiogram (ECG) (blinded classification to Minnesota criteria[13]) were performed in all cases. Wherever possible, we have adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for this type of study.[14]

Right heart failure and pulmonary hypertension

All study data were independently reviewed and adjudicated (using a consensus approach) by K.S. and S.S. Classification of complex cases with valve dysfunction was based on criteria used in a recent report on valve disease in this cohort.[9] For the purpose of this report focusing on RHF, we prospectively classified all cases using recent guidelines published by the European Society of Cardiology (relating to HF[15]) and American Heart Association (relating to PH[16]) to create the study definitions shown in the text box below.

Text box. Study definitions

Diagnosis	Clinical features
Right heart failure (RHF)	HF secondary to right-sided pathology with increased jugular venous pressure and liver size, tricuspid regurgitation and/or elevated right ventricular systolic pressure (RVSP) >35 mmHg. Usually accompanied by peripheral oedema as unique or concomitant to left HF. *Isolated RHF* excludes significant left ventricular and valvular involvement (e.g. RHD) and pulmonary disease.
Pulmonary arterial hypertension (PAH)	Documented elevated RVSP (>35 mmHg) on echocardiography; usually accompanied by shortness of breath and possibly ECG and chest X-ray changes. Confirmation by right heart catheterization was obtained in selected cases to confirm the diagnosis or where treatment with a phosphodiesterase-5 inhibitor on a trial basis was planned. *Idiopathic PAH*: no identifiable causal factor for elevated pulmonary arterial pressure *HIV-related PAH*: PAH associated with a confirmed diagnosis of HIV infection and/or treatment with highly active anti-retro viral therapy *Connective tissue disorder-related PAH*: PAH associated with a prior diagnosis of connective tissue disorder (e.g. scleroderma) *Congenital PAH*: PAH associated with a congenital disorder (e.g. Eisemenger's syndrome)
Left-sided heart disease	Evidence of left-sided pathology with a documented left ventricular ejection fraction (LVEF) ≤45% and/or mitral valve disease (other than that associated with RHD). This includes idiopathic dilated cardiomyopathy (CMO) requiring additional left ventricular dimension in diastole >55 mm of indeterminate origin (coronary artery disease excluded by coronary angiography)
Rheumatic heart disease (RHD)	Medical history of acute rheumatic fever, clinical examination and according to standard echocardiographic criteria.
Chronic lung disease	Documented chronic lung condition including chronic bronchitis, asthma, COPD, and pulmonary tuberculosis supported by clinical investigations (including pulmonary function tests).
Thrombo-embolic disease	Evidence of thrombo-embolic disease (typically in the pulmonary vasculature).

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Statistical analyses

All study data were documented on standardized case report forms and entered into a dedicated database (Microsoft Access) at the Soweto Cardiovascular Research Unit, at the Chris Hani Baragwanath Hospital. Data were then verified and transferred to SPSS Statistics 17.0 for all analyses by an independent team at Baker IDI (Australia). Normally distributed continuous data are presented as mean ± standard deviation and non-Gaussian distributed variables as median plus interquartile range. Categorical data are presented as percentages with 95% confidence intervals (CI) where appropriate. For patient group comparisons, we initially used χ^2 analysis with calculation of odds ratios (OR) and 95% CI (where appropriate) for discrete variables and Student's *t*-test and analysis of variance for normally distributed continuous variables. Multiple logistic regression analyses (entry model) were performed on age, sex, and baseline risk factors to derive adjusted ORs for the risk of presenting with RHF overall, chronic lung disease, and PAH within the entire Heart of Soweto cohort. Significance was accepted at the two-sided level of 0.05.

Results

Right heart failure in 5328 *de novo* cases of heart disease

During the period 2006–08, a total of 2505 of all 5328 *de novo* cases of heart disease (47%) were diagnosed with any form of HF. Of these HF cases, 697 (28%) were diagnosed with RHF. Right heart failure was the primary diagnosis in 345 cases (50%). There were more women than men diagnosed with RHF (379 vs. 318 cases) but proportionately more men were affected (15 vs. 12% of all 5328 cases, OR 1.27, 1.08–1.49; $P = 0.003$). There were also more patients of African descent diagnosed with RHF than any other ethnic group (642 vs. 55 other ethnic cases). On an adjusted basis, compared with the remainder of the Heart of Soweto cohort ($n = 4631$), RHF cases were more likely to be African (adjusted OR 2.33, 95% CI 1.59–3.41), and have a history of smoking (OR 1.72, 95% CI 1.42–2.10). Alternatively they had a lower body mass index (OR 0.96, 95% CI 0.94–0.97 per kg/m^2) and were less likely to have a family history of heart disease (OR 0.79, 95% CI 0.64–0.96).

Overall pattern of right heart failure ($n = 697$)

Table 1 compares the clinical and demographic characteristics of all 697 cases of RHF according to gender. Overall, 57% of patients were current or ex-smokers with more men than women reporting this major risk factor (77 vs. 40%), while women had a higher mean body mass index and total cholesterol levels. From a clinical perspective, there were marked differences in left and right ventricular parameters reflective of differences in the predominant form of RHF seen in men and women (see below). Contributory causes of RHF were many and varied in the study cohort. *Figure 1* shows the spectrum of diagnoses associated with RHF according to sex. In women ($n = 379$, 54% of RHF cases) the main concurrent diagnoses were left-sided heart disease (29%; including 34 cases of idiopathic dilated CMO), PAH (28%), RHD (18%), and pulmonary disease (17%). Isolated right ventricular failure with no obvious causality occurred in 28 cases (7%). Similarly, *Figure 1* shows that the main diagnoses associated with concurrent RHF in men ($n = 318$) were similar in nature but proportionately different. Right heart failure in men was most commonly associated with concurrent pulmonary disease (36%), mainly comprising COPD (50%) and tuberculosis (23%). Other common diagnoses were left-sided heart disease (32% including 42 cases of idiopathic CMO) and PAH (15%).

Chronic lung disease ($n = 179$)

Patients presenting with a chronic lung condition or disease were on average 3 years older than the rest of the cohort (54.2 ± 17.6 vs. 51.2 ± 17.9 years; $P = 0.054$). In total, there were 64 female cases of chronic lung disease including COPD (31 cases, 48%) and pulmonary tuberculosis (19 cases, 30%). There were more equivalent male cases in men ($n = 115$, 64%) that also mainly comprised those with COPD (67 cases, 58%) or pulmonary tuberculosis (26 cases, 23%). On an adjusted basis, men and those with a history of smoking were two-fold more likely to present with concurrent lung disease when compared with women (OR 1.99, 95% CI 2.26–3.16; $P = 0.003$) and non-smokers (OR 2.07, 95% 1.27–3.34; $P = 0.003$).

Pulmonary arterial hypertension ($n = 141$)

Figure 2 shows the spectrum of PAH-related cases according to sex with almost double the number of female (66%) than male cases overall. In women, the three most common forms of PAH were idiopathic PAH (34%—with no known cause established), PAH related to concurrent HIV infection (33%) and PAH related to connective tissue disorders (27%); the latter comprising 17 cases of scleroderma. In men, the dominant form of PAH was idiopathic PAH (60% of cases) with another 11 cases (23%) of HIV-related PAH. Overall, therefore, similar numbers of both sexes were affected by idiopathic PAH whereas significantly more women were affected by HIV and connective tissue related PAH. Consistent with the wider cohort, the majority of cases were of African descent and originated from somewhere other than Soweto. Compared with the rest of the Heart of Soweto cohort ($n = 5187$), on an adjusted basis, women were almost two-fold more likely to present with PAH (adjusted OR 1.72, 95% CI 1.17–2.55; $P = 0.006$) while those with low levels of education and originating from Soweto were less likely to present with PAH compared with those with higher levels of education (OR 0.69, 95% CI 0.47–1.01; $P = 0.054$) and migrants (OR 0.64, 95% CI 0.42–0.96; $P = 0.029$).

On average, those with any form of PAH were 7 years younger than the rest of the RHF cohort (46.5 ± 16.9 vs. 53.4 ± 17.8 years; $P < 0.0001$), largely due to the fact that affected women were significantly younger than their male counterparts (43.6 ± 16.6 vs. 52.0 ± 16.3 years; $P < 0.01$). Women also presented with slightly higher RVSP levels than men (56.5 ± 17.8 vs. 50.5 ± 18.8 mmHg; $P = 0.153$). However, *Table 2* shows that within the various subgroups of PAH, there were important differences in demographic and clinical profiles.

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Table 1 Socio-demographic and clinical profile of right heart failure cases ($n = 697$)

	All ($n = 697$)	Women ($n = 379$)	Men ($n = 318$)	*P* value
Socio-demographic profile				
Mean age (years)	52.0 ± 17.8	50.5 ± 17.8	53.8 ± 17.8	0.018
African descent	642 (92%)	358 (95%)	284 (89%)	0.053
<6 years education	340 (49%)	176 (46%)	164 (52%)	ns
Originally from Soweto	269 (39%)	129 (34%)	140 (44%)	0.007
Years in Soweto	39 ± 17	39 ± 17	40 ± 17	ns
Risk factor profile				
History of smoking	395 (57%)	150 (40%)	245 (77%)	<0.001
Hypertension	261 (38%)	142 (37%)	119 (37%)	ns
Body mass index (kg/m^2)	26.2 ± 6.2	27.1 ± 6.3	25.3 ± 5.9	0.001
Diabetes	78 (11%)	44 (12%)	34 (11%)	ns
Serum cholesterol (mmol/L)	3.6 ± 1.3	3.7 ± 1.4	3.4 ± 1.2	0.049
Clinical presentation				
NYHA Class II, III, or IV	588 (84%)	323 (85%)	265 (83%)	ns
Peripheral oedema	406 (58%)	210 (55%)	196 (62%)	ns
Dizziness	420 (60%)	238 (63%)	182 (57%)	ns
Palpitations	415 (60%)	237 (63%)	178 (56%)	ns
Heart rate/min	91 ± 20	88 ± 21	92 ± 20	0.010
Systolic blood pressure (mmHg)	121 ± 23	121 ± 24	121 ± 24	ns
Diastolic blood pressure (mmHg)	72 ± 15	72 ± 15	73 ± 15	ns
Estimated glomerular filtration rate	94 ± 21	91 ± 38	97 ± 40	0.061
Echocardiography				
LVEF (%)	54 ± 17	57 ± 16	51 ± 17	<0.001
LV systolic dysfunction	205 (29%)	91 (24%)	114 (36%)	<0.001
LV end-diastolic diameter (mm)	46 ± 12	44 ± 10	49 ± 12	<0.001
LV end-systolic diameter (mm)	34 ± 13	32 ± 12	36 ± 13	<0.001
Diastolic dysfunction	51 (7.3%)	26 (6.9%)	25 (7.9%)	ns
RVSP (mmHg)	53 ± 19	54 ± 20	52 ± 18	ns
RVSP>25 mmHg	327 (47%)	162 (43%)	165 (52%)	0.016
12-lead ECG ($n = 598$)				
Atrial fibrillation	33 (5.5%)	14 (4.3%)	19 (7.0%)	ns
Right ventricular strain pattern	57 (9.5%)	28 (8.6%)	29 (10.6%)	ns
Right bundle branch block	37 (6.2%)	22 (6.8%)	15 (5.5%)	ns
Right atrial abnormality	138 (23%)	69 (21%)	69 (25%)	ns

NYHA, New York Heart Association Functional Class, LV systolic dysfunction, LVEF <45%.

12 lead electrocardiogram

Overall, 272 patients (46%) had an ECG abnormality indicative of right-sided pathology (including right axis deviation, right bundle branch block, p-pulmonale and right strain pattern indicative of right ventricular hypertrophy). Although there was no difference between the sexes in the presence of an ECG abnormality, women were more likely to present in first- or second-degree heart block [23 (7.1%) vs. 7 (2.6%) cases; OR 2.77 95% CI 1.21–6.36], while 33 (5.5%) cases presented in atrial fibrillation. Patients with ECG evidence of right-sided pathology were more likely to have left-sided disease (60%), RHD (56%), idiopathic PAH (54%), and right ventricular failure of unknown origin (50%).

Discussion

In recent years, there has been increasing awareness around the underlying prevalence and clinical significance of cor pulmonale/RHF and more specific cases of PAH. This applies equally to recognition of the importance of RHF as both a primary diagnosis[17] and as a poor prognostic marker for those primarily affected by left-sided HF.[18] It is within this context that we present the largest and most comprehensive description of RHF in sub-Saharan Africa. In the majority of studies describing HF in the region (amounting to >100 papers reflecting increasing interest in an increasingly common syndrome), a component of cor pulmonale/RHF is reported; the historical proportion of affected HF patients typically ranges from <1% to up to 10% in most regions of

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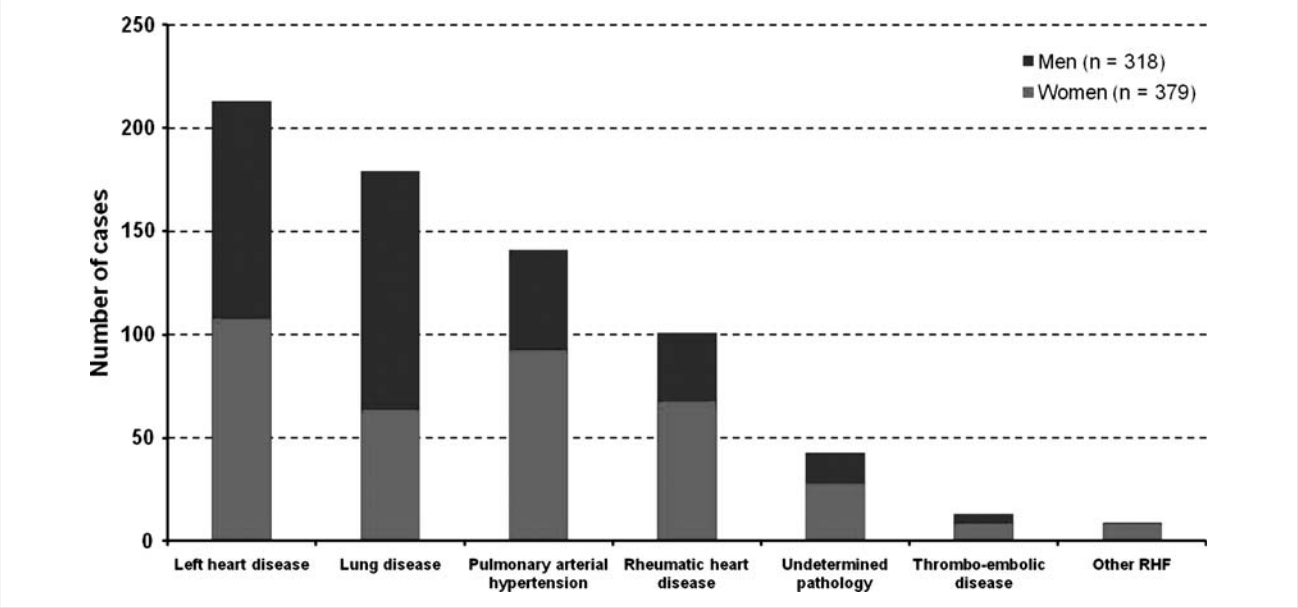

Figure 1 Diagnostic profile of all male ($n = 318$) and female ($n = 379$) cases of right heart failure.

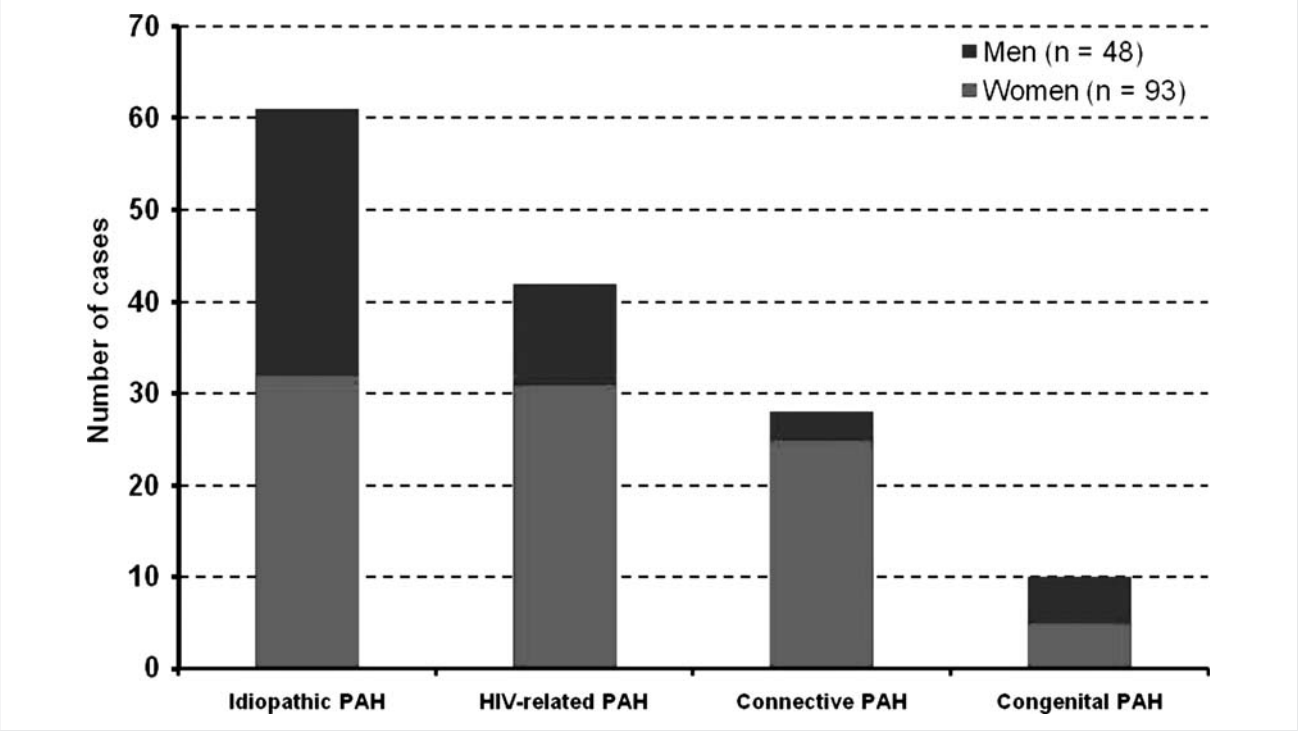

Figure 2 Diagnostic profile of male ($n = 48$) and female ($n = 93$) cases of pulmonary arterial hypertension.

Africa.[19–21] An important delineation between the Heart of Soweto Study and the majority of previous studies, however, is the size of the cohort investigated (>6000 cases), the focus on *de novo* presentations only, and the use of systematic screening with echocardiography to identify underlying HF. In the Heart of Soweto Study cohort, RHF was diagnosed in almost 700 cases (representing 28% of all HF cases).[2] Numerically, there were more women than men but proportionately more men than women were diagnosed within the entire cohort. As expected, underlying causes of RHF were many and varied including the

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Table 2 Socio-demographic profile of pulmonary arterial hypertension cases ($n = 141$)

	Idiopathic PAH ($n = 61$)		HIV-related PAH ($n = 42$)		Connective tissue-related PAH ($n = 28$)	
	Men	Women	Men	Women	Men	Women
Mean age (years)	50.5 ± 17.8	45.6 ± 18.4	50.5 ± 17.8	39.3 ± 14.4	53.8 ± 17.8	49.8 ± 15.0
Women	–	32 (53%)	–	31 (74%)	–	25 (81%)
African descent	25 (86%)	31 (97%)	9 (82%)	31 (100%)	3 (100%)	22 (88%)
<6 years education	13 (45%)	16 (50%)	6 (55%)	11 (36%)	1 (33%)	8 (32%)
Originally from Soweto	10 (35%)	6 (19%)	3 (27%)	13 (42%)	1 (33%)	6 (24%)

dilated cardiomyopathies, chronic lung disease, RHD and various forms of PAH. Those most likely to present with RHF were of African descent (greater than two-fold risk compared with other ethnic groups) and many had a history of smoking.

By highlighting the many pathways to RHF in Africans living in the urban enclave of Soweto, South Africa, these data raise a number of important clinical and public health issues. For example, in recent years, it has been increasingly recognized that the prevalence of PAH in its various forms is far higher than first imagined.[10,11] It was often reported that one in a million (predominantly young women) are affected by this disabling and deadly condition with most cases diagnosed late when undiscovered PAH has led to advanced RHF (often with increasing dyspnoea of 'unknown' origin). Certainly, there has been increased focus on screening for PAH in high-risk patients. In South Africa, this includes both connective tissue disorders and those with HIV/AIDS, with the number of detected cases (via the systematic screening of cardiac cases at Baragwanath Hospital) suggesting an incidence rate of at least 10–15 cases per annum for each form of PAH in Soweto. The other most common form, idiopathic PAH, occurred in even greater numbers with an indicative rate of 20 cases per annum. These data are consistent with contemporary reports from France[11] and Scotland[10] indicating a higher incidence of all forms of pulmonary hypertension and specifically, PAH (particularly the three most common forms found in this cohort) than first thought. Consistent with these European data, women were more likely to present with PAH, but were younger than their male counterparts (who were not only older, but tended to have a more consistent age profile across the different forms of PAH). If as prevalent in other urban African communities, these data highlight the need for not only community-based screening programmes for RHF (and its precursor PAH) in South Africa (see below), but hospital-based programmes for high-risk patient sub-groups with the capacity to perform right heart catheterization for definitive diagnosis. The availability of relatively cheap but effective oral agents (e.g. endothelin receptor antagonists and phosphodiesterase-5 inhibitors)[16] is also highly desirable in this context.

The fact that this study focused on the adult population explains the low number of PAH related to congenital heart disease. However, the importance of preventing or at least providing early effective treatments for PAH and RHF in young Africans cannot be overlooked. The lack of open-heart surgery, specialist paediatric cardiovascular services and poor parental awareness has led to the accumulation of patients with RHF as a consequence of untreated congenital heart disease, right heart valve disease, HIV/AIDS, endomyocardial fibrosis, pulmonary tuberculosis, schistosomiasis, and sickle cell disease.[7] All are endemic in the paediatric population in Africa. For instance, RHD, the most common form of acquired cardiovascular disease in children and adolescents in Africa,[22] presents in the most virulent forms usually associated with RHF, due to late presentation of patients with mitral and/or aortic valve disease.[9]

Given the high level of antecedents that could potentially contribute to a high prevalence of RHF in the region, in ideal circumstances there would be a strong argument for undertaking wide-scale screening programmes to determine its exact prevalence and antecedents; the focus of any longitudinal health study. With limited health care resources,[23] a more pragmatic approach may involve the establishment of 'breathlessness' clinics in primary care facilities (remembering that 85% of cases presented with dyspnoea) in Soweto with the capacity to undertake point-of-care assessment of brain natriuretic peptide levels (for evidence of right or left atrial stretch), lung function tests and a 12-lead ECG to determine the need for more definitive evaluation (i.e. echocardiography and right heart catheterization). The cost effectiveness of such an approach is yet to be established. However, results from the Heart of Soweto Primary Care Registry of >1000 cases presenting with a broad spectrum of conditions[24] highlights the potential benefit. Certainly, the results of the BOLD Study[5] with respect to chronic lung disease (irrespective of cardiac involvement) in South Africa support the need for dedicated programmes targeting individuals with pulmonary pathology. Any improvement in the early detection of RHF cases will require a parallel investment in potentially costly treatments including open-heart surgery for congenital cases and pharmacological therapy for cases of PAH. Beyond low-to-middle-income countries, these data are a reminder that RHF may be more prevalent in high-income countries than data from the European Heart Failure Survey II (where possible bias towards describing those with left-sided heart disease occurred) might suggest.[1] Certainly, it reinforces the potential benefits of identifying primary and secondary diagnoses of RHF in high-risk individuals to improve health outcomes.[17,18]

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There are a number of limitations that require comment. The diagnosis of RHF and PAH was, in the majority of the cases, based on the criteria outlined in the case definitions presented in the Methods using a combination of symptoms, signs, echocardiography, lung function tests, chest X-ray, and ECG changes. While only a minority had right heart catheterization (the gold-standard for diagnosing PAH[16]) elevated RVSP levels have been shown to be a reliable marker of pulmonary arterial pressures[25] and, in a resource-poor environment, we applied a pragmatic approach to classifying cases. Moreover, these data are yet to be confirmed in other communities. We also do not know the prognostic outcome for this cohort, although it is likely to be poor when considering PAH-specific reports[10] and recent results from the Euro Heart Failure Survey II, suggesting 16.4% 1 year mortality in those presenting with *de novo* acute HF (rising to 22% in those with evidence of congestion/RHF as indicated by an elevated jugular venous pressure).[26] With the support of the Pulmonary Vascular Research Institute Sub-Saharan Taskforce (led by K.S. and A.M.), a registry to describe the epidemiology of pulmonary hypertension among patients attending referral units for cardiovascular and pulmonary diseases in a number of sub-Saharan African countries is soon to be launched. This information will be crucial to the development of effective and resource-sensitive strategies to tackle this condition in the region.

In conclusion, we are unaware of any similar reports from sub-Saharan Africa specifically focusing on the nature of RHF and its key clinical components (including PAH) in such a large cohort and in such detail. Overall, these data suggest that RHF is a common, and to a large extent preventable, condition that is attributable to a range of causes among urban Africans presenting with *de novo* heart disease. If proven correct, the challenge now is to develop cost-effective screening and treatment programmes within a resource-poor environment being increasingly challenged by a combination of new- and old-forms heart disease.

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4.2.1 Possible contributors to chronic heart failure in the HOS cohort

Our data showed high levels of RHF, with one in five cases of HF involving a component of RHF, a much higher than expected incidence as compared to findings from the European Heart Failure Survey ll. This suggests that RHF and pulmonary arterial hypertension (PAH) are relatively common in this urban African cohort presenting with heart disease at a tertiary hospital [6]. The reasons for these high levels of RHF seen in Soweto may be many and varied, from occupational health hazards, such as being exposed to pulmonary irritants in underground mines, smoking and exposure to second-hand smoking, environmental pollution, as well as exposure to indoor smoke due to solid fuel heaters and stoves [7, 8]. It might also include the still high levels of infectious diseases seen in this community, such as tuberculosis (TB) and HIV/AIDS, which remain poorly diagnosed and treated [6].

While it has been established that a diet high in sodium may have adverse effects, there is limited data on other aspects of diet in HF, especially on micronutrients, or vitamins and minerals [9]. As part of the HOS we therefore endeavoured to investigate micronutrient intake and the possible effect of the nutrition transition on food choices, as experienced in a cohort of urban African HF patients.

4.3 Nutrition transition: a possible contributor to HF in the HOS cohort?

A number of comparative studies performed in rural African and urban African populations showed that the current nutrition transition due to urbanisation and economic development is characterised by lifestyle changes. Urban populations are becoming less active, their diets, eating patterns and nutrient intakes are changing, which put them at greater risk for the development of NCDs [10, 11]. These dietary changes include an increased intake of meat and other animal products high in saturated fats, decreased consumption of staple foods high in starch and fibre, decreased consumption of legumes and vegetables, insufficient intake of fruit and an increased intake of convenience and processed foods that are high in energy, but low in nutrients [12].

People's nutritional status hugely impacts on their health outcomes as illustrated by the MRC's comparative risk assessment for South Africa, published in 2007. This study showed that 9 out of the 17 selected risk factors contributing to mortality in South Africa were related to nutrition, namely overweight, high blood pressure, high cholesterol, increased alcohol consumption, diabetes mellitus, childhood and maternal malnutrition, vitamin A deficiency, iron deficiency anaemia and insufficient fruit and vegetable intake [13].

Dietary information can help advance our understanding of the nature of nutrition within a specific community and population group, help us to identify opportunities for action to accelerate improvements in nutrition, highlight key data gaps that needs to be filled and enable us to engage all relevant decision makers. We therefore undertook a study as part of the HOS of patients presenting with HF at a tertiary hospital in Soweto, South Africa, to determine where this cohort of patents were positioned on the nutrition transition and the possible impact of nutrition on the progression and outcome of their disease, as well as to identify habitual and cultural food intake.

Our study therefore, focused on the non-pharmacological aspects of heart disease management, firstly by describing the food choices and macro- and micronutrient intake of this cohort as potential contributors to CVD, and secondly to develop culturally sensitive and economical dietary recommendations, as described in publications 4.2 [14] and 4.3 [10].

Publication 4.2: Feeding the emergence of advance heart disease in Soweto: a nutritional survey of black African patients with heart failure (Statement of originality document: Please see Appendix C) [14].

Cardiovascular Topics

Feeding the emergence of advanced heart disease in Soweto: a nutritional survey of black African patients with heart failure

SANDRA PRETORIUS, KAREN SLIWA, VERENA RUF, KAREN WALKER, SIMON STEWART

Summary

Aim: **To describe dietary habits and potential nutritional deficiencies in black African patients diagnosed with heart failure (HF).**

Methods and Results: **Dietary intake in 50 consecutively consenting HF patients (mean age: 47 ± 18 years, 54% female) attending a major hospital in Soweto, South Africa were surveyed using validated quantitative food frequency questionnaires. Food intakes, translated into nutrient data were compared with recommended values. In women, food choices likely to negatively impact on heart health included added sugar [consumed by 75%: median daily intake (interquartile range) 16 g (10–20)], sweet drinks [54%: 310 ml (85–400)] and salted snacks [61%: 15 g (2–17)]. Corresponding figures for men were added sugar [74%: 15 g (10–15)], sweet drinks [65%: 439 ml (71–670)] and salted snacks [74%: 15 g (4–22)]. The womens' intake of calcium, vitamin C and vitamin E was only 66, 37 and 40% of the age-specific requirement, respectively. For men, equivalent figures were 66, 87 and 67%. Mean sodium intake was 2 372 g/day for men and 1 972 g/day for women, 470 and 294% respectively, of recommended consumption levels.**

Conclusions: **The nutritional status of black African patients with HF could be improved by recommending healthier food choices and by reducing the intake of sweet drinks and excess salt.**

Keywords: heart failure, Africa, food preferences, malnutrition, salt

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Heart failure (HF) has become a major public health problem in that, unlike other cardiovascular diseases, the number of people discharged from hospital with a diagnosis of HF is increasing.[1] In developed countries, HF can be observed in 2 to 3% of the population and asymptomatic ventricular dysfunction is evident in about 4% of the population.[2] This will increase with age, and in the 70- to 80-year age group, HF can be observed in between 10 and 20% of people.[2,3] The epidemic of cardiovascular disease (CVD) has probably stabilised in developed countries, but developing countries are increasingly suffering from the emerging burden of CVD.[4]

As populations in South Africa and sub-Saharan Africa undergo economic development, the disease profile shifts and CVD becomes a growing cause of death and disability.[5] Previously considered a rarity in Africa and predominantly caused by infectious disease or idiopathic dilated cardiomyopathy,[6] the syndrome of heart failure (HF) has emerged as a challenging public health problem in sub-Saharan Africa.[7]

The Heart of Soweto (HOS) study[8] has documented a much higher-than-expected burden of modifiable risk factors[9] and advanced forms of heart disease[10] linked to epidemiological transition in one of Africa's largest urban concentrations of black Africans. Data from the HOS study showed that during the period from 2006 to 2008, of the 5 328 *de novo* cases captured with heart disease, 2 505 (47%) of these cases presented with chronic heart failure.[11,12] Ominously, in addition to the 'traditional' causes of HF in Africa, such as idiopathic dilated cardiomyopathy, rheumatic fever, HIV-related cardiomyopathy, peripartum cardiomyopathy and hypertensive heart failure, 'lifestyle' factors, including hypertension, obesity, dyslipidaemia and type 2 diabetes mellitis (particularly in women), appear to have expanded the pathways to, and burden of, HF in this community.[8]

Although the natural history of HF in Africa is still different from that of high-income countries, it results in the same high level of preventable morbidity and premature mortality.[13,14] In those countries already in the midst of an epidemic of HF, multidisciplinary management programmes targeting the common factors leading to clinical instability have been successfully developed.[15-17] Certain positive measures have been implemented in low- and middle-income countries for disease prevention, including WHO initiatives.[5] However, inadequate funding hinders efforts to establish adequate multidisciplinary management programmes targeting the common factors leading to heart disease in South Africa.[5] Moreover, the role of dieticians has been largely confined to patients with lipid disorders, obesi-

ty, diabetes and/renal failure.[18] If, however, nutritional education and promotion of good nutrition could be better understood and recognised to be inclusive of behavioural change, then it will be viewed as a necessary component within contemporary cardiac rehabilitation and self-management programmes.[18]

One cornerstone of HF management particularly relevant to urban Africans affected by HF is dietary modification. For example, sodium restriction (2–3 g/day) is standard therapy in the management of symptomatic chronic HF, and black individuals are particularly responsive to this strategy.[19,20] However, lack of adherence and poor self-care behaviours persist, with dietary indiscretions contributing to a substantial portion (up to 20%) of hospital readmissions.[21] Specific dietary interventions play an important role in improving health outcomes.[21,22]

Three major studies addressing food choices and dietary patterns in adult black South Africans were identified from the literature. However, given the historical rarity of the syndrome, there are very little data to describe the dietary habits of specifically urban African patients with HF. The Dikgale study[23] examined food choices, nutrient intake and weight status of black adults. The Transition, Health and Urbanisation study (THUSA)[24] examined the food choices, health status and the effect of urbanisation on a black population. The Black Risk Factor study (BRISK)[25] examined the risk factors for developing CVD in urban black Africans. Data from these studies show that rural black adults have a very low consumption of fat and a high consumption of carbohydrates, typical of the traditional rural African diet.[23,25]

Urbanisation is associated with markedly increased intake of fat, sugar, meat and beverages.[23-25] Although a decrease in the consumption of maize porridge with urbanisation was found, it is still consumed in high amounts by these black population groups.[23] As the traditional diet is abandoned in favour of a Western diet, food choices shift away from complex carbohydrates and higher fibre to foods high in fat, bringing an increased risk for chronic diseases of lifestyle.[26] According to Stewart *et al*., data on the population of Soweto have shown a low prevalence for CVD and the underlying risk factors.[8] This situation however may be changing, as urbanisation and the nutritional transition in South Africa is accompanied by an increase in the CVD risk factors in black Africans.[27]

The overall study aim was therefore to provide a detailed description of the dietary habits and potential nutritional deficiencies in a subgroup of urban black African patients diagnosed with HF, living in Soweto, South Africa, and managed via the Cardiology Unit of the Chris Hani Baragwanath Hospital. It focused on the impact of varied dietary patterns, the poor socioeconomic status of many patients and probable lack of awareness of the contribution of poor nutrition to cardiovascular disease. Ultimately, these data will be used to identify key targets for more culturally sensitive support and to argue for a greater role for dieticians in the management of an increasing number of urban black South Africans affected by HF.[12]

Methods

As part of the previously described Heart of Soweto study,[8] detailed demographic and clinical data are captured from all individuals with heart disease presenting to the Chris Hani Baragwanath Hospital, Soweto, via a prospective clinical registry. In 2006, this included 1 960 patients presenting with a primary or secondary diagnosis of HF (an average of 162 patients per month). All were diagnosed by echocardiography and specialist cardiological review. This was a prospectively planned study of 50 consecutively consenting black Africans (28 females, 22 males), referred to the Heart Failure Clinic in 2006/7 with a documented diagnosis of HF.

The study was approved by the Human Research Ethics Committee (Medical), University of the Witwatersrand, Johannesburg, M050550. All participants provided written informed consent. The study fully conformed to the principles outlined in the Declaration of Helsinki.

Dietary instrument, data and nutrient analyses and recommendations

In addition to the detailed clinical and demographic data collected as part of the Heart of Soweto Clinical Registry, an interviewer-administered quantitative food frequency questionnaire (QFFQ) was collected at a point in time when patients had received either limited, or no instructions for a low-sodium, low-fat therapeutic diet for HF.[28,29] A quantitative food frequency questionnaire is a validated questionnaire to determine food choices and consumption. The previously validated QFFQ used in this study was developed by a researcher at Northwest University. This QFFQ has previously been used to evaluate the food choices of the African population living in the North West Province, South Africa, as part of the THUSA study.[30,31]

The quantitative QFFQ has been validated via statistical methods in an African population.[30] It includes 139 types of food and records how often a given type of food is consumed as: time/s per day, per week, per month. It also records preparation methods. Quantities of food eaten were determined in relation to pictures of standardised portions of the most commonly consumed foods (e.g. maize meal porridge, rice, meat, etc.). The researcher also used standardised cups, teaspoons etc. to estimate portion sizes. The patients were also asked to name foods eaten that were not included in the questionnaire and to point out questions that were unclear or difficult to understand.

The QFFQ was administered through interview by the researcher, SP, who is a registered dietician in the Heart Failure Outpatient Clinic, Chris Hani Baragwanath Hospital, and trained in administering the QFFQ.

Food data were translated into nutrient data using the Medical Research Council (MRC) Food Finder 3, 2007, which is based on South African food composition tables. Total dietary starch was calculated from the total amount of carbohydrates minus the sum of total dietary fibre plus added sugars. To assess the consumption of high-sodium foods, data were aggregated to provide percentages of high-sodium foods consumed both daily and weekly.

Collated dietary patterns and nutritional intake data were compared to the South African Food-Based Dietary Guidelines. Importantly, one guideline advises that unrefined or minimally processed starchy foods, such as maize, wheat, sorghum, oats, rice in the form of porridges, breads, pastas, samp, breakfast cereals and other products should be the main food around which the rest of the meal is planned.[32] Promotion of carbohydrate-rich foods contributes to optimal nutrient intake, particularly in low-income groups. Largely unrefined carbohydrate-rich foods are

excellent sources of dietary fibre and provide several important vitamins and minerals.[33] It is also recommended that in a healthy, balanced diet, protective against chronic diseases of lifestyle, at least 55% of the total energy (%E) should be provided by a variety of carbohydrate-rich foods, with around 30%E provided by fat and 15%E by protein. To provide at least 55%E in an 8 500 kJ diet, at least 275 g carbohydrate should be consumed daily.[32]

Demographic and clinical data

At the time the QFFQ was administered, body mass was measured with an electronic digital scale, measuring up to 200 kg in graduations of 0.1 kg (Seca 767), and body height was taken with a telescopic measuring rod (Seca 220) attached to the scale, to the nearest 1 mm. Data on the clinical [including left ventricular ejection fraction, New York Heart Association (NYHA) functional class and concurrent diagnoses] and socio-demographic profile (including age, gender and educational status) were collected prospectively.

Statistical analyses

Data were analysed using SPSS for Windows version 14.0.1 (SPSS Inc, Chicago, Illinois). Normally and non-normally distributed continuous data are given as the mean (standard deviation: SD) and median (interquartile range: IQR), respectively. Categorical data are presented as counts and percentages. Proportional data were compared via the Chi-squared test while all nutrient data were compared via the Mann Whitney U-test according to gender, and actual versus recommended dietary intake. Significance has been accepted as $p < 0.05$ (two-tailed).

Results

The demographic and clinical profile of the study cohort is shown in Table 1. Reflective of the overall Heart of Soweto study cohort, there were more women (56%) than men. Women were slightly, but not significantly younger than the men and the entire HF cohort was typically two decades younger than that seen in high-income countries. Hypertension and obesity were highly prevalent in both genders. Concurrent diabetes was also common, particularly in men. The majority of patients had left ventricular systolic dysfunction (LVEF < 45%) and symptoms of exercise intolerance and dyspnoea indicative of NYHA functional class II or III.

The daily food consumption of the cohort as measured by the QFFQ according to gender is shown in Table 2. Significantly, more women (79%) than men (65%) reported eating brown or wholemeal bread, 75% of women and 48% of men consumed sweets and chocolates, processed meat were eaten by 89% of women and 78% of men, and packet soup was consumed by 57% of women and 43% of men. Women, but few men also reported eating stock cubes, 18% and 4% respectively, possibly since

TABLE 1. DEMOGRAPHIC AND CLINICAL PROFILE OF THE STUDY COHORT

Socio-demographic profile	*Men* n = *22 (%)*	*Women* n = *28 (%)*
Mean age (years)[1]	51 ± 12	47 ± 18
No education	1 (4.5)	4 (14)
1–5 years' education	5 (23)	7 (25)
6–10 years' education	15 (68)	16 (57)
Post-matriculation qualifications	1 (4.5)	1 (3.6)
Risk profile		
Body mass index (kg/m²)[1]	25.2 ± 4.8	26.5 ± 6.4
Hypertension	14 (65)	18 (65)
Diabetes	2 (10)	2 (7.6)
Heart failure profile		
NYHA class II	11 (50)	12 (43)
NYHA class III	4 (19)	9 (32)
NYHA class IV	0 (0)	1 (3.6)
Left ventricular ejection fraction[1]	37.3 ± 9.1%	36.4 ± 13.4%

[1]Data are given as mean ± SD or as number (%).

TABLE 2. DAILY FOOD CONSUMPTION OF HF PATIENTS ACCORDING TO THE QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE

	Men (n = *22*)		*Women* (n = *28*)	
Foods/food groups	*Proportion (%)*	*Median daily intake (interquartile range)*	*Proportion (%)*	*Median daily intake (interquartile range)*
Maize meal (g)	91	516 (200–750)	93	424 (140–688)
Mabella (g)[1]	52	78 (25–64)	57	111 (55–136)
Oats (g)	26	88 (55–107)	32	80 (50–100)
Potatoes (g)	78	76 (28–91)	86*	59 (28–89)
White bread (g)	22	88 (50–60)	29	73 (38–98)
Brown/wholegrain bread (g)	65	102 (43–120)	79***	87 (60–113)
Cereals: refined (g)	13	13 (13–15)	14	7 (4–10)
Cereals: wholegrain (g)	22	29 (25–30)	21	17 (9–15)
Mageu (ml)[2]	30	208 (43–321)	39	64 (16–71)
Added sugar (g)	74	15 (10–15)	75	16 (10–20)
Sweets and chocolates (g)	48	19 (7–30)	75***	11 (3–12)
Cakes and biscuits (g)	48	45(15–25)	57	7(5–10)*
Cold drinks (sweetened) (ml)	65	439 (71–670)	54*	310 (85–400)
Meat, chicken, fish, eggs (g)	100	150 (105–190)	100	127 (83–168)
Milk and milk products (ml)	87	262 (129–370)	93*	113 (58-145)*
Legumes (g)	43	18 (10–24)	43	18 (9–28)
Fruit (fresh) (g)	100	174 (150–160)	100	147 (40–160)
Vegetables (fresh) (g)	100	76 (40–103)	100	78 (50–91)
Margarine on bread (g)	83	15 (7–20)	75	16 (10–20)
Salt added to cooked food (g)	91	2 (2–2)	75***	2 (2–2)
Salted snacks (g)	74	15 (4–22)	61**	15 (2–17)
Take-away foods (g)	48	23 (10–15)	32***	16 (10–25)
Sauces and condiments	57	7 (2–10)	64	4 (2–5)
Stock cubes	4	1 (1–1)	18***	1 (1–2)
Packet soup	43	3 (1–5)	57**	2 (1–2)
Processed meat	78	35 (8–54)	89**	26 (8–35)

[1]Unrefined porridge made from sorghum; [2]dried and broken corn kernels; [3]a carbohydrate-rich drink made from fermented mealie (maize) meal and malt.
Significant difference between men and women, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 3. ENERGY AND DAILY NUTRIENT INTAKE OF HF PATIENTS BASED ON A QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE

	Daily intake [median (interquartile range)]	
Nutrient	*Men (n = 22)*	*Women (n = 28)*
Energy (kJ)	9 145 (6 857–12 879)	7 472 (5 568–9 478)
Protein (g)	74.0 (101–62)	58.8 (51–66)*
% plant-derived	42.8	43.5
% total energy	13.8	13.4
Total carbohydrate (g)	272 (223–404)	245 (170–336)
% total energy	47.6	52.5
Starch (g)	17.8 (13–27)	11.0 (8–17)
Dietary fibre (g)	20.6 (14–25)	16.2 (13–23)
Added sugars (g)	40.2 (23–76)	33.1 (19–69)
Total fat (g)	65.7 (5–91)	47.4 (39–81)
% total energy	26.6	23.5
Saturated fat (g)	19.9 (16–29)	15.1 (12–20)*
% total energy	8.1	7.5
Monounsaturated fat (g)	22.9 (17–31)	17.0 (14–26)
% total energy	9.3	8.4
Polyunsaturated fat (g)	15.7 (11–22)	12.7 (9–25)
% total energy	6.3	6.3
Total trans fat (g)	0.94 (0.62–1.8)	0.46 (0.28–0.67)**
Cholesterol (mg)	308 (177–403)	214 (160–307)

Significant difference between men and women, *$p < 0.05$, **$p = 0.001$.

the women were more aware that they were added during food preparation. Conversely, more men than women reported the consumption of takeaway foods, 48 and 32%, respectively. Salted snacks were eaten by 74% of men and 61% of women, while more men than women reported adding salt to cooked food, 91% and 75% respectively. Despite differences in the proportions of men and women selecting certain foods, the median daily intake of foods eaten was broadly similar for men and women. Specific differences included a higher median intake for men of milk and milk products, and for cakes and biscuits (both $p < 0.05$).

Median daily nutrient intake in this HF population group is shown in Table 3. Although men consumed a significantly greater quantity of protein ($p < 0.05$), protein as a percentage of energy was similar (around 13%E) for both men and women. Both men and women consumed high amounts of carbohydrate (47–52%E). Although added sugar intake was low (< 10%E), fibre intake was moderately low, suggesting that many carbohydrate foods eaten came from refined sources, rather than from wholegrain cereals, as recommended. Both women and men consumed < 30%E from fat. Consumption of saturated fat and *trans* fat was significantly lower in women than men ($p < 0.05$, $p = 0.001$, respectively). Four men (18%) consumed alcohol, with one reporting consumption equivalent to 27 g per day. Only one woman (3.5%) drank alcohol.

Table 4 indicates mean daily micronutrient intake for men and women. In men, the mean intake of calcium and magnesium and of vitamins C, D, E and folate was inadequate. Mean intakes of these nutrients were also inadequate in women although mean intakes of vitamin D and magnesium were only marginally low. The mean intake of iron in women was only 50% of the level recommended, while mean intakes of riboflavin, vitamin B_6, pantothenate and niacin were also moderately low.

Fig. 1 indicates that often over half of this patient group had inadequate micronutrient consumption, while all the women and the majority of men consumed excessive amounts of sodium.

TABLE 4. MICRONUTRIENT INTAKE OF HF PATIENTS IN RELATION TO RECOMMENDED DIETARY INTAKES

Micronutrient deficiency	*Daily intake men*	*Difference from DRI (%)*	*Daily intake women*	*Difference from DRI (%)*
Vitamin D (mcg)	4.5	–0.5 (90)	4.7	–0.3 (6)
Vitamin C (mg)	78	–12 (87)	47	–28 (37)
Magnesium (mg)	361	–59 (86)	292	–29 (9)
Vitamin E (mcg)	10	–5 (67)	9	–6 (40)
Calcium (mg)	655	–345 (66)	411	–789 (66)
Folate (mcg)	227	–173 (57)	187	–213 (53)
Iron (mg)			9	–9 (50)
Riboflavin (mg)			1.0	–0.1 (9)
Vitamin B_6 (mg)			1.2	–0.1 (8)
Pantothenate (mg)			4.6	–0.4 (8)
Niacin (mg)			13.4	–0.6 (4)
Potassium (mg)			1938	–0.62 (4)
Adequate intake				
Sodium (mg)	2.372	+1 872 (470)	1 972	+1 472 (294)
Potassium (mg)	2512	+0.512 (150)		
Vitamin B_{12} (mcg)	6.3	+3.9 (260)	6.1	+3.7 (254)
Pantothenate (mg)	6.5	+1.5 (130)		
Biotin (mcg)	39	+9.0 (130)	34	+4 (13)
Iron (mg)	11	+3 (125)		
Riboflavin (mg)	1.5	+0.2 (115)		
Niacin (mg)	18	+2.0 (113)		
Vitamin B_6 (mg)	1.4	+0.1 (108)		
Thiamine (mg)	1.3	+0.1 (108)	1.1	0 (0)
Vitamin A (RE) (mcg)	949	+49 (105)	970	+270 (39)

Sodium intake was 470% above recommended intake levels in men and 294% above recommended intake levels in women. As seen in Fig. 2, most sodium came from bread and processed foods. In the body, the ratio of sodium (in extracellular fluid) to potassium (in intracellular fluid) is about 2:3. As seen in Table 4, the intake of potassium in relation to sodium was too low, due to the increased consumption of processed food and the inadequate intake of fruits, vegetables and unrefined cereals.

The likely cost of consuming a healthy diet in Soweto was calculated based on food prices relative to minimum income support available in May 2008. Current food intake required an expenditure of approximately 40% of the current disability grant, which in 2008 was R940 per month. A recommended food intake, where maize meal porridge is supplemented with mabella (coarse), legumes, carrots, spinach, apples, oranges and full-cream milk would require an expenditure of only 30% of this benefit and therefore represents an attractive option both from a financial and health status perspective.

Discussion

The most significant finding is the inadequate nutrient intake and excessive salt consumption in this high-risk HF patient cohort. Processed and convenience foods contributed to the high intake of salt as well saturated and *trans* fatty acids. Low consumption of fruit and vegetables contributed to the low micronutrient and dietary fibre intake. Overall, the pattern of dietary consumption observed is likely to have been a major contributor to the pattern of sub-optimal health outcomes (i.e. premature mortality and recurrent morbid events) found in these patients from Soweto

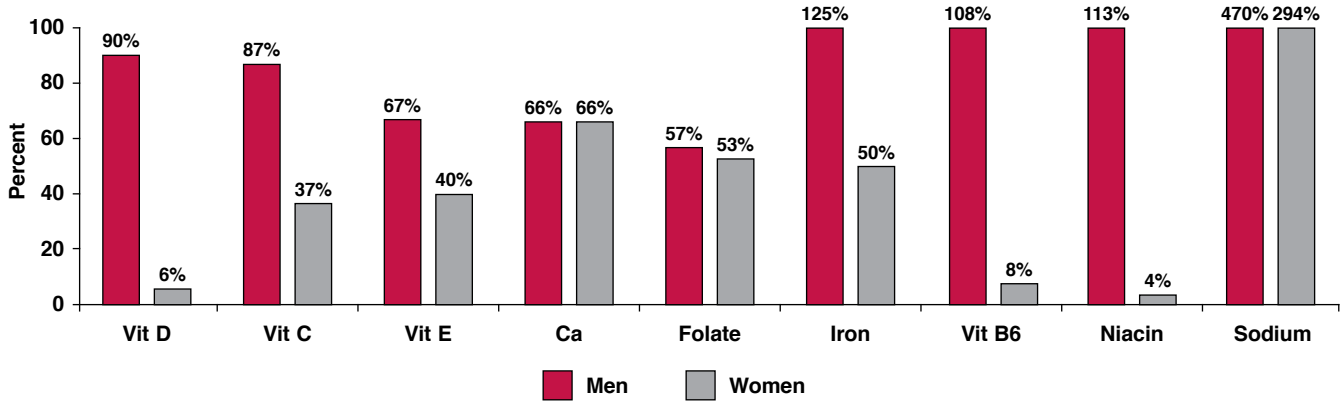

Fig. 1. Proportion of men and women consuming more than the recommended daily intake of sodium or with less than the daily recommended intake of selected micronutrients. Significant difference between men and women, *$p < 0.01$, **$p < 0.001$.

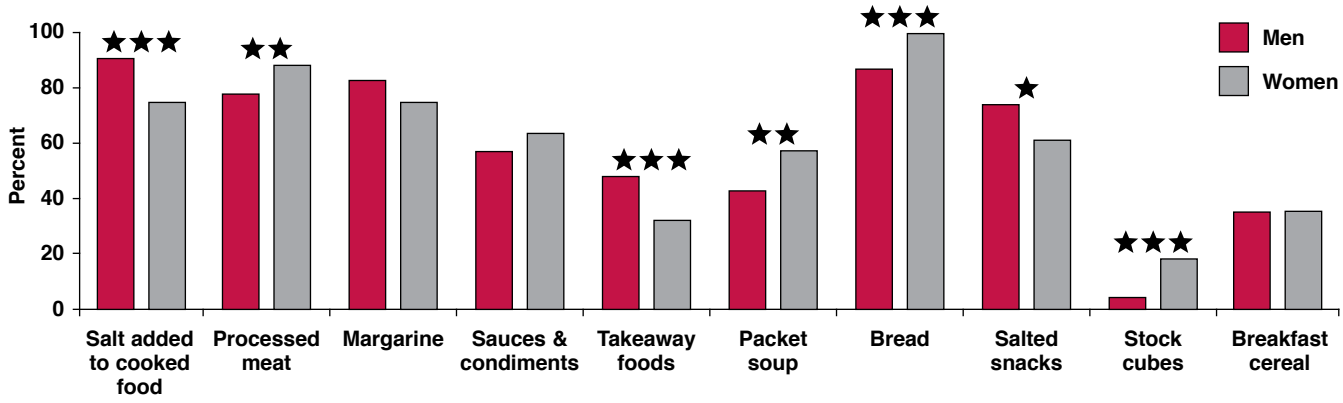

Fig. 2. Percentage of men and women consuming the 10 foods contributing most to mean sodium intake in HF patients.

with HF.[8]

High salt intake, particularly in men, was a major problem in this black urban patient group. This, related to a high consumption of bread, processed and take-away foods and the use of high-salt stock cubes and sauces, consistent with North American findings where salt in bread and pre-prepared and cereal foods contributed to around one-quarter of total salt intake.[33] Possible barriers to adherence to a healthy, low-salt diet in this black population were: lack of knowledge regarding high-salt foods and healthy affordable alternatives, perceptions that meals prepared without added salt were tasteless and boring, and lack of support for dietary change from family members.[34]

Although a salt restriction (2–3 g/day) is standard therapy for HF,[35] black Sowetans with HF commonly consumed 5–7 g per day.[36] This indicates the need for higher levels of dietetic education to achieve sodium-restricted diets. At Chris Hani Baragwanath Hospital, 10 registered dieticians currently provide a nutritional service to 2 500 patients; clearly an inadequate ratio of 1:250, instead of the more acceptable ratio of 1:50.[37]

In contrast to the rural areas of South Africa where more 'traditional' food patterns still apply, in the urban areas undergoing very rapid epidemiological transition, poor quality 'Westernised' diets are common.[26,38] The South African Dietary Guideline (SADG) addresses these nutritional issues, although compliance with recommendations is not readily achieved by disadvantaged urban populations.[38] The SADG for example recommend servings of 'meat, fish, chicken or eggs' should be eaten daily as nutrient-rich sources of high-quality protein. As selection of fatty meats and full-fat dairy foods can increase cardiovascular disease risk, Scholtz and colleagues[39] suggest a safe daily intake would comprise: 400–500 ml milk, two to three servings of fish and four eggs, and no more than 560 g of meat per week.

In this group of CHF patients, median intake is less than half this amount, presumably as these foods are not affordable. Nevertheless, the proportion of dietary protein was within accepted levels (13%E), although the majority came from plant rather than animal sources, with implications for micronutrient intake. Calcium intake, particularly in women was inadequate. Some more affordable sources of plant protein, notably legumes, rich in many nutrients, were not selected in quantity, suggesting lack of familiarity with preparing meals using these foods.

The total fat intake seen in this HF cohort was within recommended levels (< 30%E) but saturated fat intake was excessive, particularly in men, and was related to choice of poor-quality fatty meat, high-fat dairy foods, cakes and biscuits, and take-away foods. This is consistent with the trend for higher total fat and saturated fat consumption seen with urbanisation throughout South Africa.[40] This patient group continued to eat more traditional carbohydrate foods such as maize porridge, oats and mabella, but also consumed highly refined carbohydrate foods such as cakes, biscuits, cold drinks, sweets, chocolates and added sugar, liable to increase triglycerides and to promote insulin resistance and obesity.[33]

Fruit and vegetables provide alternative sources of carbohydrates and contain many cardioprotective nutrients,[41] including potassium (lowers blood pressure), folate (reduces plasma homo-

cysteine), vitamin C and many polyphenolic compounds (with antioxidant activities), and soluble fibre (lowers cholesterol). Green leafy vegetables are also high in magnesium (associated with a lower CVD risk). The SADG therefore recommend an intake of five to eight portions (400–600 g) of fruit and vegetables daily.[41] Black urban Sowetans with HF however, consumed only around one piece of fruit and one vegetable serving per day. Poor affordability and availability probably accounted for this low intake.[41,42] The 1999 South African National Food Consumption Survey indicated that where household income was less than R12 000 per annum, few foods were found in the house (maize, salt, white sugar, tea, fat/oils, white rice and white bread were most common) and micronutrient intakes were frequently low.[42]

This study has several limitations. Firstly, it was a preliminary investigation, performed in a fairly homogeneous group of HF patients. The study was unable to explore the effects of gender roles (women in Soweto still buy and prepare most of the food), effects of differences in average household income, and seasonal variance or the availability of food. These factors limit the extrapolation of these data to other patient populations. It would be of interest in further studies to explore the effects of the media on exposure to Western processed foods, as well as barriers to knowledge on the selection and preparation of healthier foods. However, data presented here were meticulously collected using validated tools.

Conclusion

This study found that urbanised black Sowetans with HF have high-salt intakes and a nutrient-poor diet, placing them at high risk for deteriorating cardiac function and a premature death. Many poor households remain food insecure, which limits their ability to improve their food choices and their overall management, with potentially life-saving consequences. Nutritional education should therefore focus on foods that are varied, available, affordable, culturally acceptable and popular, as well as consistent with the low-salt, low-fat, high-fibre guidelines.[43] Home cooking should also be encouraged. By not adding salt to cooking and not eating processed foods high in salt, salt intake can be reduced,[35,36] while dietary compliance can be improved by encouraging use of herbs and spices and by providing recipes for appealing low-salt foods. Patient education on reading food labels and recognising high-salt foods should also be expanded.

Recommendations for future research include, therefore, sustainable, practical self-management programmes for black patients with HF living in developing urban areas, where their socio-economic circumstances often remain poor. When combined with other aspects of culturally specific multidisciplinary care, the positive impact of such programmes is likely to be profound.

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4.3.1 Discussion

The findings from our study support the fact that this is a population undergoing nutrition transition, with our results being similar to those from other studies performed in South Africa on black population groups living in urban areas, which showed that the traditional way of life and food choices are being exchanged for a more Westernized diet with a resultant increase in chronic diseases of lifestyle [15, 16]. According to Abrahams et al (2011), South Africa, together with other sub-Saharan countries such as Ghana, Gabon and Cape Verde, have the highest nutrition transition scores indicative of a population well established in the nutrition-related NCD phase of the nutrition transition [17]. Poor social circumstances, food insecurity, lack of education and unemployment may contribute to a lack of knowledge about CVD risk factors and little interest in primary prevention, for example, by following a diet low in saturated fat, high in fibre and unrefined starch and sufficient amounts of fruit and vegetables, as described in the following publication 4.3 [18].

Both men and women had insufficient intakes of vitamins C, D, E, folate and calcium, although in women, their intakes of vitamin D and magnesium were only marginally lower than recommended [14]. Deficiencies of certain micronutrients in patients with CHF might occur due to reduced intake of food and/or the increased loss through the use of diuretics, exacerbated by the general loss of body tissue associated with HF [9], which can be seen with the relatively low BMI of the women (26.5 ± 6.4), especially when compared to the BMI of 29.9 ± 9.2 found in the women seen at primary care level [6]. In this cohort, the insufficient intake of calcium can be ascribed to the reduced consumption of milk and milk products [14]. An association has been reported between reduced calcium intake and an increased mortality from ischemic heart disease in post-menopausal women, as well as an increased prevalence of osteopenia or osteoporosis in patients with severe HF [9]. The low consumption of fruits and vegetables in this cohort contribute to vitamin C and folate intakes below the recommended levels [14]. Epidemiological evidence supports an inverse link between folate intake and risk of coronary heart disease and a reduced risk of death from stroke with higher intakes of vitamin C [2, 9]. Results from our study also showed that both men

and women consumed sodium in excess of the recommended daily intakes for HF patients of 2000 to 3000 mg per day because of an increased consumption of bread and processed foods.

There is limited data available on the food choices of the broader adult Soweto population. However, studies undertaken with adolescents and fieldworkers in Soweto by Feeley et al (2009), showed an increased consumption of fast-food items with a resultant increase in energy, total fat and salt [19]. These findings support our food intake data as described above, and in publication 4.2, which demonstrate damaging food choices and potential nutritional deficiencies in this cohort of subjects with CHF and serves as a clear indication that following a healthy diet may contribute to improved outcomes [14].

A potential limitation in this study was the use of QFFQ to estimate sodium intake, as the 24-hour urinary sodium test is considered to be the gold standard for estimating sodium intake. However this method is expensive and is not useful for large participant groups as it is time-consuming and labour intensive. Urinary sodium estimations cannot identify specific dietary sources of sodium and are therefore not appropriate to estimate individual sodium intakes [20]. We therefore, decided to use the food frequency questionnaire, as it measures the participant's usual consumption of the listed food items over a stipulated time period, places a modest demand on the participants, is relatively inexpensive for large sample groups and is representative of a usual dietary intake.

In order to prevent the development of deficiencies and NCDs and to assist the South African population in making healthy food choices, the food based dietary guidelines (FBDGs), based on local food and eating patterns and described in publication 4.3, were developed to serve as recommendations for healthy eating and to meet all nutrient requirements [12].

When an individual's requirements in terms of sufficient amounts of water, energy, macro- and micronutrients are met on a daily basis, it can be considered that an individual has food security and is following a healthy diet. For optimal nutritional health many nutrients are required and as no single food contains all of these nutrients, it is advised to consume a variety of foods, e.g. dietary diversity, as part of a healthy diet. Diets with limited variety are more likely to be deficient in certain nutrients and may lead to food insecurity and malnutrition [21]. In order to measure dietary

diversity in South Africa, a national study was undertaken in 2009, whereby a dietary diversity score (DDS) was calculated according to nine food groups [22];

1. Cereals, roots and tubers
2. Meat, poultry and fish
3. Dairy
4. Eggs
5. Vitamin A-rich fruit and vegetables
6. Legumes
7. Other fruit
8. Vegetables (other than legumes)
9. Fats and oils

According to their findings, inter-ethnic DDS differences showed that black ethnic groups had the lowest mean DDS of 3.63 (CI: 3.55-3.71) and furthermore, that women living in a low-resource environment in Gauteng had a mean DDS of only 3.71 [21, 22]. A barrier to people consuming a diet rich in diversity, is the cost (or perceived cost) of available healthy foods. Foods that are high in energy (energy-dense), but low in micronutrients are generally less expensive and therefore people with a low income may choose these foods because of the perceived lower cost [21]. A diet high in energy-dense foods, with low micronutrient content is however, associated with a higher BMI in women, increased waist circumference in men and women, as well as elevated fasting insulin levels and metabolic syndrome [21]. The purpose of the following study was therefore to determine the cost of a diet based on healthy food choices compared to that of a habitual diet observed in Soweto.

Publication 4.3: Perspectives and perceptions on the consumption of a healthy diet in Soweto, an urban African community in South Africa (Statement of originality of document: Appendix C) [18].

A HEALTHY DIET IN SOWETO

Perspectives and perceptions on the consumption of a healthy diet in Soweto, an urban African community in South Africa

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ABSTRACT

In Soweto, like in many other urban communities in sub-Saharan Africa, rapid urbanisation and epidemiological transition have left this urban African population vulnerable to diseases of lifestyle such as obesity, cardiovascular disease, hypertension and diabetes. The Heart of Soweto (HOS) study was established to examine the emergence of heart disease in Soweto and other African communities in epidemiological transition and found multiple threats to the current and future heart health of Soweto. Food intake data from the HOS has shown damaging food choices and potential nutritional deficiencies in a subgroup of urban black African patients diagnosed with CHF, living in Soweto. This preliminary data focused on the impact of changing dietary patterns, low income levels and a probable lack of knowledge of what constitutes a healthy diet and the contribution of these, to cardiovascular disease.

It seems that the traditional diet is being abandoned in favour of a more Western diet typified by increased consumption of processed and convenience foods, and therefore an increased intake of salt, sugar and saturated fat. The decreased intake of fruit and vegetables has lead to a decreased consumption of fibre and vitamins and minerals. The traditional diet is associated with a low prevalence of degenerative diseases, whereas the Western diet is associated with increased prevalence. Factors that might possibly contribute to the change in dietary patterns include socio-economic circumstances, urbanisation, food insecurity, awareness around healthy food choices, as well as perceptions on obesity and overweight.

Our comparison, based on currently available food prices, shows that the consumption of a healthy diet in Soweto represents a more cost effective and affordable choice than an unhealthy diet. Healthy food choices therefore, should be promoted both from a health, as well as a financial perspective.

Creating awareness around risk factors that might contribute to chronic diseases of lifestyle and the prevention there of, has become essential in this urban African population. Nutrition education and intervention programmes should focus on foods that are varied, available, culturally acceptable and popular, with the emphasis on affordability, as well as being consistent with the South African Food Based Dietary Guidelines. SAHeart 2011; 8:178-183

INTRODUCTION

South Africa is still a complex mixture of both developed and developing areas in terms of its population and its economy, with a variety of living conditions spanning wealthy and middle-income suburbs, deprived peri-urban areas and under-developed rural areas.[1,2] Urban black South Africans living in Soweto represent a population subset that is undergoing rapid social and economic development.[3,4]

The South Western Township, later named Soweto, was developed in the proximity of Johannesburg, South Africa, approximately 100 years ago. It is home to the largest number of urban black Africans on the African continent.[4,5] According to an official census done in 2001, the number of people living in Soweto counted just below 1 million people. This number is rising, as there is a steady influx of migrants.[6] It is a population in transition, with old squatter misery and new prosperity existing side by side.[4,5] According to Stewart, et al. (2006), data on the population of Soweto has shown a low prevalence for cardiovascular disease (CVD) and the underlying risk factors.[4] This might however be changing, as several studies have shown that urbanisation and the nutrition transition in South Africa is accompanied by an increase in the CVD risk factors in black Africans. More data is however needed to determine whether this increase in CVD risk is related to urbanisation per se or whether socio-economic position influences the nutrition transition and related increase in CVD risk.[7]

The HOS Study is one of the largest and most comprehensive prospective registries on heart disease emanating from Africa to date, and is a collaborative project that was established to examine the emergence of heart disease in Soweto and other African communities in epidemiological transition. According to Sliwa, et al. (2008), data from the HOS provide good evidence that the phenomenon of epidemiologic transition in Soweto, South Africa has broadened the complexity and spectrum of heart disease in this community. We found multiple threats to the current and future heart health of Soweto including a high prevalence of modifiable risk factors for atherosclerotic disease, and a combination of infectious and non-communicable forms of heart disease, with late clinical presentations.[8]

Food intake data from the HOS has shown damaging food choices and potential nutritional deficiencies in a subgroup of urban black African patients diagnosed with CHF, living in Soweto. This preliminary data focused on the impact of changing dietary patterns, low-income levels and a probable lack of knowledge of what constitutes a healthy diet and the contribution of these, to CVD.[9] The increased intake of processed and convenience foods, that were in the past not part of the local diet, will contribute to the development of newer forms of heart diseases and other chronic diseases of lifestyle, such as diabetes and high blood pressure, especially with relatively young persons and women.[9,10] Data reported by Feeley (2008) that almost ninety percent of 17-year-olds living in Soweto consume fast foods three or more times per week, support these findings from the HOS.[11]

A clear need therefore exists in this urban African population to identify the perceptions and possible barriers to the consumption of a healthy diet and to develop and implement targeted, culturally sensitive and economical nutritional programmes.

POSSIBLE CONTRIBUTORS TO UNHEALTHY FOOD CHOICES

Socio-economic circumstances

Data from the HOS reported that the link between socio-economic circumstances and the increase of non-communicable heart disease poses the biggest threat in the Soweto population.[10] Financial security is essential to ensure a regular and adequate supply of a variety of foods, thereby preventing malnutrition (under- and over-nutrition) and reducing the risk of developing chronic diseases of lifestyle.[1,12] Socio-economic inequities are still present in South Africa and are reflected in the food choices and macro-and micro-nutrient consumption, as well as the nutritional status of people living in South Africa, as well as Soweto.[1,10]

Data from the HOS has shown a gradient in total cholesterol levels according to educational experience; 3.6 ± 1.4, 3.7 ± 1.3, and 4.2 ± 1.5 mmol/L in those with <6, 6-10 years and >10 years education, respectively.[10] This is supported by results from the Transition, Health and Urbanisation Study (THUSA) study that showed, that with urbanisation, increased income and increased education, there were marked and sustained increases in some CAD risk factors, notably total serum and LDL cholesterol levels in men and women, and BMI in men.[13]

Urbanisation

Increased urbanisation in South Africa can be attributed to a change in social structure, political changes in the country, as well as economic factors.[1,10,14]

We could show recently that less than half of the 5 328 cases screened for cardiovascular disease at the only tertiary clinic for a population of more than 1.1 million were living longer than 5 years in Soweto.[10]

With urbanisation new challenges and problems have to be faced together with a possible improvement in economic circumstances. These challenges include living in squatter camps and informal houses with poor sanitation and sewage disposal, water still has to be carried from one central tap, no electricity, no refrigeration and food has to be cooked on paraffin stoves or wood fires, as well as increased exposure to crime and violence.[1]

With urbanisation, people have moved away from their families and familiar surroundings with the resultant loss of support structures, as well as having to adjust to a new environment and surroundings. The lifestyle changes that are most frequently observed are an increased sedentary lifestyle and a change in dietary patterns. In rural areas people tend to be more physically active, working in and around their houses, walking to town and to visit friends and children playing outside. In urban areas, transport is more available and shopping centres very accessible and people therefore do not need to walk long distances. Instead of playing sports outside, people stay in to play video games or watch television or sit in front of the computer.[15]

In Soweto, as in other parts of the country, urbanisation has impacted negatively on dietary patterns. A more Westernised diet is followed, that is higher in energy, contains more salt, saturated fat and more sugar. The decreased intake of fruit and vegetables has lead to a decreased consumption of fibre and vitamins and minerals.[1,9,16] In addition, increased alcohol and tobacco consump-

tion is seen.[1] Working longer hours and being away from home for longer periods of time, as well as fast foods being more available and affordable, have led to a change in dietary behaviour.[1,15] These changes in lifestyle and diet contribute to increasing levels of chronic diseases of lifestyle risk factors.[1, 9,15]

CAN WESTERN DIETARY GUIDELINES BE APPLIED TO AN URBAN AFRICAN COMMUNITY?

Data from the HOS showed an increased intake of salt as well as saturated and trans fatty acids due to the increased consumption of processed and convenience foods. A tendency still exists to eat fruit, vegetables and salads only on weekends, which leads to a decreased consumption of fruit and vegetables and subsequently to a low micronutrient and fibre intake.[9]

One of the hypotheses supported by rural/urban comparisons of African populations has been that the traditional diet is abandoned, with urban exposure, for a Western diet typified by decreases in carbohydrate and fibre and increases in fat. The traditional diet is associated with a low prevalence of degenerative diseases, whereas the Western diet is associated with increased prevalence.[17]

Incorporating cultural preferences and beliefs into recommended dietary guidelines

The South African population consist of a diversity of ethnic and cultural groups with different traditional eating patterns. The white population consumes a typical Western diet, which has high fat (>30% E) intake, low carbohydrate intake (<55% E), low fibre and high free sugar intake (>10%E). The Indian and coloured (mixed ancestry) populations have a similar pattern to the white population, with the addition of certain popular and commonly consumed foods. The black African population on the other hand, has two distinct types of eating patterns. The rural population still follows a very traditional diet, which is high in carbohydrates (>65%E), low in fat (<25%E), low in sugar (<10%E), and moderately high in fibre. Dietary patterns of the black African urban population, however, is changing to a more Westernised diet, with lower carbohydrate (<65%E) and fibre intakes, and higher fat intake (>25%).[1,9,17]

Previously, guidelines in South Africa were either nutrient-based or aimed only at a population eating a typical Western diet. Motivated by the FAO/WHO initiatives, the Nutrition Society of South Africa (NSSA) decided to form a focus or working group that has since developed positive, affordable, sustainable and culturally sensitive Food Based Dietary Guidelines (FBDGs) to help South Africans over the age of 5 years to choose and adequate but prudent diet.[18]

The FBDGs consist of 10 short, clear and simple messages targeted at different ethnic population groups in both rural and urban areas.[18] The guidelines are:

- **Enjoy a variety of foods.**[18] A lack of dietary variety could contribute to low micronutrient intakes, low energy intakes and chronic diseases of lifestyle.[18,19]
- **Be active.**[18] This guideline is based on the well-established link between physical activity and lowered risk of mortality and morbidity associated with many chronic diseases of lifestyle and is compatible with the increasing focus on healthy lifestyle and habitual physical activity, including household and gardening activities, transport and leisure time.[18,20]
- **Make starchy foods the basis of most meals.**[18] Unrefined or minimally processed cereals and grains such as maize, wheat, sorghum, oats and rice in the form of porridges, breads, pastas, rice, samp, maize rice, breakfast cereals and other products should be the central or main food, and the rest of the meal planned around this food. The aim of this guideline is to promote an increased intake of carbohydrate-rich foods in those people who have low intakes, and to maintain optimal intakes among those currently eating high-carbohydrate diets.[18]
- **Eat plenty of fruit and vegetables.**[18] Fruit and vegetables provide a good source of fibre-rich carbohydrate and additionally supply many cardioprotective nutrients.[21] These include potassium (lowers blood pressure), folate (can reduce plasma homocysteine), vitamin C and many polyphenolic compounds (with antioxidant activities) and soluble fibre (lowers cholesterol). Green leafy vegetables are also high in magnesium which has also been associated with lower CVD risk. The FBDGs, therefore, recommends an intake of 5 to 8 portions (400 to 600g) of fruit and vegetables daily.[18,21]
- **Eat dry beans, peas, lentils and soya often.**[18] These foods are an excellent source of soluble fibre and micronutrients and an economical source of plant protein.
- **Meat, fish, chicken, milk and eggs can be eaten every day.**[18] Literature indicates that it is possible, but difficult, to achieve adequate and balanced diets without inclusion of foods from animals. It is, however, very important to choose low-fat products and fats should be used sparingly in the preparation, cooking and serving of these foods. Although expensive, even small amounts will add valuable nutrients, such as calcium, iron, zinc and the essential omega-3 fatty acids, to the diet.[22]
- **Eat fats sparingly.**[18] The aim would be to lower fat intakes, especially the intake of saturated fatty acids (SFAs) among

those who follow a typical Western diet high in fat, and to control the fat intake in those following a diet low in fat.[23]

- **Use salt sparingly.**[18] Salt should be used sparingly, if at all, at the table and in the preparation of meals, and the intake of processed foods high in salt should be limited.[24]
- **Drink lots of clean, safe water.**[18] Water is an essential nutrient and the recommended intake is 1ml/kcal energy expenditure for adults. This equates to 2.9l/day for men and 2.2 l/day for women under average conditions. Children require 50% more water per kcal energy expenditure. Water loss occurs via the lungs, sweat glands and kidneys.[25]
- **If you drink alcohol, drink sensibly.**[18] This guideline seeks to encourage members of the South African population who misuse alcohol, particularly by binge drinking, to engage in "low-risk drinking" or "sensible drinking". "Low-risk drinking" is defined as no more than four units of alcohol per day for men and no more than two units for women, with at least two alcohol-free days per week. Documented beneficial effects of alcohol include the French paradox, and the indication that moderate alcohol intake may reduce the incidence of coronary heart disease by increasing high-density lipoprotein cholesterol concentrations, and favourably modifying platelet and other clotting functions. In addition, sorghum beer, a traditional African beverage, has been found to make positive contributions to dietary intake, particularly when the beer is brewed with sorghum adjunct.[26]

The FBDGs therefore seek to addresses such nutritional issues, but compliance with recommendations is not always readily achieved by disadvantaged urban populations. Although South Africa produces enough food for all its inhabitants, and even exports food, many poor households are food insecure, especially in rural areas and in informal housing areas inhabited by people in transition.[18] Barriers to the application of the FBDGs, as cited by South African women, were affordability, availability, household taste preferences, time constraints, traditional/habitual food purchasing and/or preparation methods, and persistent attitudes.[21]

The implications of food security on the consumption of a healthy diet

Poverty and high levels of household food insecurity are therefore the greatest barriers for the majority of people (especially those in rural and urban informal areas) to the application of many of the FBDGs.[21]

Food security is a broad concept which cuts across many dimensions. At its most basic level, it means access to adequate food for a healthy life.[27] Poverty continues to be the main factor in household food insecurity. Sufficient, safe and varied food supply can prevent under- and over-nutrition and reduce the risk of chronic disease.

Household food security depends substantially on household income and asset (or wealth) status. A low-income household is more likely to suffer food shortages than a wealthier household. Food expenditure comprises a large share of the spending of poor households, making them relatively more vulnerable to the impacts of food price inflation.[27] The 1999 South African National Food Consumption Survey indicated that where household income was less than R12 000 per annum, few foods were found in the house (maize, salt, white sugar, tea, fat/oils, white rice and white bread were most common) and micronutrient intakes were frequently low.[9,27]

The relationship between a household's food security status and its purchasing power is far from static; it changes over time. All other factors remaining constant, changes in income alter the quantity and quality of foods purchased and consumed. Price movements of food and non-food items also affect the ability to buy food. For example, to cope with rapid food inflation a household could cut its food purchases and adjust its consumption patterns. Typical coping strategies are: buy smaller quantities of food, switch to different types of food, reduce dietary diversity and skip meals. As a large proportion of new jobs in the South African economy are relatively precarious, a household that sits close to the precipice can also be seen as food insecure.[27] Therefore, food choices should be evaluated in the context of total lifestyle and living circumstances. In South Africa, socio-economic circumstances have a major influence on food choices and dietary patterns.[18]

The implications and perceptions of obesity and overweight

The prevalence of overweight and obesity is very high in South Africans, with 56% of women and 29% of men having a body mass index ≥25kg/m2.[15]

Our own research from Soweto highlights the very high prevalence of obesity in particular in women. Data collected at 1 311 consecutive patients attending two primary care clinics in Soweto, South Africa showed that amongst 862 women (aged 41 ± 16 years) and 449 men (aged 38 ± 14 years) women were more likely to be obese (42% vs. 14%; or 4.54, 95% CI 3.33 - 5.88).[28]

Like many other urban communities in sub-Saharan Africa, Soweto is sitting on a time bomb of modifiable risk factors, most notably obesity.[29] Again, voluntary community screening at Soweto taxi-ranks showed a markedly higher prevalence of being overweight or obese amongst females. For the ethnic groups, obesity is highest in black women and in white men. According to SADHS data, obesity seems to start at a young age in these women. By the age of 15 to 24 years, 10% of these women were already obese.[1,30] It has, however, been observed previously in literature that amongst the black African population, obesity is perceived as less of a problem, with less social pressure to lose weight.[17,31]

A link between obesity and food insecurity has also been established during the last few years in the literature. Food insecurity with hunger has been associated with an increased risk of obesity.[15]

Cost of Dietary Intake in Soweto

The likely cost of consuming a healthy diet in Soweto was calculated based on food prices available in July 2011and compared to current intake that does not adhere to the South African Food Based Dietary Guidelines. As can be seen in Table 1, current food intake requires an expenditure of approximately R18.42 per day. A recommended food intake, where maize meal porridge is supplemented with mabele (coarse), legumes, carrots, spinach, apples, oranges and full cream milk would require an expenditure of R17.72 per day, and therefore, represents an attractive option both from a financial and health status perspective.[28]

Many factors affect food choices and methods of food preparation. Poverty, lack of knowledge and social instability in the black population militate against healthy eating being a priority in the minds of township dwellers. The long commuting distances of employed city dwellers frequently result in choices of easy-to-prepare foods and snacks away from home, which are generally refined and high in fat content. Conversely, the more traditionally orientated individuals are frequently the under-employed "newer arrivals", who may have the time to prepare relatively low-cost maize- and legume-based dishes, which have long cooking times. Dietary interventions have to consider these and other factors.(18)

CONCLUSION

Food intake data from the HOS shows that urban Africans living in Soweto might be in the early stages of the nutrition transition and that their food choices are affected by urbanisation. Their diets are being supplemented by highly refined carbohydrate sources, such as added sugar, sweets and chocolates, cakes, biscuits and cold drinks, as well as increased fat and salt intake through processed and convenience foods. It also shows a decreased intake of fruit

TABLE 1: Cost of healthy eating compared with habitual intake[32]

Current daily intake			Recommended daily intake		
Food item	**Weight (g/mL)**	**Cost (R)[1]**		**Weight (g/mL)**	**Cost (R)[1]**
Bread	150	2.25	Mabele (coarse)	40	0.30
Margarine	15	0.70	Apple	160	1.77
Polony	30	0.80			
Milk (full cream)	150	1.23	Milk (full cream)	500	4.25
Sugar	15	0.12	Sugar	15	0.12
Maize meal porridge	1 000	4.80	Maize meal porridge	1 000	4.40
			Beans in tomato sauce	90	1.30
Chicken (cooked)	90	3.00	Chicken	90	3.00
			Canola oil	10	0.21
Tomato	45	0.50	Spinach	75	1.25
Apple	160	1.77	Carrots	75	0.72
			Orange	180	0.40
Cold drink	500	3.25			
Total cost:		**R18.42**			**R17.72**

[1]*Based on food prices in Soweto, July 2011.*

and vegetables that contributes to a decreased intake of micro-nutrients and fibre.[9] Whereas the traditional rural diet is low in fat and high in unrefined carbohydrates, vegetables and fruit, consisting mainly of maize porridge with leafy green vegetables, spinach and/or pumpkin with a high consumption of legumes and fruit when available. It is therefore, likely that this changing pattern of dietary consumption can contribute to a pattern of sub-optimal health outcomes and increased risk for the development of chronic diseases of lifestyle.

Creating awareness around risk factors that might contribute to chronic diseases of lifestyle and the prevention there of, has become essential in this urban African population. Nutrition education and intervention programmes should focus on foods that are varied, available, culturally acceptable and popular, with the emphasis on affordability, as well as being consistent with the South African Food Based Dietary Guidelines.

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4.4 Conclusion

Dietary recommendations should encourage diets rich in diversity, incorporating healthy traditional foods and dishes that include legumes and vegetables, utilising seasonal availability, as well as other cost saving measures, such as traditional 'stokvel' groups whereby members buy in bulk and share amongst themselves, preserving and using fuel-saving cooking methods. It should also be a holistic approach and encourage people, where possible, to enjoy meals with family and/or friends [18].

Using all of the above information available to us, we therefore identified gaps and areas that needed to be addressed if we wanted to make a difference in the health outcomes of people living with chronic heart failure, and initiated a randomized controlled study of a multidisciplinary, community-based, chronic heart failure management program at tertiary care level in Soweto, compared with usual care, to improve health outcomes in CHF patients. We also wanted to examine the potential value of the type of CHF management that has successfully been developed and implemented in high income countries in a low-resource urban black African community. These interventions will be described in the following chapter.

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CHAPTER 5

HEART FAILURE DISEASE MANAGEMENT WITHIN A MULTIDISCIPLINARY CARE NETWORK

5.1 Introduction

Chronic heart failure (CHF) is a major public health problem and one of the leading indications for hospitalization in older adults, accounting for almost 25% of all cardiovascular hospitalizations and with a high morbidity and mortality rate [1,2]. This impacts heavily on medical resource consumption, which again has major socio-economic implications [1]. Reports from developed countries indicate that CHF consumes around 1% to 2% of their total health care expenditures [2], while in African countries these costs might be much higher, but accompanied by a higher burden of out-of-pocket cost for the individual suffering from CHF [3]. The African and South African setting poses unique challenges to healthcare services and the individuals suffering with chronic diseases, especially vulnerable and previously disadvantaged groups living in poor socioeconomic circumstances.

CHF is characterised by an unstable course of illness and is progressive in nature, often accompanied by debilitating symptoms, such as oedema, weight gain or weight loss, dyspnoea, fatigue and a loss in functional status and quality of life [4]. As it is a chronic disease, treatment is usually on an out-patient basis, which necessitates frequent follow-ups either at home or at an outpatient clinic to evaluate medication effectiveness, monitoring of symptoms and to promote self-care behaviour [4].

Patients with CHF frequently lose weight, which might increase with worsening symptoms. There might be many reasons for this weight loss, such as patients being less active due to the CHF, which might result in muscle loss, acerbated by the disease itself [5]. In patients with CHF there is a shift towards a catabolic state, with catabolic steroids being elevated and increased relative to anabolic steroids [6]. Another contributing factor to poor nutritional status is gastrointestinal malabsorption possibly due to gut edema, which might negatively affect the absorption of macro- and micronutrients and therefore, negatively affect outcomes in patients with CHF [5].

As reported from the HOS study [7], and supported by data from Nigeria [8], the average age of patients presenting with HF is younger than reported from high-income countries [7,8]. A challenge faced in sub-Saharan Africa is the lack of community based or nurse-led or home care

of patients suffering from CHF and the lack of family support. These patients then have to visit their out-patient clinics more frequently to refill prescriptions or to see a doctor, which contributes to high transport costs and days lost at work [3]. Because of the younger age of CHF patients in these settings, CHF is therefore, associated with longer DALY's and places a huge burden on families and society at large [3,4]. It essential that not only healthcare authorities, but the general public as well, recognise the clinical, economic and social importance of appropriate CHF care, adequate resources and research, as awareness around the causes, symptoms and management of CHF might assist in making the necessary lifestyle changes [9].

Pharmacological treatments have been shown to improve outcomes in patients with CHF, but the overall prognosis of these patients remains poor, therefore the focus should also be on assisting patients to benefit from existing effective treatment regimens [10]. However, effectiveness of treatment relies substantially on the patient's ability to adhere to the regimen [11]. CHF patients must usually follow a treatment regimen consisting of multiple components that include medications, dietary and exercise programmes and the management of individual symptoms [12]. There is thus a need for additional approaches to disease management, and a number of studies have demonstrated that among patients hospitalised with CHF, those who received multidisciplinary care had increased medication adherence and appropriate medication prescription, reduced hospitalizations, improved compliance to treatment and reduced costs [2,11,12,13]. Therefore, best-practice management of CHF should involve multidisciplinary care.

5.2 Development of a comprehensive heart failure management program in a low-resource setting in South Africa.

Self-monitoring, compliance to treatment and timely response by CHF patients to worsening symptoms caused by fluid overload are important cornerstones in the care of CHF [14]. Awareness of treatment benefits, knowledge of disease management and participation in cardiac rehabilitation programs could aid in compliance and prevention of hospital re-admissions in CHF patients and can limit the adverse physiological and psychological effects. Unfortunately, according to previous studies the utilisation of cardiac rehabilitation programs remains low, with about one third of those eligible participating [15].

In the HOS very late presentation of more than 50% of the cases meant that the patients presented in 'heart failure'. We found antecedents common to high-income countries and a spectrum of aetiology beyond the traditional causes of HF in Africa that no doubt contributed to the unexpectedly large (and inherently preventable) volume of cases from this large urban region. Numerous studies performed by our unit described the characteristics and the management of heart failure due to idiopathic and dilated cardiomyopathy [15,16,17,18]. Consistent with outcome data derived from patient cohorts in developed countries, 20% of hospitalized patients with CHF at CHBH die within one year and 60% of survivors are re-admitted to hospital within 18 months [16,18].

In the developed countries there has been increasing interest in the role of dedicated CHF management programs that provide individualized education, care and support to patients and families affected by this deadly and disabling syndrome. They have now become part of the gold-standard management of the syndrome with meta-analyses showing significantly prolonged survival and reduced all-cause re-admissions [19, 20]. Phillips et al (2005) set out to determine the effectiveness and benefits to the patient of a nurse-led HF intervention program as compared to usual care and found that hospital re-admission rates were lower in patients on a intervention program that included discharge planning, but found no discernible effect on quality of life and all-cause mortality [19]. However, there are no data to support their use in the developing world. Therefore, the potential role of CHF management programs in sub-Saharan Africa is huge.

The successful management of patients with CHF needs to be a multidisciplinary effort with all the necessary health care workers involved. The team will typically consist of a doctor and a cardiac nurse to plan and monitor pharmacological treatment, as well as a physiotherapist or biokineticist and dietician for the non-pharmacological treatment of patients with CHF. Structured, tailored physical activity is recommended for patients with CHF, as it has been shown to improve functional capacity, symptoms and neuro-hormonal abnormalities [21, 22].

Another one of the more difficult aspects of self-management of CHF is initiating and maintaining a low-sodium, low fat, high fibre diet. Data evaluating the efficacy of nutrition education within

cardiac rehabilitation programs are limited, but at least one study has shown that, as part of a comprehensive cardiac rehabilitation program, nutrition education under the direction of a dietician can lead to long-lasting favourable changes [17].

5.2.1 Principles of multidisciplinary care for patients with CHF

Evidence from systematic reviews, suggest effective management programmes should include the following elements [2,20,21,22];

- using a team approach across healthcare sectors; including health professional from a range of disciplines
- optimisation of pharmacological and non-pharmacological therapies through the implementation of evidence-based guidelines
- development and implementation of individualised care plans
- discussion of the aims and goals of the care plan and inclusion of the patient's family and/or support system
- effective protocols for symptom management and the monitoring of signs and symptoms for early identification of decompensation
- self-care promotion and support (e.g. monitoring and interpreting of symptoms, taking medication, adherence to lifestyle advice on smoking cessation, physical activity, nutrition and fluid/alcohol intake) as appropriate to the patient's needs, capacities and preferences
- support patients with risk factor modification and adherence to management plans by using behavioural strategies
- a continuum of care across healthcare services, that include acute care, primary care and community care where possible
- evaluate and monitor programme outcomes and systems for continuous quality improvement [2,20,21,22]

Recommendations as to optimal time of commencement, duration and intensity of a CHF management programme will depend largely on the patient's care needs and the intensity of interventions will depend on the patient's overall risk of his/her CHF getting worse [2].

The aim of our HF management programme was to construct a culturally sensitive, economical and comprehensive self-management program for people living with CHF in a low-resource setting in South Africa and to establish a comprehensive clinical and socio-demographic profile of the patients to determine the factors that are likely to increase or decrease the probability of future morbid/fatal events (as part of the HOS Registry). Such a programme should aim to achieve sustainable behaviour modification and disease management through awareness, knowledge and on-going support. The HOS multi-disciplinary team developed education and intervention programs on different platforms. This ranged from one-on-one sessions, printed educational material, practical cooking lessons, videos, as well as a website easily accessible for anyone having access to a smartphone or computer and an internet connection, as described below.

5.2.2 Components of our targeted culturally specific heart failure management programme

Table 5.1: Components for a multidisciplinary CHF management programme [22]
(adapted from National Heart Foundation of Australia, 2010)

Identifying programme objectives
A. Define the intended recipients, e.g. patients admitted to hospital with a primary diagnosis of CHF.
B. Recruit the target population, e.g. establish effective referral links with inpatient hospital services and outpatient cardiology clinic.
C. Define outcome goals, e.g. to reduce the rate of hospital re-admissions.
Biomedical care: Assessment and documentation
D. Confirm CHF diagnosis, e.g. echocardiography to document CHF diagnosis.
E. Assess functional capacity.
Biomedical care: Individualised medical management
F. Prescribe and titrate medicines according to treatment guidelines, e.g. ESC guidelines for the management of CHF were used to ensure gold-standard pharmacological treatment within the limitation of the availability of specific treatment in South Africa.
G. Develop a treatment plan, e.g. gold-standard treatment was implemented: regular visits until the patients are prescribed an optimal treatment regimen.

H. Provide preventative care, e.g. assessment of lifestyle risk factors, prevention of thromboembolism.
Multidisciplinary CHF care components
I. Develop individualised management plan, e.g. lectures about heart failure and importance of compliance given by a cardiologist, and the patient received a 'Living with heart failure in SOWETO' booklet, as shown in picture 5.1 (Appendix F).
Self-care education and support: Assessment of self-management status
J. Assess patient's ability for self-care, e.g. formal pathways were established to facilitate effective communication among all members of the patient's health care team.
Self-care education and counselling
K. Provide appropriate and culturally sensitive information and support for self-care to patient and family, e.g. lectures on dietary recommendations were given by myself, as well as practical cooking demonstration, adhering to dietary guidelines for HF and using culturally adapted recipes as in the 'Living with heart failure in Soweto' booklet (Appendix F), as shown in picture 5.2, using nutritional educational material and dietary guidelines as per booklet (Appendix F). Effective non-pharmacological management strategies, including fluid management, exercise regimen and dietary recommendations, were applied in a culturally specific basis, as per 'Living with heart failure in Soweto' booklet (Appendix F),
L. Develop action plan together with patient and carers. Thus, patients randomised to intervention care were provided with a management diary (e.g. document changes in weight and medications) (Appendix F).
Psychosocial care: Assessment
M. Determination of individual needs, e.g. assesses quality of life, depression, social support needs and coping of family.
N. Management of psychosocial factors, e.g. support groups in community etc.
Palliative care
O. Assess and discuss the long term goals and treatment care with the patient and family, e.g. clinical stability was established: regular visits until the patient's clinical signs and symptoms have been optimised relative to available treatment options. Limitation of risk

status: regular visits to address potentially modifiable risk factors for clinical instability/death (e.g. treatment non-adherence and smoking).

5.2.3 Study design of our heart failure management programme

5.2.3.1 Study setting and design

We performed a randomized controlled study of a multidisciplinary, community-based, CHF management program in Soweto, compared with usual care, at CHBH Heart Failure Clinic located at the SOCRU, or at the General Cardiac Clinic (standard care) in Soweto. CHBH at the time of the study had 3500 beds, and could be described as one of the largest hospitals in the Southern Hemisphere. It is situated on the main road between Soweto and Johannesburg and provided the only point of public funded, specialist health care for the population of Soweto. At the time of the study, usual care of CHF patients consisted of assessment by a cardiologist at the first visit to CHBH. Patients received treatment with diuretics, ACE-inhibitors and carvedilol for 3 months. After three months, patients were re-evaluated by a cardiologist and when stable, referred to primary care clinics in Soweto, where management consisted solely of medication prescribed by either a general practitioner or a primary health care nurse.

A total of 49 consenting, eligible patients were individually randomized on a 1:1 basis (via a computerized protocol) to either usual care or to the study intervention. Care was provided at CHBH Heart Failure Clinic, located at SOCRU or at the General Cardiac Clinic (standard care) - the first provided core components of the study intervention and the second provided usual care. Patients randomized to usual care had access to lectures and the Living with Heart Failure booklet after their 6-month block had been completed. Using the now well-established Heart of Soweto clinical registry, all de novo cases were screened for eligibility for this component of the study.

5.2.3.2 Inclusion criteria:

The following criteria were applied (pilot data from the Heart of Soweto registry demonstrated that at least 250 newly diagnosed patients per annum, referred for active management at the CHBH Heart Failure Clinic fulfilled these criteria)

- Aged ≥ 18 years;
- Diagnosed with moderate-severe CHF, defined by the European Society of Cardiology criteria, confirmed via ECG or radionuclide ventriculography showing impaired left ventricular systolic function (LVEF ≤ 45%); and
- Persistent functional impairment/symptoms indicative of NYHA class II, III, or IV.

5.2.3.3 Exclusion criteria:

Patients were excluded within 3 months of an admission for an acute coronary syndrome that may have precipitated a transient impairment of cardiac function. Other exclusion criteria included presence of terminal malignancy and planned corrective, cardiac surgery (e.g. coronary artery by-pass).

5.2.3.4 Data collection

All data collected in the study was of a quantitative nature. Data was collected as follows:

- **Demographic data and risk profile form** (Appendix D)
- **Anthropometric and clinical measurements at baseline and 6 month follow-up**
  - Height (m), weight (kg) and BMI (kg/m^2)
  - Blood pressure (BP) was assessed following 5 min rest; seated systolic (SBP) and diastolic (DBP) BP (in mmHg)
  - Heart rate (beats per minute)
  - LVEF by ECG
  - Blood samples were taken and frozen for measurements of vitamin C (plasma) and thiamine (whole blood)

A research assistant was present to assist with translation and interpretation where necessary.

5.2.3.4.1 Motivation for vitamin C and thiamine analysis

We decided to measure thiamine, as thiamine deficiency can induce high-output cardiac failure due to the accumulation of pyruvate and lactate, leading to intense vasodilation, and low thiamine levels have been documented in patients with CHF [6].

Vitamin C was measured because of anti-oxidative properties and therefore its possible protective effect on vasculature [6]. We previously described the insufficient intake of fresh fruit and vegetables in this population group and reduced intake of vitamin C and we therefore, hypothesized that plasma levels of vitamin C might be low in our cohort.

5.2.3.4.2 Plasma vitamin C analysis

Plasma vitamin C was measured using high performance liquid chromatography (HPLC) with electrochemical (EC) or ultraviolet (UV) light detection. Existing UV-HPLC methods for plasma total vitamin C analysis (the sum of ascorbic and dehydroascorbic acid) were modified to develop a constant-low-pH sample reduction procedure followed by isocratic reverse-phase HPLC separation using a purely aqueous low-pH non-buffered mobile phase [23].

5.2.3.4.3 Thiamine (vitamin B1), whole blood analysis

Thiamine diphosphate is the active form of thiamine and is most appropriately measured to assess thiamine status. Thiamine diphosphate in circulating blood is present in erythrocytes, but is undetectable in plasma or serum. HPLC analysis of thiamine diphosphate in whole blood or erythrocytes is the most sensitive, specific, and precise method for determining the nutritional status of thiamine and is a reliable indicator of total body stores. This assay specifically targets and quantitates the active form of vitamin B1 (thiamine diphosphate) as an indicator of vitamin B1 status [24].

5.2.3.5 Sample size

A group of 49 consenting, eligible patients (28 females, 21 males) was individually randomized on a 1:1 basis (via a computerized protocol) to either usual heart failure management care or to the study intervention. This sample number was chosen based on convenience and was restricted by infrastructural constraints.

However, a *post hoc* sample size calculation was performed in order to determine what the optimal sample size would have been for this study. This was based on the use of the Students paired t test and the variable used for the calculation was the ejection fraction, due to its large standard deviation (see Table 5.2). Thus, assuming a power of 80%, a $p<0.05$, a mean change in ejection fraction of 3.52 (we do consider this a clinically significant improvement in ejection fraction) with an SD of 10.1, the number of subjects required per group would be 67.

5.2.3.6 Statistical analysis

All data were documented on standardized forms and entered into a database. Normally distributed data is expressed in text and tables as mean ± SD, whilst non-parametric data is expressed as median (interquartile range). The non-parametric data (BMI, vitamin C and thiamine) were log transformed to normality. Change in BMI and change in diastolic and systolic blood pressure could not be normalised and therefore these variables were compared across groups using the Mann-Whitney U-test. Comparisons between the standard care and managed care groups and across genders at baseline and follow-up were performed using Students t-test for normally distributed variables whilst comparisons within groups between baseline and follow-up levels were made using Students paired t-test. In order to increase the power of the analysis, the standard and managed care groups were combined for the comparison of variables between the baseline and follow-up time points.

Variables that correlated significantly with change in heart rate and change in ejection fraction were identified using Pearson correlation analysis for the total dataset with both groups combined. Each variable that correlated with the dependent variable at $p<0.5$ was included in multiple

regression models and stepwise, backward removal of non-significant variables was undertaken until only independent variables that correlated significantly i.e. $p<0.05$ were left in the regression model. Independent variables that could not be normalised i.e. change in diastolic and systolic blood pressure and change in BMI were each converted to categorical variables and coded as 1 if they did not change or fell during the 6 months of follow-up and were coded as 2 if they increased.

5.2.3.7 Components of the multidisciplinary CHF care

To effectively manage the care of a patient with CHF, a comprehensive approach is recommended [22]. We therefore, used a checklist as described in table 5.1 consisting of four broad domains namely, biomedical care, self-care education and support, psychosocial care and palliative care.

5.2.3.7.1 Self-care education and support to patient and carers: Nutritional management

A cornerstone in the management of CHF is nutritional management and all participants randomised to the intervention group were registered for a cooking class to promote dietary compliance in a practical manner. The cooking classes, all the educational material and recipes were developed and implemented by myself as a registered dietician and the main researcher, as in the attached booklet 'Living with heart failure in Soweto', and included the following important dietary guidelines; (1) *Control the salt in your diet*. Decreasing the total amount of sodium you consume to no more than 1,500 mg (1.5 grams) per day is one of the most important ways to manage heart failure, (2) *Learn to read food labels*. Use the label information on food packages to help you to make the best low-sodium selections, (3) Eat a variety of foods to get all the nutrients you need**, *(4) Include high-fiber foods in your diet.*** Fiber is the indigestible part of plant food that helps move food along the digestive tract, controls blood sugar levels, and may reduce the level of cholesterol in the blood. Vegetables, beans (legumes), whole-grain foods, bran, and fresh fruit are high in fiber. The goal for everyone is to consume 25 to 35 grams of fiber per day, (5) *Limit your intake of saturated fat* to <7% of energy, *trans*-fatty acids to <1% and cholesterol to <300mg per day, (6) Minimize your intake of beverages and foods with added sugars, (7) *Carefully follow your fluid management guidelines.* Reduce your fluid intake if you have become more short of breath

or notice swelling, (8) *Maintain a healthy body weight*. This includes losing weight if you are overweight. Limit your total daily calories and exercise regularly to achieve or maintain your ideal body weight, (9) *Reduce alcohol consumption*. Because alcohol can affect your heart rate and worsen your heart failure, your doctor may tell you to avoid or limit alcoholic beverages. Alcohol may also interact with the medications you are taking. Moderate alcohol intake is permitted, but should not exceed one drink per day for women and two drinks per day for men, whereby a drink is equivalent to 30 ml of alcohol (distilled liquor) or 150 ml wine or 360 ml beer [7,8,10].

Awareness was created in the patient and patient's support system, such as friends and/or family members on the early detection/management of disease condition and potentially fatal clinical deterioration with patient-initiated contacts via the specialist CHF nurse at Baragwaneth hospital. Evaluation of compliance to the self-management programme consisted of;

- Weight and fluid management
- Compliance to medication regime as prescribed by the study intervention cardiologist
- Regular visits to the clinic

Picture 5.1: Living with heart failure in Soweto



Picture 5.2: Nutrition education made practical in the HOS heart failure management program

Patients met with the heart failure team prior to the cooking class to discuss their treatment and address potential issues of concern.	This particular activity shows patients being shown how to cook nutritious and cheap meals that are "heart healthy" and based on traditional recipes.	Cooking Demonstrations and tasting the food consisted of providing patients with hints, ideas and recipes on how to prepare meals according to dietary guidelines for heart failure management. This enhanced compliance to dietary education.
		

5.3 Results

Table 5.2: Change in measured variables over 6 months of follow-up for subjects in standard and managed care and in both groups combined

Variable	Subject group	Level at baseline	Level at follow-up	Change in variable
Age (years)	Standard care	44.3 ± 14.3	-	-
	Managed care	42.6 ± 12.7	-	-
	Groups combined	43.4 ± 13.4	-	-
Males (%)	Standard care	37.5	-	-
	Managed care	64.0	-	-
	Groups combined	51.0	-	-
Vitamin C (µmol/L)	Standard care	6.53 (3.80, 9.22)	-	-
	Managed care	3.65 (1.75, 8.23)	-	-
	Groups combined	5.84 (2.45, 8.84)	-	-
Thiamine (nmol/L)	Standard care	19.0 (16.6, 21.2)	-	-
	Managed care	19.3 (17.1, 25.3)	-	-
	Groups combined	19.1 (16.7, 22.6)	-	-
BMI	Standard care	24.9 (23.3, 27.0)	24.9 (23.3, 27.0)	0.00 (0.00, 0.00)
	Managed care	25.4 (23.3, 27.0)	25.1 (23.3, 27.3)	0.00 (0.00, 0.00)
	Groups combined	25.3 (23.3, 27.0)	25.1 (23.3, 27.3)	0.00 (0.00, 0.00)
Systolic BP (mm/Hg)	Standard care	130 ± 28.3	127 ± 23.3	-2.50 (-6.50, 1.50)
	Managed care	125 ± 25.1	129 ± 20.3	0.00 (-7.00, 5.00)
	Groups combined	128 ± 26.6	128 ± 21.7	-1.00 (-7.00, 3.00)
Diastolic BP (mm/Hg)	Standard care	83.6 ± 19.2	85.1 ± 14.9	2.50 (-1.00, 5.00)
	Managed care	78.9 ± 21.2	85.4 ± 16.3	4.00 (-2.00, 10.0)
	Groups combined	81.2 ± 20.2	85.2 ± 15.5	3.00 (-2.00, 7.00)
Ejection fraction (%)	Standard care	29.8 ± 8.32	30.8 ± 8.01	0.96 ± 3.23
	Managed care	30.0 ± 9.41	33.6 ± 10.3	3.52 ± 10.1
	Groups combined	29.9 ± 8.80	32.2 ± 9.27*	2.27 ± 7.57

Variable	Subject group	Level at baseline	Level at follow-up	Change in variable
Heart rate (beats/min)	Standard care	90.0 ± 14.5	88.2 ± 13.8	0.00 (-3.50, 2.00)
	Managed care	96.6 ± 19.2	91.6 ± 15.5*	-2.00 (-10.0, 1.00)
	Groups combined	93.4 ± 17.2	89.9 ± 14.6*	-1.00 (-5.00, 2.00)

Data is expressed as mean ± SD, median (interquartile range) and %; *$p<0.05$ versus baseline; n=24 for standard care, n=25 for managed care and N=49 for combined group

The data in Table 5.2 shows that there were no statistically significant differences for any of the measured variables between the 2 treatment groups either at baseline or follow-up. With regards intra-group differences, the ejection fraction was significantly higher ($p<0.05$) at follow-up compared to baseline when the groups were combined. Heart rate was significantly lower at follow-up compared to baseline for both the managed care group and the combined group ($p<0.05$ for both comparisons).

A two-way ANOVA was carried out on all variables for which there was follow-up data but no significant time X group interaction were observed.

Table 5.3: Comparison of measured variables across genders

Variable	Subject group	Level at baseline	Level at follow-up	Change in variable
Age (years)	Males	49.9 ± 10.9††	-	-
	Females	37.2 ± 12.8	-	-
Vitamin C (µmol/L)	Males	6.50 (3.25, 7.40)	-	-
	Females	4.60 (2.39, 9.80)	-	-
Thiamine (nmol/L)	Males	17.9 (16.2, 21.4)	-	-
	Females	20.4 (17.2, 25.3)	-	-
BMI	Males	25.9 (24.7, 27.2)	25.8 (24.3, 27.4)	0.00 (0.00, 0.00)
	Females	23.6 (23.2, 26.4)	23.6 (23.2, 26.4)	0.00 (0.00, 0.00)
Systolic BP (mm/Hg)	Males	133 ± 26.6	130 ± 19.0	-3.50 (-9.00, 2.00)
	Females	122 ± 25.8	125 ± 24.1	0.00 (-5.00, 5.00)
Diastolic BP (mm/Hg)	Males	84.4 ± 22.3	87.1 ± 15.8	1.50 (-3.50, 6.00)
	Females	78.2 ± 17.9	83.4 ± 15.3	4.00 (0.00, 8.00)
Ejection fraction (%)	Males	28.2 ± 8.09	29.5 ± 8.27†	1.21 ± 5.33
	Females	31.6 ± 9.30	34.8 ± 9.56	3.28 ± 9.23
Heart rate (beats/min)	Males	91.9 ± 14.4	88.9 ± 13.0	0.00 (-3.00, 1.50)
	Females	94.8 ± 19.8	90.9 ± 16.3	-2.00 (-6.00, 2.00)

Data is expressed as mean ± SD or median (interquartile range); †$p<0.05$, ††$p<0.005$ versus females; n=24 for males and n=25 for females

When comparing males with females (see Table 5.3), the only significant differences were for age, where males were significantly older than females ($p<0.005$) and at follow-up females had a significantly higher ejection fraction than males ($p<0.05$).

Table 5.4: Multiple regression models for change in ejection fraction and change in heart rate over 6 months of follow-up and for systolic blood pressure at follow-up

Model number	Dependent variable	Independent variables with β-values[a] (p-level)		Adjusted R^2 (p-level) for full model
1	Change in ejection fraction (%)	Gender[b]	3.90 (0.05)	0.25 (0.001)
		Baseline EF	-0.40 (0.0009)	
		Increase in DBP[c]	-5.38 (0.009)	
2	Change in heart rate (beats/min)	Increase in BMI[d]	-6.67 (0.02)	0.46 (<0.0001)
		Baseline HR	-0.31 (<0.0001)	
		Change in EF	-0.52 (0.0005)	
3	SBP at follow-up (mmHg)	Baseline SBP	0.42 (<0.0001)	0.70 (<0.0001)
		Follow-up DBP	0.66 (<0.0001)	
		Thiamine	-0.68 (0.04)	

[a]β-value is unstandardised; EF=ejection fraction, DBP=diastolic blood pressure, SBP=systolic blood pressure, HR=heart rate; [b]Males coded as 0 and females as 1; [c]DBP coded as 1 (no change or decrease) and 2 (increase); [d]BMI code as 1 (no change or decrease) and 2 (increase); N=49 for all models

Table 5.4 shows the results of backward, stepwise regression analyses for the isolation of the principal correlates for the change in ejection fraction (Table 5.4, model 1) and the change in heart rate (model 2) over the 6 month follow-up period. Regression model 1 demonstrates that females increased their ejection fraction by 3.90% compared to males over the 6 month follow-up period, although this trend was marginally significant (p=0.05). Model 1 also shows that for every 1 unit

rise in baseline ejection fraction the change in ejection fraction over the 6 month period was -0.40%, and this trend was very significant (p=0.0009). Furthermore, if diastolic blood pressure increased over the follow-up period, ejection fraction fell by 5.98% in comparison to cases where diastolic blood pressure remained the same or fell. This trend was also highly significant (p=0.009). Regression model 2 for change in heart rate shows that if BMI increased over the 6 month period then heart rate fell by 6.67 beats/min (p=0.02) when compared to subjects in whom BMI did not change or fell. Model 2 also shows that for every 1 unit increase in baseline heart rate the change in heart rate over the 6 months of follow-up was -0.31 beats/min, which was a very significant trend ($p<0.0001$). In addition, for every 1 unit increase in ejection fraction the heart rate fell significantly (p=0.0005) by 0.52 beats/min during follow-up.

Pearson univariate correlations demonstrated that thiamine levels at baseline correlated significantly and negatively with systolic blood pressure level at follow-up (r=-0.34, p=0.02). Therefore, a multiple regression model was developed to determine the principle correlates of the follow-up level of systolic blood pressure, and the resulting regression model is shown in Table 5.4 (model 3). This shows that thiamine levels remain significantly and negatively correlated with the systolic blood pressure at follow-up independently of baseline systolic blood pressure and follow-up diastolic blood pressure.

5.4 Discussion

The main findings in this study were that in the combined group ejection fraction fell significantly whilst heart rate increased significantly in the managed care group and the combined group. An increase in diastolic blood pressure was associated with a fall in ejection fraction over the 6 months

of follow-up whilst increases in BMI or ejection fraction were both associated with a fall in heart rate. In addition, the higher the thiamine level at baseline, the lower the systolic blood pressure was at follow-up.

An interesting finding of this study was that BMI remained stable over the 6 month period of follow-up in both intervention groups. The progression of HF and the worsening of a patient's condition is often characterised by a loss in body tissue and body weight due to reduced intake of food and a catabolic state [5,6]. Furthermore, regression analysis showed that an increase in BMI over the follow-up period was associated with a fall in heart rate. This further suggests that weight gain, or at the minimum weight maintenance, may have positive consequences for cardiac health.

The ejection fraction was significantly higher at follow-up compared to baseline when the groups were combined, and heart rate was significantly lower at follow-up compared to baseline for both the managed care group and the combined group. These data suggest that cardiac function improved in these patients and that the managed care group had a greater improvement in cardiac function in terms of heart rate attenuation, than did the standard care group. Improved cardiovascular outcomes have been shown with a reduction of heart rate in patients with CHF, caused by ischemic and idiopathic cardiomyopathy, and increased mortality and morbidity is associated with a high rate and a low SBP, which is quite common in patients with CHF [25]. It has been reported by Wilcox et al, (2012), that patients with CHF who received multidisciplinary intervention care at an outpatient cardiology clinic, had shown a 10% improvement in LVEF, after receiving a repeat LVEF assessment at 24 months follow-up [26].

No gender differences were noted in the response to either intervention, however females did demonstrate a greater increase in ejection fraction over the 6 months of follow-up when compared to the males. The reasons for this are not known however, it is possible that compliance may have been better in the females although we collected no data to support this hypothesis.

Plasma thiamine (vitamin B1) levels were below the recommended level (<70 nmol/L) for all groups and across genders at baseline. Baseline thiamine levels remained significantly and negatively correlated with the systolic blood pressure at follow-up independently of baseline systolic blood pressure and follow-up diastolic blood pressure. According to Klaus et al 2001, when supplementing patients with moderate-to-severe CHF who was taking 80 mg of frusemide with thiamine, it induced a significant improvement in their LV ejection fraction, and improved symptoms [5]. Furthermore, a study from Saudi Arabia showed that serum thiamine levels were lower in hypertensive subjects [27]. Optimal thiamine levels are therefore, important in patients with CHF and should therefore be monitored and corrected or maintained through appropriate dietary guidelines and/or supplementation.

Plasma vitamin C levels were below the recommended level (<50 μmol/L) for all groups and across genders at baseline. Vitamin C has strong anti-oxidative properties and is needed for the growth and repair of tissues and for healthy blood vessels [6]. As reported by Klaus et al 2001, data from a large cohort study over a period of 20 years showed that with higher levels of vitamin C intake, there was a reduced risk of death from stroke [5]. This supports the importance of giving appropriate dietary advice to patients with CHF particularly with regards to the consumption of fruit and vegetables.

5.5 Conclusion

There are limitations to this study, such as the small sample size and the fact that vitamin C and thiamine levels could only be measured at baseline and therefore these findings need to be interpreted with caution. However, these results do suggest that this CHF management program has positive effects on cardiac recovery following heart failure. Furthermore, we observed that elevated serum thiamine levels predict lower systolic blood pressure suggesting that dietary interventions may improve cardiovascular function. These results also demonstrate that when managed properly, with the support of a multidisciplinary team and the patient's family and/or support group, CHF need not be a progressive disease. More research is needed to establish the role of a multidisciplinary CHF management program in low- to middle-income countries and to analyse its effects on the patient's quality of life, its fiscal implications, and ability to alleviate an already overburdened health system.

The preceding studies in this thesis have described risk factors for heart disease and for other NCDs that predispose to HF, studied dietary intake in subjects with HF and analysed management programmes for patients with HF. However, the prevalence of heart disease in the Soweto population is not known and therefore in the final study we measured the prevalence of both heart disease and known risk factors in patients visiting 2 primary health care clinics within Soweto.

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CHAPTER 6

PREVENTION OF CHRONIC DISEASES OF LIFESTYLE

6.1 Introduction

The burden of diseases related to NCD's is rapidly increasing in South Africa, affecting the population as a whole, but especially vulnerable and previously disadvantaged groups living in poor socioeconomic circumstances in urban areas [1]. Recent estimates are that NCD's contribute about 28% to the total burden of disease in South Africa as measured by DALY's in 2004 [1]. Evidence from the Agincourt study, which is a major health and sociodemographic surveillance study tracking the population dynamics of around 70 000 people living in rural areas in Mpumalanga, South Africa, suggests that the burden of disorders requiring chronic care has increased disproportionately relative to diseases requiring acute care [2]. This has major implications for the delivery of acute and chronic health care services at all levels, from primary through to tertiary levels [3].

Unhealthy lifestyles and behaviours contribute substantially to the social and environmental origins of CVD and other NCD's. However, limited data is available on the burden of heart disease and other chronic disease risk factors in urban, African low-resource environments, where NCDs are thought to be prevalent. We therefore, extended our research into the primary care setting in Soweto, South Africa and collected data from 1311 patients at two primary health care clinics in Soweto [3], with a confirmed diagnosis, or with clinical symptoms of underlying heart disease and performed advanced cardiac profiling of these patients to determine the prevalence of heart disease and associated NCDs. These subjects were the same as those described in paper 3.2. The results of this study are described in the following paper [3].

Publication 6.1: Elevated risk factors but low burden of heart disease in urban African primary care patients: a fundamental role for primary prevention (Statement of originality document: please see Appendix C) [3].

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Elevated risk factors but low burden of heart disease in urban African primary care patients: A fundamental role for primary prevention

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ABSTRACT

Background: Few data describe the case burden of heart disease and cardiovascular risk factors relative to other conditions in urban Africans seeking primary health care.
Methods: A clinical registry captured data on 1311 consecutive primary care patients (99% African) from two primary care clinics in Soweto, South Africa. Those with suspected sub-clinical heart disease had more advanced cardiologic assessment.
Results: Overall, 862 women (66%, 41 ± 16 years) and 449 men (38 ± 14 years) were studied. Whilst more men were smokers (47% *vs.* 14%; OR 5.23, 95% CI 4.01–6.82), more women were obese (42% *vs.* 14%; OR 4.54, 95% CI 3.33–5.88); blood glucose levels doubling with age in obese women. Although 33% were hypertensive, only 4.9% had type 2 diabetes (n = 45), heart disease (n = 10) and/or cerebrovascular disease (n = 12). Overall, 16% (n = 205) had an abnormal 12-lead ECG with more men than women showing a major abnormality (24% *vs.* 11%; OR 2.63, 95% CI 1.89–3.46). Of 99 cases (7.6%) subject to advanced cardiologic assessment, 29 (2.2%) had newly diagnosed heart disease: including hypertensive heart failure (13 women *vs.* 2 men, OR 4.51 95% CI 1.00–21.2), coronary artery disease (n = 3), valve disease (n = 3), dilated cardiomyopathy (n = 3) and 2 cases of acute myocarditis.
Conclusions: These data demonstrate a relatively low burden of heart disease in urban African patients seeking primary health care. Alternatively, high antecedent risk, particularly among obese women, highlights a key role for enhanced primary prevention.

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1. Introduction

The *Heart of Soweto Study* previously described the impact of epidemiological transition in broadening the spectrum of heart disease [1]. This study included over 5000 *de novo* presentations of heart disease to a tertiary referral hospital servicing one of sub-Saharan Africa's largest urban concentrations of Africans. A key related finding was the clear differential in the nature of heart disease according to the origin of presenting patients; women born in Soweto were more likely to present for tertiary health care with non-communicable forms of disease at an older age. Alternatively, migrants were more likely to present with historically prevalent disease (e.g. rheumatic heart disease) [1]. Community screening programs appear to support observed patterns of elevations in modifiable risk factors for heart disease [2–4]. However, it is unclear if apparently high levels of risk factors and advanced forms of heart disease are reflected in the case-mix seen in primary care. In the *Heart of Soweto* clinical registry, only 6.8% of confirmed cases of heart disease were directly referred from local clinics [1].

Recognising the central importance of primary health care [5] to assess cardiovascular risk and implement proactive prevention and treatment programs to reduce non-communicable forms of disease in urban communities like Soweto [6], we extended our research into the primary care setting. Using the annual number of incident and prevalent cases managed by the Chris Hani Baragwanath Hospital, we estimated that the case-load of heart disease in each of the 12 primary care clinics in Soweto would be ~350 cases per annum (equivalent to 1 in 200 patient contacts given a typical annual case-load of >15,000). We also postulated that hypertension, as a highly prevalent risk factor [4], would be responsible for many primary care encounters. We further hypothesised that a systematic approach to risk factor profiling and referral for advanced investigation in primary care would reveal a previously hidden burden of sub-clinical heart disease.

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2. Methods

2.1. Study setting

Consistent with the *Heart of Soweto* clinical registry [7] we systematically collected data on consecutive patients attending two pre-selected primary care clinics from a total of 12 in Soweto (644 and 667 patients from Mandela Sissulu and Pimville primary care clinics, respectively). Both of these practices are located in diverse socio-economic locations within the combined townships of Soweto near Johannesburg. The study was undertaken over a 6 month period and involving 50 discrete days of screening (commencing June 2009) and approved by the University of the Witwatersrand Ethical Committee. It conforms to the principles outlined in the Declaration of Helsinki.

2.2. Participants

Each primary care clinic typically managed more than 300 patients per day with wide-ranging health issues. A study team comprising an experienced cardiac nurse, ECG technician and co-ordinator invited consecutive consenting patients aged over 16 years who presented to the primary care clinic to be screened. All patients were reviewed by a primary health care nurse prior to assessment. A target of assessing approximately 25 consecutive patients each screening day (to study a minimum of 1000 patients) was maintained during the study period. Refusal was rare with no systematic bias in case presentation evident.

2.3. Study data

Each participant was subject to a standardised program of assessment as follows:

- Self-reported cultural and socio-demographic profile; including ethnic origin, duration of residence in Soweto and education status.
- Risk factor profiling; including family history of diabetes or any heart disease and smoking status. Random blood glucose levels (fasting in most cases) were obtained using the Accu-Chek Active (Roche Diagnostics).
- Anthropometric profile; including height and weight with calculation of body mass index (BMI, kg/m^2).
- Clinical assessment; including average seated systolic and diastolic blood pressure (BP, mm Hg) and heart rate (beats per minute) using a calibrated Dynamap (Critkon) monitor and physical examination for assessment of any signs and symptoms indicative of potential heart disease (e.g. angina pectoris, exercise intolerance, palpitations, raised jugular venous pressure and audible cardiac murmurs).
- Medical history and management; including prior or current diagnoses and pharmacological therapy related to the prevention or treatment of cardiovascular disease (CVD).
- 12-lead ECG; all ECGs were subject to blinded and standardised coding (by SS) according to Minnesota criteria [8] to document any clinical abnormalities.

Based on all data at the point of primary care assessment, KS and SS categorised all cases into the same CVD categories [9] used in previous *Heart of Soweto* Study reports in addition to broad disease categories using the International Classification of Disease descriptors.

2.4. Advanced cardiac profiling

Any participant with a confirmed diagnosis or high suspicion of underlying heart disease was referred to the Cardiology Unit of the Chris Hani Baragwanath Hospital for further investigation. The same standardised protocol of assessment (including echocardiography using gold-standard guidelines [10]) and classification, as described in previous reports [11,12], were applied.

2.5. Statistical analyses

Data were documented on standardised forms and entered into a database (Microsoft Access) in Soweto and then verified and transferred to SPSS Statistics 17.0 for independent analyses at Baker IDI. Normally distributed continuous data are presented as the mean ± standard deviation and non-Gaussian distributed variables as the median plus interquartile range. Categorical data are presented as percentages with 95% confidence intervals (CI) shown where appropriate. For patient group comparisons, we initially used Chi Square (χ^2) analysis with calculation of odds ratios (OR) and 95% CIs (where appropriate) for discrete variables, Student's *t*-test and analysis of variance were applied for normally distributed continuous variables. Multiple logistic regression analyses (entry model) were performed on demographic and baseline risk factor profiles to derive adjusted ORs for the risk of recording elevated BP and blood glucose levels (including an interaction term for sex and weight status) and being diagnosed with heart disease. Wherever possible, we have applied the STROBE guidelines [13].

3. Results

3.1. Clinical and socio-demographic profile

In total, 1311 primary care patients were studied. The clinical and socio-demographic profile of the study cohort are summarised in Table 1 according to sex. Overall, there were more women (66%) than men and nearly all (99%) were of African descent and/or originated from Soweto (92%). Women were on average three years older than their male counterparts, were more likely to be unemployed and be longer term residents of Soweto.

3.2. Case presentation

Fig. 1 shows that from a broad range of documented conditions (1597 for women and 764 in men), CVD was evident in 4.9% of cases. Primary forms of atherosclerotic disease, including stroke (0.9%) and coronary artery disease (CAD, 0.2%) were extremely rare. In total, 48 cases had a combination of hypertension and an established form of CVD. Other than hypertension, the most common conditions seen were respiratory disease (21% — predominantly pulmonary complications secondary to tuberculosis and other chronic lung diseases), musculoskeletal disorders (17% — predominantly back pain), systemic infectious disease (16% — including HIV/AIDS), neurological disorders (16% — mainly headaches), gastro-intestinal disorders (15% — predominantly diarrhoea) and skin disorders (predominantly fungal

Table 1
Initial clinical and socio-demographic profile (n = 1311).

	All (n = 1311)	Women (n = 862)	Men (n = 449)	P value
Socio-demographic profile				
Age (years)	40 ± 16	41 ± 16	38 ± 14	<0.001
African descent	1292 (99%)	853 (99%)	439 (98%)	0.089
From Soweto	1207 (92%)	786 (91%)	421 (94%)	0.101
Years in Soweto	29 ± 19	30 ± 20	26 ± 18	<0.001
<6 years education	282 (22%)	193 (22%)	89 (20%)	0.646
Unemployed	744 (57%)	613 (71%)	131 (29%)	<0.0001
Risk profile				
Family history of heart problems	640 (49%)	455 (53%)	185 (41%)	<0.0001
History of smoking	334 (25%)	124 (14%)	210 (47%)	<0.0001
Dyslipidaemia	16 (1.2%)	12 (1.4%)	4 (0.9%)	0.443
Body mass index (kg/m^2)	28.2 ± 9	29.9 ± 9.2	24.8 ± 8.3	<0.0001
Waist circumference (cm)	90 ± 18	93 ± 19	85 ± 15	<0.0001
No regular exercise	1172 (89%)	787 (91%)	385 (86%)	0.004
Pre-existing CVD				
Hypertension	430 (33%)	333 (39%)	97 (22%)	<0.0001
Diabetes	45 (3.4%)	32 (3.7%)	13 (2.9%)	0.441
Stroke	12 (0.9%)	6 (0.7%)	6 (1.4%)	0.248
All forms of CVD	65 (4.9%)	42 (4.9%)	23 (5.1%)	0.751
Clinical presentation				
NYHA Class II or III	215 (16%)	154 (18%)	61 (14%)	0.049
Palpitations	200 (15%)	144 (17%)	56 (12%)	0.045
Chest pain on exertion	220 (17%)	143 (17%)	77 (17%)	0.784
Syncopal episodes	218 (17%)	160 (19%)	58 (13%)	0.009
Peripheral oedema	40 (3.1%)	30 (3.5%)	10 (2.2%)	0.209
Heart rate/minute	72 ± 12	73 ± 12	72 ± 12	0.134
Systolic blood pressure (mm Hg)	132 ± 22	132 ± 22	131 ± 20	0.321
Diastolic blood pressure (mm Hg)	84 ± 157	85 ± 16	84 ± 14	0.119
Blood glucose level (mmol/L)	5.5 ± 2.0	5.5 ± 2.0	5.3 ± 2.0	0.113

CVD = cardiovascular disease; NYHA = New York Heart Association.

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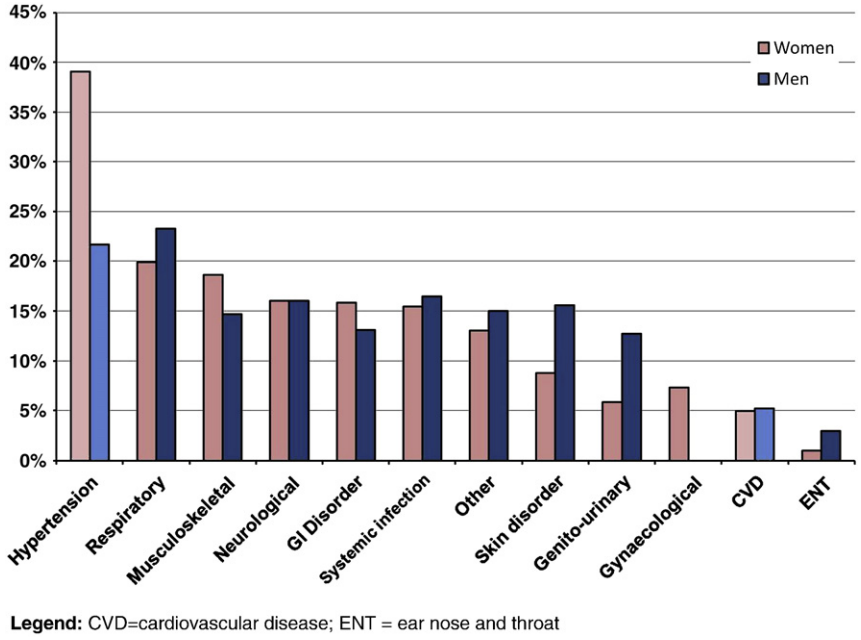

Fig. 1. Major diagnostic groups in male (n = 449) and female (n = 862) case presentations.

disorders). Of the "other" reasons for seeking primary health care, the most common was family planning (e.g. advice on contraception).

3.3. Cardiovascular risk profile

On presentation, women were more likely to report a family history of any form of heart condition (OR 1.28, 95% CI 1.16–1.46). Women were also more likely to have a personal history of hypertension (OR 1.79, 95% CI 1.47–2.17), far more likely to be obese (42% *vs.* 14%; OR 4.54, 95% CI 3.33–5.88) and report symptoms suggestive of underlying heart disease (including exercise intolerance, palpitations, chest pain on exertion and syncope). Alternatively, men were far more likely to smoke (OR 5.23, 95% CI 4.01–6.82) and men with hypertension had higher BP than their female counterparts ($151 \pm 22/97 \pm 16$ *vs.* $146 \pm 22/92 \pm 15$ mm Hg; $p < 0.05$ for both comparisons). Both sexes reported high levels of sedentary behaviour (89%) although 282 individuals (22%) reported having physically active employment. Those undertaking formal exercise (n = 125) typically reported running on a regular basis (38%), attending aerobic programs (11%) and/or playing a team sport (11%). Overall, 3.4% of all patients were diagnosed with type 2 diabetes. However, of 968 random blood glucose levels, 9.8% were >7.0 mmol/L; when accounting for diabetic cases this proportion fell only slightly to 7.9%.

Fig. 2 compares the BP, heart rate and blood glucose and body fatness levels in non-obese (left panels) and obese (right panels) men and women according to age. Regardless of weight status, there was an age gradient in all these parameters. However, the largest gradients were found in obese women, particularly in respect to systolic BP and blood glucose levels; the latter rising from 4.5 ± 1.0 to 6.8 ± 3.2 mmol/L in the youngest *vs.* oldest age group. This compared to a more modest rise from 5.2 ± 0.6 to 6.2 ± 1.3 mmol/L in obese men. On an adjusted basis, obese women were 2.0-fold (95% CI 1.19 to 3.45) and 2.2-fold (95% CI 1.25 to 4.00) more likely to record a blood glucose level >7.0 mmol/L ($p = 0.01$) and a systolic BP >140 mm Hg ($p = 0.007$), respectively, than obese males.

Consistent with a low-level of diagnosed CVD but a relatively high number of hypertensive cases (102 of which were newly diagnosed and yet to be prescribed treatment), the most commonly prescribed cardiac related medications were thiazide diuretics (n = 302, 23%), angiotensin converting enzyme inhibitors (n = 147, 11.2%) and calcium antagonists (n = 112, 8.5%). Very few cases were prescribed aspirin (n = 36, 2.7%), beta blockers (n = 23, 1.8%), or a statin (n = 4, 0.3%). There was a positive correlation between the number of prescribed anti-hypertensive agents and elevated BP ($p < 0.001$). For example, in those prescribed single (n = 127), double (n = 138) or triple (n = 63) anti-hypertensive therapy, mean BP were $141 \pm 19/90 \pm 13$, $152 \pm 29/95 \pm 14$ and $161 \pm 28/100 \pm 21$ mm Hg, respectively (all comparisons <0.05).

3.4. 12-Lead ECG

Table 2 summarises the ECG profile of the study cohort. In total, 1106 cases (84%) had no major abnormality evident. Men were 2.6-fold more likely to have an ECG abnormality (95% CI 1.89–3.46) including evidence of right ventricular hypertrophy (OR 4.65, 95% CI 2.45–8.81), left ventricular hypertrophy (OR 2.94, 95% CI 1.95–4.45) and a tachyarrhythmia (OR 1.97, 95% CI 1.12–3.48). Only two patients had ECG evidence of atrial fibrillation.

3.5. Advanced cardiac assessment (n = 99)

A total of 99 cases, comprising 63 women (7.3% of all women, aged 40 ± 16 years) and 36 men (8.0% of all men, aged 37 ± 14 years), were referred for more advanced cardiologic assessment via the Cardiology Unit of the Chris Hani Baragwanath Hospital (all subsequently attended). This included 68 cases with hypertension, comprising 56 cases without pre-established heart disease, 10 cases of established heart disease and 2 with a prior stroke requiring further investigation. The remainder comprised 31 cases (2.4% of the entire cohort, comprising 16 women and 15 men) with a high index of suspicion for underlying heart disease but without a cardiovascular risk factor. On an adjusted basis, individuals who were older (adjusted OR 1.03, 95% CI 1.02–1.05 per year), male (OR 1.64, 95% CI 1.02–2.64), a smoker (OR 2.43, 95% CI 1.30–4.52) or in NYHA Class II or III (OR 1.74, 95% CI 1.08–2.81) were more likely to be referred for more advanced cardiac assessment.

Mean left ventricular ejection fraction (LVEF) was similar for women ($56 \pm 11\%$) and men ($59 \pm 11\%$). Overall, 17 patients were

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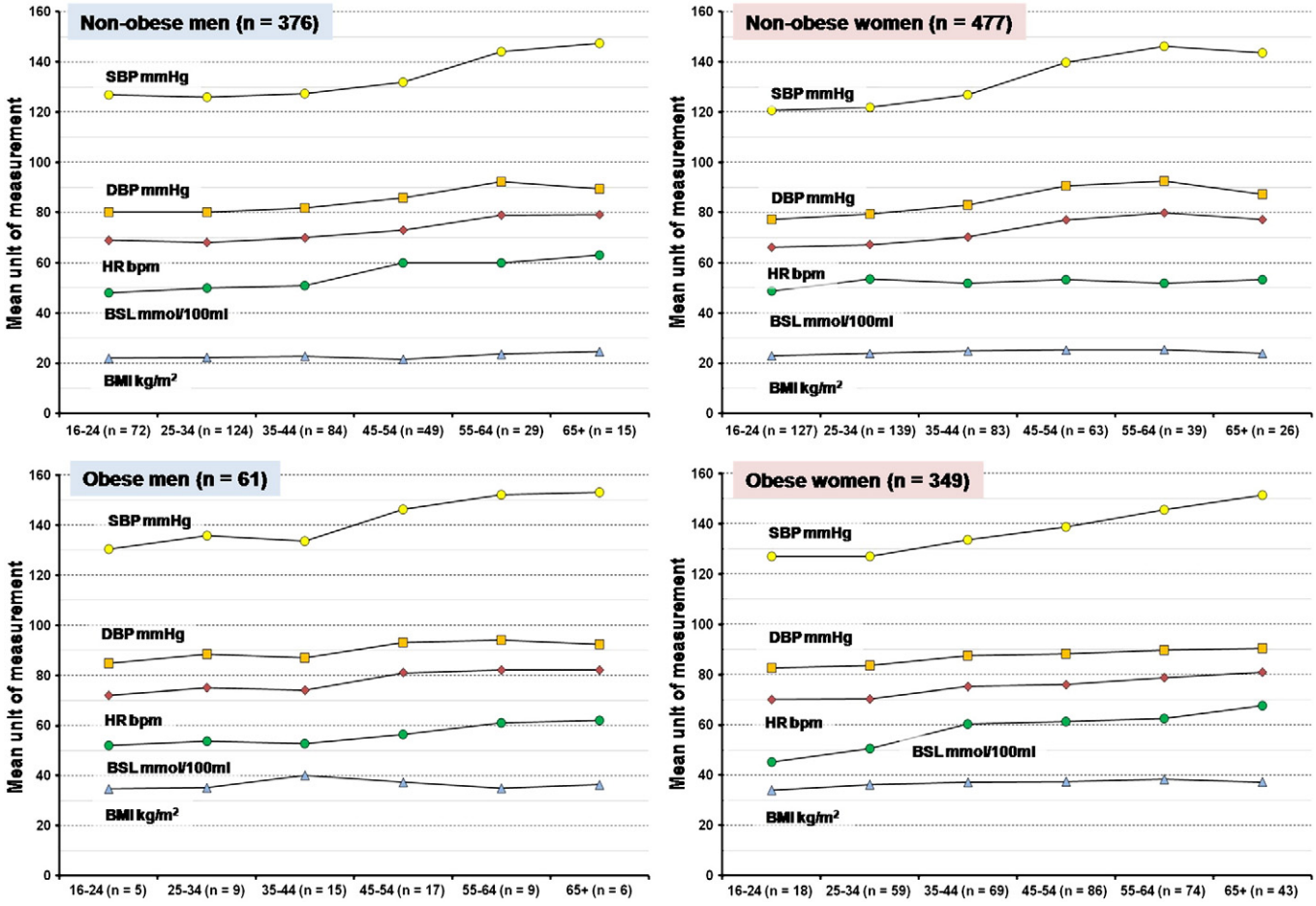

Fig. 2. Key risk factor parameters in non-obese and obese individuals according to age.

found to have left ventricular systolic dysfunction and 12 had evidence of diastolic dysfunction. Of these 29 cases, 5 had normal BP and one individual had no history of CVD. In addition to the 12 cases with pre-established CVD, a further 15 cases were found to have hypertensive heart failure (HF). The majority of these cases were women (n = 13; OR 4.51 95% CI 1.00–21.2 — p = 0.041) and 14 had previously diagnosed hypertension. An additional 3 cases were diagnosed with CAD, 3 cases with degenerative valve disease (a total of 28 cases having some form of valvular dysfunction but none with rheumatic heart disease), 3 cases with a serious tachyarrhythmia (including the two cases of atrial fibrillation plus one Wolf–Parkinson–White Syndrome), 2 cases with idiopathic cardiomyopathy (CMO), 2 cases with acute myocarditis (post viral infection) and 1 case with post partum CMO. Of these 14 cases, 8 came from the sub-group who had no history of CVD or a cardiovascular risk factor.

Table 2
12-Lead ECG profile.

	All (n = 1311)	Women (n = 862)	Men (n = 449)	P value
No major abnormalities detected	1106 (84%)	766 (89%)	340 (76%)	<0.001
Rhythm				
Tachyarrhythmia	50 (3.8%)	25 (2.9%)	25 (5.6%)	0.017
Bigeminy/trigeminy	19 (1.5%)	13 (1.5%)	6 (1.3%)	0.805
Conduction defects				
1st degree heart block	29 (2.2%)	17 (2.0%)	12 (2.7%)	0.413
Bundle branch block	12 (0.9%)	8 (0.9%)	4 (0.9%)	0.946
Other abnormalities				
Right ventricular strain	46 (3.5%)	14 (1.6%)	32 (7.1%)	<0.001
Left ventricular strain	103 (7.9%)	43 (5.0%)	60 (13.4%)	<0.001
Left atrial strain	22 (1.7%)	8 (0.9%)	14 (3.1%)	0.003
P pulmonale	16 (1.2%)	5 (0.6%)	11 (2.5%)	<0.001

4. Discussion

To our knowledge, this represents the first systematic attempt to quantify the contribution of clinically overt and sub-clinical heart disease in a primary care setting in sub-Saharan Africa. Specifically, we compiled a registry of consecutive case presentations to two representative primary care clinics in the urban African community of Soweto, South Africa. This extends upon our approach to uncovering the evolving spectrum and burden of risk factors and heart disease in this community via the *Heart of Soweto* Study during 2006–2008 [1,7]. Consistent with other reports outlining the broad spectrum of disease in the region [14], infectious disease predominated, both in the form of systemic infection such as HIV/AIDS and localised manifestations such as tuberculosis, with respiratory disease and musculo-skeletal disorders common reasons for presentation. Although the contribution of diagnosed forms of heart disease was very small (1 in 100 case presentations), the risk factor burden of the cohort, conversely, was high with around 1 in 3 case presentations being hypertensive. This is consistent with previous estimates of this highly modifiable cardiovascular risk factor [3] and resembles BP levels often seen in high income countries [15]. The disproportionate contribution of obese women was important in this regard.

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Although the prevalence of diagnosed type 2 diabetes was relatively low (3.4%), 7% of patients (mainly obese women) were at risk of metabolic disorders on the basis of their blood glucose profile. Significantly, obesity is associated with other rarely reported forms of CVD in Soweto, with obese women in the *Heart of Soweto* cohort being more likely to present with atrial fibrillation [16]. Therefore, the potential impact of enhanced primary prevention in this context is obvious, particularly in truncating a future rise in hypertensive heart disease [17,18] as life-expectancy and unhealthy lifestyles escalate. However, secondary prevention is also important when considering that a further 2 in 100 case presentations (15 of 29 of whom had hypertensive HF) were subsequently diagnosed and appropriately treated.

These data provide an immediate perspective of the currently small contribution of heart disease to primary care presentations in an urban African community in epidemiological transition. It also signals two clear warnings for its immediate and future health. First, the historically large burden of advanced and complex cases of heart disease at the tertiary care level in Soweto [7] is likely to rise if there is no provision for a systematic screening and linked referral program for more advanced disease. Second, the latent pool of hypertensive individuals in Soweto, which we have now confirmed in all three key public health settings — the broader community [4], the primary care setting (these data), and the tertiary care setting [18], is likely to fuel a sustained burden of neurologic [19] and cardiologic cases in the future if successful cost-effective prevention strategies are not implemented. African women with high levels of obesity, hypertension and potentially latent diabetes are particularly vulnerable and must be targeted accordingly. Determining the most cost-effective treatments in a resource poor environment will be important [20]. For example, although anti-hypertensive treatment (including a thiazide diuretic [21]) was consistent with reports from the region those prescribed combination therapy had systolic and diastolic BP readings approximately 5 and 10 mm Hg higher than those on single therapy.

Unfortunately, beyond broader population studies [22,23] there are few comparable primary care studies reported in the literature. Certainly, the large differential between male and female smoking habits is well documented [24] and an estimated 5% of Africans in the region had diabetes in 2000 [25]. The combination of diagnosed diabetes and elevated blood glucose levels in our cohort suggests that diabetes might affect 5–10% of cases. One notable study worthy of comparison is the Hi Hi Study of 403 Africans being managed by primary care services in Cape Town [26]. Renal impairment was found in around one in four cases whilst ECG evidence of left ventricular hypertrophy and/or ischaemic S-T segment changes were found in 35% and 49% of cases, respectively. Although we did not specifically measure renal function in our cohort, data from the Hi Hi cohort are consistent with data from the *Heart of Soweto* tertiary cohort [7].

Overall, our findings are consistent with our initial estimates that <1 in 100 primary care patients in Soweto have an established form of heart disease. However, this number increases to 3 in 100 cases when a system of cardiac referral that is common to most health systems in high income countries is implemented. Such a "return for effort" needs to be carefully evaluated, particularly in association with other potentially more sophisticated strategies (e.g. cardiac bio-markers and hand-held imaging). In addition, more basic methods such as well-defined clinical assessments for heart disease (e.g. auscultating for cardiac murmurs) and utilisation of the 12-lead ECG should be instigated. Consistent with a global strategy to limit the impact of non-communicable heart disease in South Africa [27], our group is planning a primary care prevention trial in this setting with a strong focus on hypertension and metabolic disorders that will formally evaluate strategies to detect those who have already developed heart disease.

This study has a number of limitations that require comment. Due to the volume of cases managed by the participating primary care clinics and the nature of their medical record system, we were unable to provide accurate estimates of the proportion of cases captured by our registry. Wherever possible, we studied consecutive patients to avoid selection bias. By relying upon a combination of self-report and primary care clinic records, we were unable to verify each and every diagnosis. All 12-lead ECG data were retrospectively and systematically analysed following the study, however not every patient with an abnormality (e.g. 3.5% had ECG evidence of right ventricular strain and often with accompanying p pulmonale) was referred for more advanced assessment. It is also probable that more individuals with sub-clinical or undiagnosed heart disease would have been identified if all patients were subject to the same level of screening.

In conclusion, we examined the burden of cardiovascular risk factors and heart disease cases in a primary care setting in Soweto, South Africa and found that <1 in 100 case presentations were being managed for pre-existing heart disease. This figure rose to 3 in 100 case presentations when suspicious cases were referred for more definitive assessment. Whilst the overall burden of existing heart disease appears to be currently low in Soweto, the role of enhanced primary care prevention applied on a sex-specific basis to truncate a potential epidemic of disease related to hypertension and metabolic disorders is obvious.

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Disclosures

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The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology [28].

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6.2 Conclusion

Our findings as described in publication 6.1, showed a small number of diagnosed forms of heart disease (1 in 100 cases) reported at primary health care level, but a high risk factor burden with about 1 in 3 cases presenting with high blood pressure, as well as a disproportionately high number of obese women [3]. This clearly indicates the importance of upscaling gender-specific primary care prevention in order to stem this potential tide of chronic diseases of lifestyle.

It is therefore, of the utmost importance to develop and implement health promotion and disease prevention programmes targeted at entire populations through comprehensive interventions and a Primary Health Care approach that is based on the Alma Ata Declaration of 1978 [4]. It has been shown that population-wide prevention approaches to reduce risk factors for development of NCDs can be very effective if structured and implemented correctly, thus preventing the emergence of future epidemics [4]. Such integrated actions for the prevention of NCDs should include: laws and regulations, e.g. non-smoking in public spaces; tax and price interventions, e.g. the recent sugar tax implemented in South Africa and price increases on tobacco and alcohol products; improving our environment in terms of pollution and built structures; creating awareness and screening of risk factors in communities, schools, workplace and in primary healthcare facilities [4,5].

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CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 Introduction

It is becoming increasingly clear that although the burden of non-communicable diseases (NCDs) is stabilizing in high-income countries, the same cannot be said for low-to-middle-income countries (LMICs) [1]. The major causes of death and disability are shifting in these LMICs from communicable or infectious diseases to non-communicable diseases as part of the health transition or epidemiological transition [2]. Decreases in infectious diseases, which usually disproportionately affects children, lead to greater survival into adulthood and a population that is getting older [3]. This aging population is more exposed to complex changes in patterns of health and disease, and morbidity and mortality as a result of demographic, economic and societal changes as defined by the epidemiological transition [4].

All indications are that non-communicable diseases are drastically going to increase in the coming years in sub-Saharan African countries as opposed to high income countries, with not only age in itself posing a risk for development of NCDs, but also the prolonged exposure to risk factors due to longevity [3]. Some of the key drivers behind the epidemiological transition are urbanization and lifestyle changes, such as changes in diet, physical activity, smoking, alcohol use and adiposity, which are associated with economic development [4]. In South Africa it is predominantly the black African population who is currently experiencing a rapid process of urbanization and the negative health effects thereof [4].

Our data from the HOS supports evidence that black urban Africans are facing a double burden of disease with the historical burden of infectious diseases, which now also includes HIV/AIDS and TB, existing alongside an emerging epidemic of chronic diseases, especially heart disease [2]. This emerging epidemic of NCDs in the South African black population as seen in Soweto, is characterized by high rates of obesity in females, increased blood pressure levels in men and women, stroke, and as yet low rates of CHD [4]. However, as reported by Lyons 2014, we found low levels of HDL-cholesterol in individuals with a history of infectious diseases, which may leave them at increased risk for atherosclerotic disease [5].

Food intake data from the HOS indicates that the food choices and dietary patterns of black urban Africans living in Soweto are characteristic of a population in the early stages of the nutrition transition [6]. Thus, having moved away from consuming their more traditional or rural diet, low in fat and refined sugars, they have shifted to the consumption of a diet that provides more than 30% of their energy intake as fat and with a high content of sugar, salt and refined carbohydrates [4,7]. As previously mentioned, this is a population facing a double burden of disease and mounting evidence points to the fact that in addition to genetic contributions, fetal and childhood malnutrition also add to

this vulnerability, increasing susceptibility to the consequences of exposure to a more Westernised diet and over-nutrition [8, 9].

Therefore, to decrease the risk of developing chronic diseases of lifestyle, the focus should be the prevention of under nutrition in women of childbearing age, pregnant mothers, babies and children, as well as over-nutrition during all stages of life [9].

Due to this collision of epidemics of NCD and infectious chronic disease (ICD), including HIV and TB in LMIC, a different pattern of multi-morbidity is emerging than in high-income countries, which led to the development of the Innovative Care for Chronic Conditions (ICCC) Framework by the WHO and draws together the golden triad of patient and family, community and health care team [10]. The ICCC Framework emphasizes a continuum of care, from prevention to tertiary care, but does not include comorbid non-communicable and infectious chronic disease (CNCICD), as well as the interaction between chronic diseases and the psychosocial environment, understanding patient workload, coping mechanisms and the ability to manage his/her disease [10].

It might therefore, be wise to take into consideration changing patterns of morbidity and especially the increase in CNCICD, incorporating biological and environmental interactions, patient and healthcare provider capacity and workload when planning intervention programs for improved health outcomes [10].

7.2 Intervention programs for the prevention of chronic diseases of lifestyle in a low-resource black urban African community

Before planning any intervention strategies or making any recommendations towards addressing an epidemic of chronic diseases of lifestyle, it is important to better understand the underlying dynamics and drivers of the epidemiological and health transition in a low-resource urban black African community, such as Soweto, especially as the factors underlying the increase seen in NCD and risk factors, are so complex and multifactorial, [2]. Data from the HOS re-confirm that there is an urgent need to develop and implement cost-effective, culturally sensitive and region-specific primary and secondary intervention programs for the prevention of NCDs [1]. As well as establishing and evaluating management programmes, as described in previous chapters of this thesis, that focused on patients who presented with advanced heart disease, we have also initiated a specific programme of research that addresses the potential interaction between HIV/AIDS, its treatment (highly active antiretroviral therapy – HAART) and CVD [11].

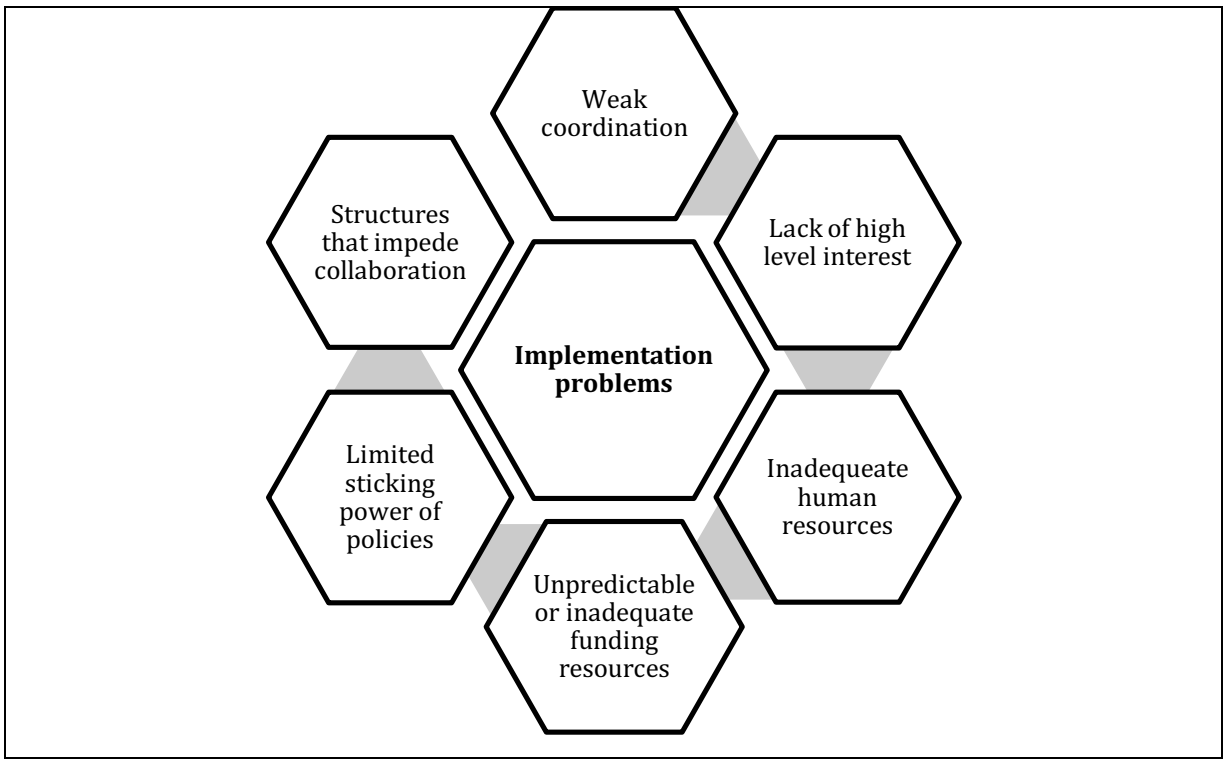
Intervention programs focused on healthy lifestyles should be designed in such a way that they address both under- and over nutrition simultaneously, with the emphasis on optimal nutrition and physical activity [9]. Comprehensive action is needed and should span a continuum of therapeutic intervention or treatment, rehabilitation, prevention of non-communicable diseases and promotion of health, with a strong emphasis on the social determinants of nutritional health [12]. Within a broader framework of all the political and economic forces impacting on the health and nutritional status of a population and in collaboration with all sectors and communities involved, it is essential to create awareness around risk factors for chronic diseases of lifestyle, dietary trends and food security on a local and global level and to advocate for policy changes related to these issues [12].

7.2.1 Challenges facing the implementation of intervention programs

The limited successes in addressing the rise in NCDs, as well as the issue of malnutrition in South Africa, cannot be attributed to inappropriate policies and strategies or even a lack of knowledge about relevant solutions, but is rather due to inadequate and ineffective implementation [12,13]. A few of the core problems contributing to the ineffectiveness of successful implementation are depicted in figure 8.1 below [12,14].

One of the key challenges on how to optimise primary prevention and improve the development of intervention strategies at a community level is the cost-effective screening of modifiable risk factors, such as obesity and hypertension [13]. In this bid to optimise prevention strategies, two mainstream approaches have been put forward, namely, a ‘population-based’ approach whereby the burden of disease is reduced in the community as a whole, but providing small benefits to the individual, or a ‘high-risk’ approach whereby vulnerable individuals benefit the most, but the benefits to the larger population are limited, some of whom might have derived immediate or long-term benefits from being treated [13].

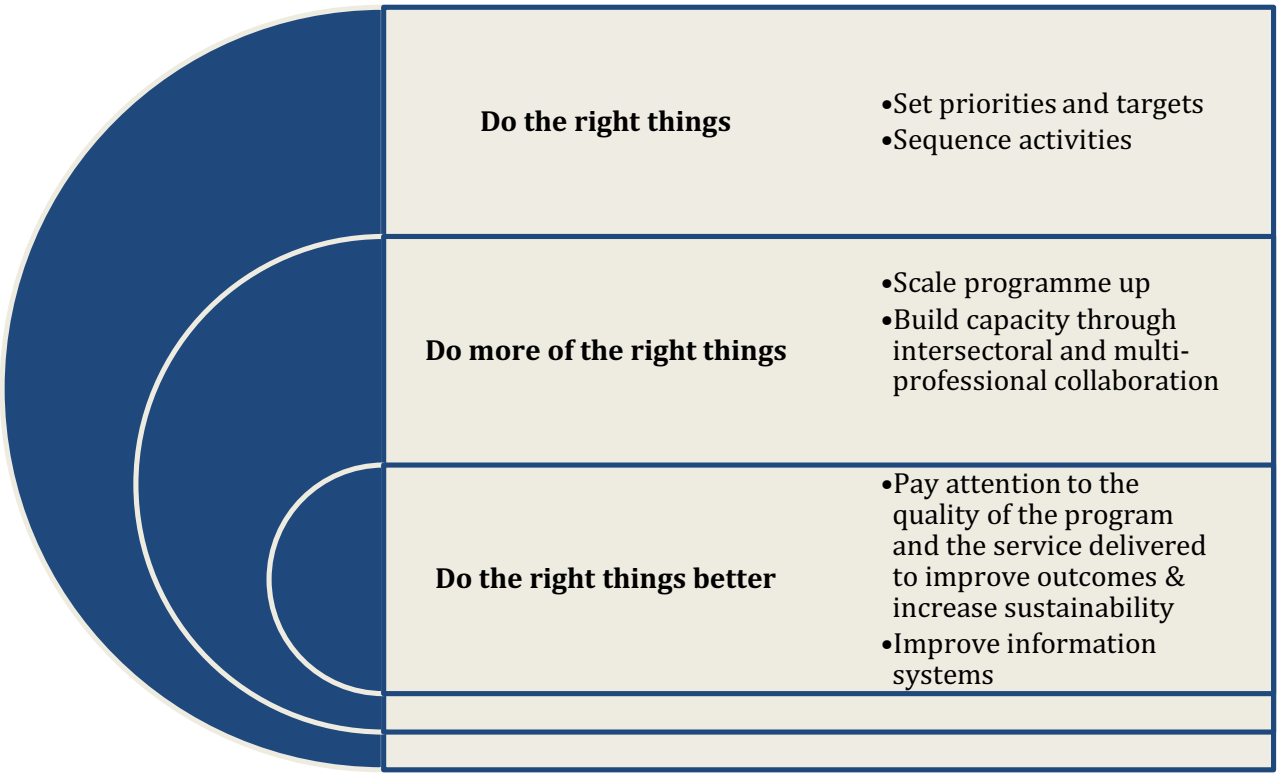
Figure 7.1: Key factors contributing to ineffective implementation of intervention programs (adapted from Swart R et al 2008) [12]



7.2.2 Recommendations for the successful implementation of intervention strategies and programmes

If we are to make a sustainable impact on the reduction or prevention of chronic diseases of lifestyle, such as obesity, heart disease and high blood pressure, particularly in a black urban African population living in a low-resource environment, we will have to ensure that the intervention strategies implemented are targeted and effective. This will depend to a large extent on programme choices, development of operational, programme and action research, information management and strategic capacity building through appropriate collaborations and the availability of appropriately skilled human resources [12]. The following aspects, as illustrated in figure 8.2, should therefore receive attention [12, 14].

Figure 7.2: Recommendations for the successful implementation of primary prevention strategies (adapted from Swart R et al, 2008) [12]



It is important to highlight a few lessons learned from the HOS, when recommending how to plan a successful intervention programme. This can be linked with the above recommendations and serve to build a much more comprehensive picture, especially when aiming to develop and implement such programmes in previously disadvantaged, low-resource black urban African populations. What we have learned from the HOS can be condensed into a few key messages as follows [13]:

- Build partnerships with a strong research or clinical group that can provide instant access to funding sources and can bring to the table a combination of skills currently lacking
- Establish partnerships with the community and important role players in the community to ensure their buy-in and participation in the programme and to address the actual need in that community on an appropriate level,
- It is important to set clear objectives and achievable goals rather than trying to address the whole scope of the problem all at once and risking the programme to fail, while on the other hand not shying away from addressing a problem because of an assumption that it is too hard or that it has all been done before,

- Sufficient and reliable funding and investing in the right people is key to the success of a program. By providing opportunities for other health professionals to undertake higher degrees within the framework of the programme, the growth and sustainability of the programme are ensured,
- When working in a resource-poor and challenging environment, it is important to find innovative solutions that is appropriate for that environment,
- Don't settle for poor quality outcomes, but rather adjust the programme to the particular needs of the population and their environment based on a logical and rationale plan of research or healthcare activities as even the 'simplest' of programmes can provide valuable contributions to the literature when performed correctly [13].

7.3 Strengths and limitations

Although the strengths and limitations of each of the studies have been highlighted in the respective chapters and publications, I would like to highlight some general strengths and limitations of the thesis.

When collecting data for the HOS clinical registry, a small proportion of potential cases (<10%) were not captured without evidence of systematic bias in case selection. Although CHBH is one of the major hospitals in Soweto to manage advanced forms of disease, it does not reflect the full spectrum of disease (from minor to fatal events) in the community [1]. However, in an effort to address this, the HOS subsequently undertook a survey to quantify the contribution of clinically overt and sub-clinical heart disease in a primary care setting [15].

Although data collected on sleep duration and smoking were cross-sectional and true causality could therefore not be determined, as well as the fact that it was self-reported, data from the HOS primary care survey still suggests that sufficient sleep should be a recommendation as part of prevention programmes and that further research is needed [16].

A limitation of the heart failure management programme is the small number of subjects (n=50), which might contribute to a lack of statistical power.

7.4 Conclusions and the way forward

Soweto can be described as one of the largest, predominantly black urban areas in South Africa, with living conditions ranging from the low socio-economic spectrum to the more affluent. Our research

clearly provides evidence that the population living in Soweto are undergoing a epidemiologic, as well as nutrition transition, as described for other populations in low, middle-income, and less developed countries. Soweto is facing a unique conundrum, of still experiencing communicable (infectious) diseases, while at the same time starting to feel the pressure of an increasing burden of non-communicable diseases and modifiable cardiovascular and metabolic risk factors, which might reach epidemic proportions if left unchecked.

We found high levels of obesity, especially amongst women, a high prevalence of hypertension and RHF, especially in younger persons. Contributing to this is changes in lifestyle and dietary patterns with a high consumption of more refined high fat, high sugar, high salt, low fibre, low fruit diets and an increased intake of processed and convenience foods and lower levels of activity as well as the lower levels of vitamin C found in the heart failure cohort. We also identified certain environmental factors that might have an exacerbating role, such as sleep habits, smoking and/or being exposed to second hand smoke and showed an association between longer sleep duration and a lower BMI in older females, while men napping for >30 minutes during the day presented with a lower BMI, as well as lower systolic and diastolic blood pressure. On the other hand, longer night-time sleep had an adverse effect on females, as it was associated with higher diastolic and systolic blood pressure. All of these underlying risk factors pose major challenges to the health and socio-economic well-being of the individual, as well as on available government resources.

A theme clearly emerging from this thesis is that the health and well-being of an individual are determined by many factors and that the development of chronic diseases and the prevention thereof, are multifaceted. We have described the emerging epidemic of chronic diseases, such as heart disease, obesity and high blood pressure in Soweto, as well as the changes in diet and lifestyle and have provided targeted culturally specific solutions for primary, as well as secondary health care level. However, I feel a clear need still exist to examine certain less well-described risk factors further, especially the influence of environment and sleep habits on this population, should we wish to make a long-term sustainable difference in the emerging problem of chronic diseases. I therefore, would like to investigate and answer the following questions: 1. Is there an association between climate changes, such as increasing droughts and heat waves, storms and floods and unstable global and local economic markets on food and job insecurity and the development of chronic diseases? 2. As the earth's population keeps on growing with its negative impact on the earth's resources and increasing pollution, what will the effect of this continuous exposure to pollution be on the health of individuals? 3. How has the epidemiologic transition influenced sleep habits in Soweto and how can this be addressed? I believe by collecting data through studies designed to answer these questions; we might be in a position to comprehensively address the problem.

The development and implementation of targeted culturally appropriate, affordable and disease specific prevention and multi-disciplinary intervention strategies, that will influence behaviour in an affordable and sustainable manner, cannot be delayed any more. We have as health professionals, researchers and policy makers a collective responsibility to inform the public and to put the necessary strategies in place for the prevention of chronic diseases of lifestyle.

The best way to apply what we have learned from our research in a low-resource, urban African community, other than through the awareness, screening and intervention programs we developed and implemented at primary health care level and to the broader Soweto community in relation to optimal CVD prevention strategies, would be via an integrated health program that has the potential to improve cardiovascular health outcomes in a sustainable manner in an urban African low-resource community, such as Soweto and to sub-Saharan Africa in general.

Such a targeted Cardiovascular Health in Africa Prevention Program should span generations and the central component of such a program should be *maternal and early childhood health* with clear links to establishing *healthy lifestyles in young adults* and *pro-active primary prevention.* This program would engage family units in integrated prevention by making use of a sustainable combination of face-to-face and multi-media/information technology-based processes. According to Lamont et al, 2016, 86.4% of pregnant women in Soweto taking part in the REACH US study, used smart phones and had access to the Internet, even though two-thirds of the women were unemployed. Of those women, 77 % indicated a willingness to receive health messages via their cell phones [17]. If planned carefully, such a program has the clear potential for health promotion and could be applied in other communities and target populations throughout South Africa and wider sub-Saharan Africa.

There are many reasons why maternal and child survival are not receiving appropriate attention. Thus, lack of data is an important reason why on public, as well as local, national and provincial levels many officials remains unaware of the predicaments facing women and children in the developing world. This situation is compounded by the HIV/AIDS pandemic reaching its highest prevalence in South Africa and is a critical factor for the additional development of CVD (e.g. HIV-cardiomyopathy, coronary artery disease and premature strokes in young adults) [18]. Moreover, immunosuppression as a consequence of longstanding HIV infection is the leading cause of acute and chronic respiratory tract infections (e.g. tuberculosis and pneumocystis pneumonia amongst many others) [18].

As embodied in the *Millennium Development Goal 5*, there is now clear awareness that there needs to be more focus on maternal health needs, as the death of a mother not only affects the immediate

survival of the offspring, but also has effects throughout the lifecycle of the child, as well as the next generation [19]. Furthermore, it is now known that poor maternal nutrition during pregnancy and postnatally can have metabolic consequences for the offspring [20]. A program on ‘preventing cardiac disease in maternity’, is clearly in line with the Millennium Developmental Goal 5 and is highly necessary and appropriate for South Africa and sub-Saharan Africa.

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16. Pretorius S, Stewart S, Carrington MJ, Lamont K, Sliwa K, Crowther NJ. Is there an association between sleeping patterns and other environmental factors with obesity and blood pressure in an urban African population. PLoS One 2015; 10 (10); e0131081.
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APPENDIX A: Human Research Ethics Committee clearance documents

M130681

R14/49 Mrs Sandra Pretorius

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M130681

NAME: (Principal Investigator)	Mrs Sandra Pretorius
DEPARTMENT:	Cardiovascular Research Unit CH Baragwanath Academic Hospital
PROJECT TITLE:	Development of a Comprehensive Heart Failure Management Programme in a Low Resource Set Up in South Africa (Previously M080440)
DATE CONSIDERED:	Ad hoc
DECISION:	Renewal Approved
CONDITIONS:	
SUPERVISOR:	Prof K Sliwa
APPROVED BY:	Professor PE Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 03/07/2013

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**.

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Pretorius

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER M080440**
PROJECT	Development of a comprehensive heart failure managment programme in a low resource set up in South Africa
INVESTIGATORS	Ms S Pretorius
DEPARTMENT	Cardiovascular research unit
DATE CONSIDERED	08.04.25
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 08.05.30 **CHAIRPERSON** ..... (Professor P E Cleaton Jones)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Prof K Sliwa

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX B: Protocol approval document

University of the Witwatersrand

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
FACULTY OF HEALTH SCIENCES
ASSESSORS MEETING

CANDIDATE: S. PRETORIUS

Date of Assessor Group Meeting: 23/6/2011

School / Department / Division: MEDICINE

Yes | No

Is the research question clearly identified and described?

Comments: In-part, but need clarification.

Yes | No | Not entirely

Is the design of the study and methods the methods used appropriate for the research question being asked?

Comments:
- Change title to describe evidence to relationship between dietary-socio-economic status and CV disease including heart failure
- Highlight in introduction the gaps that is using that will be addressed in the thesis.
- Describe outcome in relationship to aim.
- Describe the analysis in relationship to study design.

Is the study feasible within:

i. the applicant's resources? Yes | No

ii. the departments resources? Yes | No

iii. the time frame? Yes | No

Do you recommend:

i. shortening / lengthening of the protocol? Please specify and explain.

No modification required as
tested on previous page

Yes ☐ No ☑

ii. the appointment of a co-supervisor?

Nominee/s :

Overall recommendation regarding the protocol :

i. revision of the protocol to the Supervisor (if HOD approval is also required, please specify):
(**Candidates**: one copy, list of corrections, supervisor approval letter – submit to PG Office) Yes ☑ No ☐

ii. revision of the protocol to the satisfaction of the Assessor Group:
(**Candidates**: six copies, list of corrections, supervisor approval letter – submit to PG Office) Yes ☐ No ☐

iii. revision of the protocol and resubmission of the revised protocol to the next Assessor Group Meeting:
(**Candidates**: six copies, list of corrections, supervisor approval letter – submit one copy to PG Office / 5 to school assessor group administrator/ for PhD all six copies to be submitted to the PG Office) Yes ☐ No ☐

iv. candidate goes ahead: Yes ☐ No ☐

Assessor Names and Signatures :

G. NORTON — G Norton

A. J. WOODISS — A Woodiss

A Bentley — Bentley

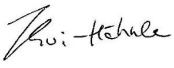
23/6/2011

Date

Assessor Group Chair

APPENDIX C: Statement of originality of publications included in the thesis

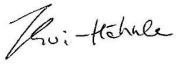
Publication 3.1. Stewart S, Carrington M, **Pretorius S**, Methusi P, Sliwa K. Standing at the crossroads between new and historically prevalent heart disease: effects of migration and socio-economic factors in the Heart of Soweto cohort study. **Eur Heart J 2011;32(4):492-9**

NAME	**RESPONSIBILITY**
Simon Stewart, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Conceived and designed the research Acquired the data Analysed and interpreted the data Performed statistical analysis Drafted the manuscript
Ana O Mocumbi, Instituto do Coracao, Maputo, Mozambique	Contributed to interpretation of the data and the final draft of the manuscript
Melinda J Carrington, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Acquired the data Analysed and interpreted the data
Sandra Pretorius, University of the Witwatersrand	Acquired the data Analysed and interpreted the data
Rosie Burton, University of Cape Town	Acquired the data Analysed and interpreted the data
Karen Sliwa, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Handled funding and supervision Drafted the manuscript
Candidate: I declare that I contributed substantially to this work (as listed above). I also acknowledge the contribution of others (as listed above) to this work in this Statement of Originality.  Sandra Pretorius 2015	Principal advisor: I hereby certify that all co-authors have provided their consent for the inclusion of the paper in the thesis and that the co-authors accept the candidate's contribution to the paper as described in this Statement of Originality.  Professor Karen Sliwa 2015

Publication 3.2. Sandra Pretorius, Simon Stewart, Melinda J Carrington, Kim Lamont, Karen Sliwa, Nigel J Crowther. Is there an association between sleeping patterns and other environmental factors with obesity and blood pressure in an urban African population? **PLOS One; DOI; 10.1371/journal.pone.1031081 October 8, 2015**

NAME	**RESPONSIBILITY**
Sandra Pretorius, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Performed statistical analysis Drafted the manuscript
Simon Stewart, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Conceived and designed the research Acquired the data Handled supervision Analysed and interpreted the data Performed statistical analysis Drafted the manuscript
Melinda J Carrington, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Acquired the data Analysed and interpreted the data
Kim Lamont, University of the Witwatersrand	Acquired the data Analysed and interpreted the data
Karen Sliwa, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Handled funding and supervision Drafted the manuscript
Nigel Crowther, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Handled supervision Drafted the manuscript
Candidate: I declare that this work is wholly my own accept where acknowledged as being the work of others (as listed above). I also acknowledge the contribution of others (as listed above) to this work in this Statement of Originality. Sandra Pretorius 2015	Principal advisor: I hereby certify that all co-authors have provided their consent for the inclusion of the paper in the thesis and that the co-authors accept the candidate's contribution to the paper as described in this Statement of Originality. Professor Karen Sliwa 2015

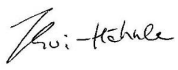
Publication 4.1. Stewart S, Mocumbi AO, Carrington MJ, **Pretorius S**, Burton R, Sliwa K. A not-so-rare form of heart failure in urban black Africans: pathways to right heart failure in the Heart of Soweto Study cohort. **Eur J Heart Fail. 2011: 13:1070-7**

NAME	**RESPONSIBILITY**
Simon Stewart, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Conceived and designed the research Acquired the data Analysed and interpreted the data Performed statistical analysis Drafted the manuscript
Ana O Mocumbi, Instituto do Coracao, Maputo, Mozambique	Acquired the data Analysed and interpreted the data
Melinda J Carrington, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Acquired the data Analysed and interpreted the data
Sandra Pretorius, University of the Witwatersrand	Acquired the data Analysed and interpreted the data
Rosie Burton, University of Cape Town	Acquired the data Analysed and interpreted the data
Karen Sliwa, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Handled funding and supervision Drafted the manuscript
Candidate: I declare that this work is wholly my own accept where acknowledged as being the work of others (as listed above). I also acknowledge the contribution of others (as listed above) to this work in this Statement of Originality.  Sandra Pretorius 2015	Principal advisor: I hereby certify that all co-authors have provided their consent for the inclusion of the paper in the thesis and that the co-authors accept the candidate's contribution to the paper as described in this Statement of Originality.  Professor Karen Sliwa 2015

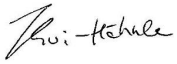
Publication 4.2. Pretorius S, Sliwa K, Ruf V, Walker KZ, Stewart S. Feeding the emergence of advanced heart disease in Soweto: A nutritional survey of black African patients with heart failure. **CVJA June 2012; 23 (5): 245 – 251**

NAME	**RESPONSIBILITY**
Sandra Pretorius, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Performed statistical analysis Drafted the manuscript
Karen Sliwa, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Handled funding and supervision Drafted the manuscript
Verena Ruf, University of the Witwatersrand	Acquired the data Analysed and interpreted the data
Karen Walker, Monash University, Melbourne, Australia	Analysed and interpreted the data Performed statistical analysis Handled supervision
Simon Stewart, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Conceived and designed the research Acquired the data Handled supervision Analysed and interpreted the data Performed statistical analysis Drafted the manuscript
Candidate: I declare that this work is wholly my own accept where acknowledged as being the work of others (as listed above). I also acknowledge the contribution of others (as listed above) to this work in this Statement of Originality. Sandra Pretorius 2015	Principal advisor: I hereby certify that all co-authors have provided their consent for the inclusion of the paper in the thesis and that the co-authors accept the candidate's contribution to the paper as described in this Statement of Originality. Professor Karen Sliwa 2015

Publication 4.3. Pretorius S, Sliwa K. Perspectives and perceptions on the consumption of a healthy diet in Soweto, an urban African community, in South Africa. **SAHeart, 2011; 8 (2): 104-113**

NAME	**RESPONSIBILITY**
Sandra Pretorius, University of the Witwatersrand	Contributed to the conception of the manuscript Contributed to data collection and interpretation Conceived and designed the research Acquired the data Performed statistical analysis Drafted the manuscript
Karen Sliwa, University of the Witwatersrand	Conceived and designed the research Acquired the data Handled funding and supervision Drafted the manuscript
Candidate: I declare that this work is wholly my own accept where acknowledged as being the work of others (as listed above). I also acknowledge the contribution of others (as listed above) to this work in this Statement of Originality.  Sandra Pretorius 2015	Principal advisor: I hereby certify that all co-authors have provided their consent for the inclusion of the paper in the thesis and that the co-authors accept the candidate's contribution to the paper as described in this Statement of Originality.  Professor Karen Sliwa 2015

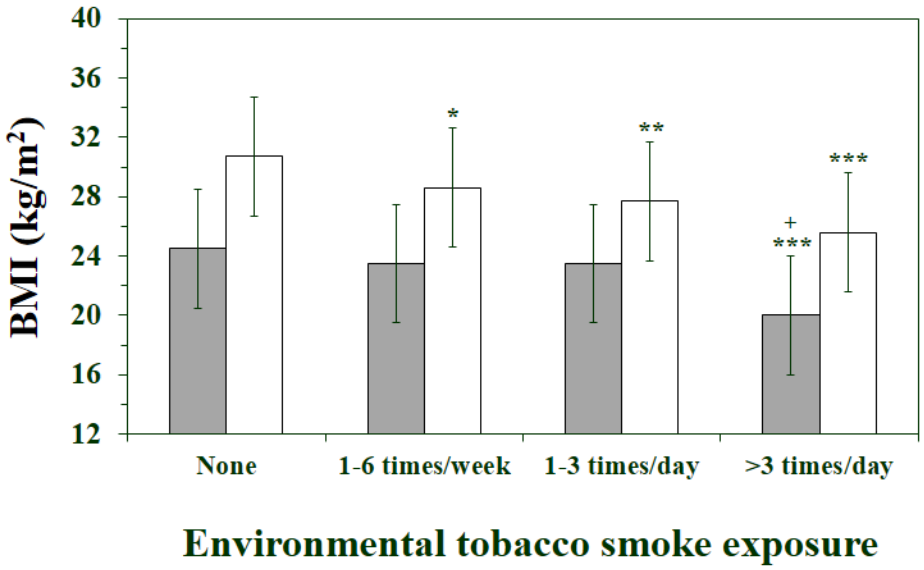
Publication 6.1. Stewart S, Carrington M, **Pretorius S**, Ogah OS, Blauwet L, Antras-Ferry J, Sliwa K. Elevated risk factors but low burden of heart disease in urban African primary care patients: A fundamental role for primary prevention. **Int J Cardiol 2012 Jul 12; 158(2): 205 – 210**

NAME	**RESPONSIBILITY**
Simon Stewart, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Conceived and designed the research Acquired the data Analysed and interpreted the data Performed statistical analysis Drafted the manuscript
Melinda J Carrington, Baker IDI Heart and Diabetes Institute, Melbourne, Australia	Acquired the data Analysed and interpreted the data
Sandra Pretorius, University of the Witwatersrand	Acquired the data Analysed and interpreted the data
Okechukwu S Ogah, University College Hospital, Ibedan, Nigeria	Acquired the data Analysed and interpreted the data
Lori Blauwet, Mayo clinic, Rochester, MN, USA	Acquired the data Analysed and interpreted the data
Jocelyn Antras-Ferry, University of the Witwatersrand	Acquired the data Analysed and interpreted the data
Karen Sliwa, University of the Witwatersrand	Conceived and designed the research Acquired the data Analysed and interpreted the data Handled funding and supervision Drafted the manuscript
Candidate: I declare that this work is wholly my own accept where acknowledged as being the work of others (as listed above). I also acknowledge the contribution of others (as listed above) to this work in this Statement of Originality.  Sandra Pretorius 2015	Principal advisor: I hereby certify that all co-authors have provided their consent for the inclusion of the paper in the thesis and that the co-authors accept the candidate's contribution to the paper as described in this Statement of Originality.  Professor Karen Sliwa 2015

APPENDIX D: SUPPORTING INFORMATION TO PUBLICATION 3.2

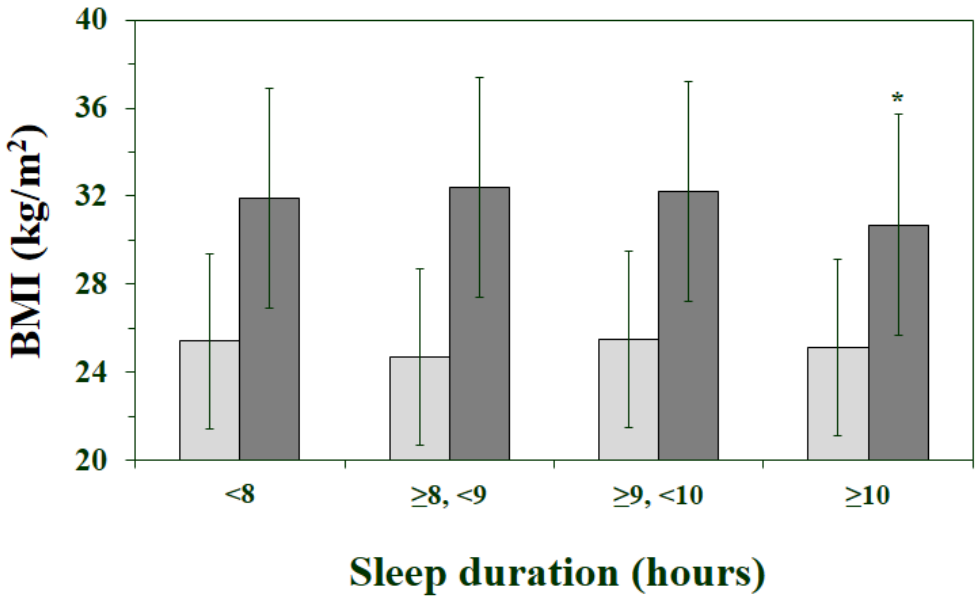
S1 Fig. The effect of environmental tobacco smoke exposure on BMI in males (n=424; grey filled bars) and females (n=829; open bars). The data is given as median with interquartile range; *p<0.05, **p<0.01, ***p<0.001 versus none, $^{+}$p<0.05 versus 1-6 times/week.

Fig. 1



S2 Fig. The effect of night time sleep duration on BMI in females < 40 years-of-age (n=414; light grey filled bars) and females ≥ 40 years-of-age (n=409; dark grey filled bars). The data is given as median with inter-quartile range; *p<0.05 versus <8 hours.

Fig. 2



APPENDIX E: Quantitative Food Frequency Questionnaire

Subject number_____ Interviewer_____

QUANTITATIVE FOOD FREQUENCY QUESTIONNAIRE

INTRODUCTION:

Greeting

Thank you for agreeing to participate in this study. Here we want to find out what kind of foods you regularly eat and drink. This information is important to know, as it will tell us whether anything you eat or drink played a role in the fracture you have experienced.

Please think carefully about the food and drink you have consumed during the past four weeks. I will now go through a list of foods and drinks with you and I would like you to tell me:

if you eat or drink the food

how the food or drink is prepared

how much of the food you eat or drink at a time

how many times a day you eat or drink it and if you do not eat it every day, how many times a week or a month you eat or drink it.

To help you describe the amount of a food you eat or drink, I will show you pictures of different amounts of the food and drinks. Please say which picture is the closest to the amount you eat or drink, or if it is smaller, between sizes or bigger than the pictures.

THERE ARE NO RIGHT OR WRONG ANSWERS.

EVERYTHING YOU TELL ME IS CONFIDENTIAL. ONLY YOUR SUBJECT NUMBER APPEARS ON THE FORM.

IS THERE ANYTHING YOU WANT TO ASK NOW?

ARE YOU WILLING TO GO ON WITH THE QUESTIONS

INSTRUCTION

Circle the subject's answer. Fill in the amount and times eaten in the appropriate columns.

I shall now ask you about the type and the amount of food you have been eating in the last few months. Please tell if you eat the food, how much you eat and how often you eat it. We shall start with maize meal porridge.

Do you eat maize meal porridge? 1 YES 2 NO

If YES, what type do you have at home now?

Brand name_____

Don't know_____2

Grind self_____3

If brand name given, do you usually use this brand 1 2 3

Where do you get your maize-meal from? (May answer more than one)

Shop 1

Employer 2

Harvest and grind self 3

Other - specify _____ 4

Don't know 5

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Maize-meal porridge	Stiff (pap)						e4225 4250	
Maize-meal porridge	Soft (slappap)						e4225 4250	
Maize-meal porridge	Crumbly (phutu)						e4225 4250	
Ting								
Mabella Coarse Fine Rice	Stiff						4082	
Mabella	Soft						4082	
Oats							4032	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Breakfast cereals	Brand names of cereals at home now: (5) Don't know_____							

Do you pour milk on your porridge or cereal? YES 1 NO 2
If YES, what type of milk (whole fresh, sour, 1%, fat free, milk blend.)_____
INSTRUCTION: Show subject examples.

If YES, how much milk?								

Do you pour sugar on your cereal/porridge/mabella YES 1 NO 2

If YES, how much sugar?							9012	
Samp	Bought Self ground						4077 4073	
Samp and beans							A014	

Are the amounts of samp and beans the same as in the picture? YES **NO**
If no, do you use more beans than in the picture or less? MORE LESS

Samp and peanuts							A013	

Are the amounts of samp and peanuts the same as in the picture? YES NO
If no, do you use more peanuts than in the picture or less? MORE LESS

Rice	White Brown Maize rice						4040 4134 4043	
Pastas	Macaroni Spaghetti Other:						4062	

You are being very helpful. Can I now ask you about meat?
How many times do you eat meat, chicken or fish? Per day: _____
Per week? _____
Other? Specify: _____

CHICKEN, MEAT, FISH

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Chicken	Boiled						1521	
	Fried: in batter/crumbs Not coated						1634 1520	
	Roasted/grilled						1520	

Do you eat chicken skin Always Sometimes never
1 2 3

Chicken bones stew							A003	
Chicken feet							A004 1609	
Chicken offal							1610	
Red meat:	How do you like meat? With fat Fat trimmed							
Red meat	Fried							
	Stewed						A001	
	Mince with tomato and onion						1585	
Beef Offal	Intestines: boiled, nothing added						1616	
	Stewed with vegetables							
	Liver						1515	
	Kidney						1518	
	Other specify:							
What vegetables are usually put into meat stews?								
Wors / sausage	Fried						1526	
Bacon							1501	
Cold meats	Polony						1514	
	Ham						1564	
	Viennas						1531	
	Other - specify							
Canned meat	Bully beef						1535	
	Other specify:							
Meat pie	Bought						1548	
Hamburger	Bought						A015	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Pilchards in tomato/chilli/ brine	Whole						2557	
	Mashed with fried onion						A005	
Fried fish	With batter/crumbs						2509	
	Without batter/crumbs						2523	
Other canned fish	Tuna						2547	
	Pickled fish Other:						2562	
Fish cakes	Fried						2531	
Eggs	Boiled/poached Scrambled Fired						1001 1025 1003	
Dried beans/peas/ lentils (10)	Soup Salad						3033 3508	
Soya products eg. Toppers	Brands at home now (5) Don't know_____ _ **Show examples**						3527	

WE NOW COME TO VEGETABLES

How often do you eat vegetables?

Per day? _____

Per week? _____

Other? Specify:_____

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Cabbage	How do you cook cabbage?							
	Boiled, nothing added						8066	
	Boiled with potato and onion and fat						A006	
	Fried, nothing added						A007	
	Boiled, then fried with potato, onion						A006	
	Other: Don't know							

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Spinach/morogo/ other green leafy	How do you cook spinach?							
	Boiled, nothing added						8071	
	Boiled fat added						8209	
	Boiled with onion/tomato and fat						A011	
	- onion, tomato & potato							
	- with peanuts							
	Other: Don't know							
Tomato and onion 'gravy'	Home made - with fat - without fat						A012 A016	
	Canned						8221	
Pumpkin	How do you cook pumpkin?							
	Cooked in fat & sugar						A010	
	Boiled, little sugar and fat						A009	
	Other: Don't know							
Carrots	How do you cook carrots?							
	Boiled, sugar & fat						8129	
	With potato/onion						A008	
	Raw, salad						8015	
	Chakalaka							
	Other: Don't know							
Mealies/Sweet corn	How do you eat mealies?							
	On cob						8033	
	Off cobb - creamed sweet corn - whole kernel						8034 8261	
Beetroot salad	Home made Bought						8005	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Potatoes	How do you cook potatoes?							
	Boiled/baked with skin						8046	
	- without skin						8045	
	Mashed						8187	
	Roasted						8189	
	French fries						8048	
	Salad Other:						8236	
Sweet potatoes	How do you cook sweet potatoes?							
	Boiled/baked with skin						8057	
	- without skin						8214	
	Mashed							
	Other: Don't know							
Salad vegetables	Raw tomato						8059	
	Lettuce						8031	
	Cucumber						8025	
Other vegetables, specify:								

FRUIT:
How often do you eat fruit?

Per day? _____
Per week? _____
Other? Specify: _____

Apples/Pears	Fresh Canned pears						7001 7054	
Bananas							7009	
Oranges/naartjie							7031	
Grapes							7020	
Peaches	Fresh Canned						7036 7038	
Apricots	Fresh Canned						7003 7004	
Mangoes	Fresh						7026	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Guavas	Fresh Canned						7021 7023	
If subject eats canned fruit: Do you have custard with canned fruit:						YES 1		NO 2
Custard	Home made Ultramel						0004	
Wild fuit/berries	Specify type						7070	
Dried fruit	Types:							
Other fruit								

BREAD AND BREAD SPREADS

How often do you eat bread and rolls?

Per day? _____

Per week? _____

Other? Specify: _____

Bread/Bread rolls	White						4001	
	Brown						4002	
	Whole wheat						4003	
Do you spread anything on the bread?		Always 1		Sometimes 2		Never 3		
Margarine	What brand do you have at home now? _____ _____ Don't know_____ Show examples							
Peanut butter							6509	
Jam/syrup/honey							9008	
Marmite/Fray Bentos							9501	
Fish/meat paste							1512	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
Cheese	Type:						0010	
Achaar							A017	
Other spreads:	Specify							
Dumpling							4001	
Vetkoek							4057	
Provita, crackers, etc.								
Mayonnaise/salad dressing	Number of spoons_____/ number in family						6573	
DRINKS:								
Tea							9514	
Coffee							9513	
Sugar/cup tea or coffee							9012	
Milk/cup tea or coffee	What type of milk do you use in tea and coffee?							
	Fresh/long life whole						0006	
	Fresh/long life 2%						0069	
	Fresh/long life fat free						0072	
	Whole milk powder Brand_____						0009	
	Skimmed milk powder Brand_____						0008	
	Milk blend Brand_____						0068	
	Whitener Brand_____						0039	
	Condensed milk						0002	
	Evaporated milk						0003	
	None							
Milk as such	What type of milk do you drink as such?							

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/ DAY
			Per day	Per week	Per month	Seldom / Never		
	Fresh/long life whole						0006	
	Sour / Maas						0006	
Milk drinks Brand	Nestle_____ _____ Milo_____ _____ Flavoured milk_____ Other_____ _____						0023	
Yoghurt	Drinking yoghurt Thick yoghurt						0044 0020	
Squash	SweetO SixO Oros/Lecol with sugar - artificial sweetener Kool Aid Other						9013 9013 9002 9013 9002	
Fruit juice	Fresh/Liquifruit/Ceres						0535	
	Tropica Show examples						0089	
Fizzy drinks Coke, Fanta	Sweetened Diet						9001 9013	
Mageu/Motogo							9562	
Home brew							9516	
Tlokwe							9516	
Beer							9506	
Spirits							9510	
Wine red							9508	
Wine white							9518	
Other specify								
SNACKS AND SWEETS:								
Potato crisps							8049	
Peanuts	Raw Roasted						6001 6007	
Cheese curls: Niknaks etc.							4076	
Raisins							7022	

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/DAY
			Per day	Per week	Per month	Seldom/ Never		
Peanuts and raisins							6007 7022	
Chocolates	Name_____ _____						9024	
Candies	Sugus, gums, hard sweets						9009	
Sweets	Toffees, fudge, caramels						9014	
Biscuits	Type							
Cakes & tarts	Type							
Scones							4029	
Rusks							4160	
Savouries	Sausage rolls Samoosas Biscuits eg bacon kips Other:						1534 4196 4162	
Jelly							9004	
Baked pudding							4181	
Instant pudding							4066	
Ice cream Sorbet							6507 6516	
Other Specify:								
SAUCES / GRAVIES / CONDIMENTS								
Tomato Sauce Worcester sauce							9505	
Chutney							9524	
Pickles							8176	
Packet soups							4069	
Others:								
WILD BIRDS, ANIMALS OR INSECTS (hunted in rural areas or on farms)								
Wild fruit								

MISCELLANEOUS: Please mention any other foods used more than once/two weeks which we have not talked about:

FOOD	DESCRIPTION	Amount	TIMES EATEN				CODE	AMOUNT/DAY
			Per day	Per week	Per month	Seldom/ Never		

Salt use:

What type of salt do you use?_____

The next few questions are to find out if you use salt, where you use it and how much you use?

Do you add salt to food while it is being cooked?

Always 1	Sometimes 2	Never 3	Don't know 4

Do you add salt to your food after it has been cooked?

Always 1	Sometimes 2	Never 3

Do you like salty foods eg. salted peanuts, crisps?

Very much 1	Like 2	Not al all 3

Do you use any of the following:

	Name of product	Amount/day
Vitamins/vitamins & minerals		
Tonics		
Health foods		
Body building preparations		
Dietary fibre supplement		
Other: specify		

THANK YOU FOR YOUR COOPERATION AND PATIENCE
GOOD-BYE!

APPENDIX F: Soweto Primary Care Registration Form

Draft Baker IDI HEART & DIABETES INSTITUTE

Heart of Soweto Study

Soweto Cardiovascular Research Unit

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

Office use only

STUDY ID: Place sticker here.

PH ID:

NATIONALI ID:

COMPLETED BY:

Soweto Primary Care - Registration Form

First name: **Surname:**

Date of Assessment: (dd/mm/yyyy) / /

PATIENT'S DETAILS

Date of birth / / (dd/mm/yyyy) **OR** **Age:** yrs

Gender O Male O Female

Race: O Black O Caucasian O Indian O Coloured

Do you stay in Soweto: O Yes O No **If yes, how many years:** yrs

Education Level: O None O Standard 1-5 O Standard 6-10 O Post Matric

RISK FACTOR PROFILE

Family history of heart problems (eg. high blood pressure, heart attack, chest pain/angina): O Yes O No O Don't know

Do you have high cholesterol: O Yes O No O Don't know

Do you smoke: O Yes O No O Used to but gave up **If yes, how many per day?**

Do you drink alcohol: O Yes O No O Used to but gave up **If yes, how many per day?**

During your longest or nocturnal sleep period, what time do you normally go to bed? : (hh:mm)

During your longest or nocturnal sleep period, what time do you normally wake up? : (hh:mm)

Do you usually take a nap? O Yes O No **If yes, total nap duration in minutes?** minutes

Primary fuel used for cooking or heating:

O Kerosene O Charcoal O Coal O Gas O Wood O Agriculture/ crop O Gobar gas O Electricity O Paraffin O Animal dung O Shrub/grass O Other

Does your kitchen/living room have a window? O Yes O No

During the past 12 months, have you been regularly (at least once per week) **exposed to other people's tobacco smoke?**
("Exposed" is defined as a minimum of 5 consecutive minutes, during which you inhale other people's smoke.)

O No Proceed to Clinical Presentation O Yes

Over the past 12 months, what has been your typical exposure to other people's smoke? (Select ONE only)
("Exposed" is defined as a minimum of 5 consecutive minutes, during which you inhale other people's smoke.)

O 1-2 times/week O 3-6 times/week O at least once a day O 2-3 times/day O 4 or more times/day

CLINICAL PRESENTATION

Blood pressure (mm/Hg):

At 1 min: /

At 2 min: /

At 3 min: /

Heart rate (beats/min):

At 1 min:

At 2 min:

At 3 min:

Weight: kg **Waist** cm

Height: cm **Hip** cm

ECG normal? O Yes O No

Draft

Soweto Primary Care - Diagnosis and Results

HISTORY / PHYSICAL EXAMINATION

Shortness of breath	O Yes	O No
Chest pain	O Yes	O No
Palpitations	O Yes	O No
Presyncope / Syncope	O Yes	O No
JVP - elevated	O Yes	O No
Murmur	O Yes	O No
Oedema	O Yes	O No

DIAGNOSIS AT PRIMARY CARE

Normal Heart	O Yes	O No
Hypertension	O Yes	O No
Valve disease	O Yes	O No
CAD	O Yes	O No
Diabetes	O Yes	O No
If yes: O diet	O oral	O insulin
Stroke	O Yes	O No
Heart failure	O Yes	O No
Headache	O Yes	O No
Stomach ache	O Yes	O No
Muscle / joint pain	O Yes	O No
UTI	O Yes	O No

Perinatal conditions	O Yes	O No
Respiratory conditions	O Yes	O No
HIV / Aids	O Yes	O No
Diarrhoeal disease	O Yes	O No
Mental disorders	O Yes	O No
Malaria	O Yes	O No
Tuberculosis	O Yes	O No
COPD	O Yes	O No
Cancer	O Yes	O No
Hepatitis	O Yes	O No
Other (Please specify below)	O Yes	O No

OUTCOME PRIMARY HEALTH CLINIC AND REFERRAL

Cardiac disease	O Yes	O No	**Refer to Heart Failure Clinic**	O Yes	O No **(RED)**
Cardiac patient screening (WHC)	O Yes	O No **(ORANGE)**	**Admit as inpatient**	O Yes	O No

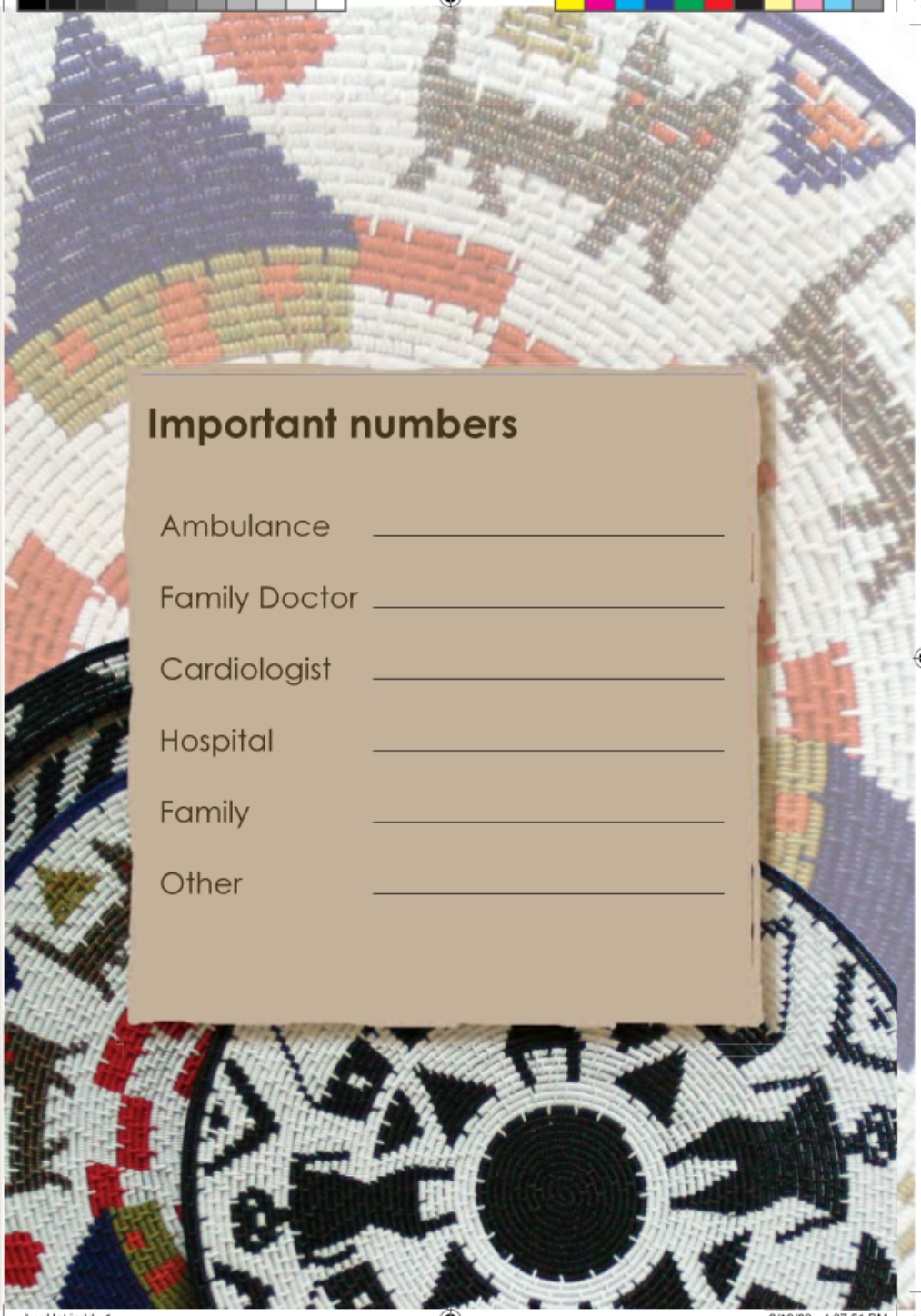
MEDICATIONS

MEDICATION	YES	DAILY DOSE
ACEi (Enalapril/Perindopril)	O	
Adalat XL	O	
Aspirin	O	
Beta-Blocker (Carvedilol/Atenolol)	O	
Furosemide/Lasix	O	
Spironolactone/Aldolactone	O	
Statins (Zocor)	O	

MEDICATION	YES	DAILY DOSE
Thiazide	O	
Digoxin	O	
Warfarin	O	
Slow K	O	
Other medication (please list on the space provided below)	O	

APPENDIX G: Living with heart failure in Soweto booklet





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Symptoms of heart failure	7
Causes of heart failure	10
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How is heart failure treated?	15
Your action plan	23
Dietary guidelines – protect your heart	24
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Working with your health care team



ABOUT THE HEALTH CARE TEAM, SOWETO CARDIOVASCULAR REASERCH UNIT

By learning about heart failure, we can work together to help you live a fuller and more comfortable life. Pictured above from left to right are:

Professor Karen Sliwa-Hahnle (director)
Sandra Pretorius (dietician)
Phuthuma Methusi (nursing sister)
Elisabeth Tshele (nursing sister)
Louis Kuneka (ECG technologist)
Bridget Phooko (study co-ordinator)
Maureen Kubekha (research nurse)

Contact Details:
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Email: Karen.Sliwa-Hahnle@wits.ac.za
Postal Address: P.O. Bertsham 2013
Soweto Cardiovascular Research Unit,
Division of Cardiology, Chris Hani
Baragwanath Hospital, 2013, Soweto, South
Africa.



Living with heart failure in Soweto

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You have been diagnosed with heart failure: Your action for the first six months

☐ *1. Book for a heart failure lecture.*

☐ *2. Book for heart failure dietary lectures.*

☐ *3. Book for cooking classes.*

☐ *4. Weigh yourself daily.*

Your weight now: _____

Date: _____



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Weight Chart

MONTH 1	MONTH 2	MONTH 3	MONTH 4	MONTH 5	MONTH 6
1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3
4	4	4	4	4	4
5	5	5	5	5	5
6	6	6	6	6	6
7	7	7	7	7	7
8	8	8	8	8	8
9	9	9	9	9	9
10	10	10	10	10	10
11	11	11	11	11	11
12	12	12	12	12	12
13	13	13	13	13	13
14	14	14	14	14	14
15	15	15	15	15	15
16	16	16	16	16	16
17	17	17	17	17	17
18	18	18	18	18	18
19	19	19	19	19	19
20	20	20	20	20	20
21	21	21	21	21	21
22	22	22	22	22	22
23	23	23	23	23	23
24	24	24	24	24	24
25	25	25	25	25	25
26	26	26	26	26	26
27	27	27	27	27	27
28	28	28	28	28	28
29	29	29	29	29	29
30	30	30	30	30	30
31	31	31	31	31	31

Your ideal body weight (IBW):

What is heart failure?

Heart failure, as the name suggests, is a condition in which the heart fails to pump enough blood around the body.

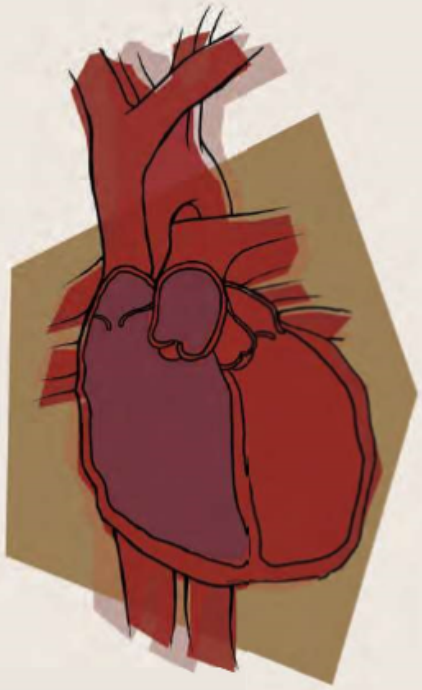
As a result of the heart's failure to pump properly, the body does not receive enough oxygen and nutrients to meet its needs.

The heart is a pump designed to deliver blood to all parts of the body. The heart's walls are made of muscle.

THE NORMAL HEART
The normal heart is about the same size as a clenched fist.

It pumps about 4 – 6 litres of blood per minute at rest, and even more during activity.

It pumps blood to all parts of the body.



AT FIRST
The heart may become larger as more blood enters the chambers. This allows more blood to be pumped out with each heart beat. At this stage you may have no symptoms at all.

The heart keeps pumping, but gets much weaker and starts to fail. Heart failure symptoms then start to develop.

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Symptoms of heart failure



THE SYMPTOMS OF FAILURE OF THE LEFT SIDE OF THE HEART INCLUDE:

- Shortness of breath (especially during exercise).
- A dry, hacking cough (caused by the irritation of the lung by the excess fluid).
- An inability to lie flat (so that more than one pillow is needed to sleep at night).
- Night awakenings with spells of breathlessness and a feeling of needing fresh air.

If the right side of the heart is affected, fluid can build up in the tissues of the body. Because of gravity, this fluid tends to settle in the lowest parts of the body, usually the ankles.

MAJOR SYMPTOMS OF RIGHT-SIDED HEART FAILURE ARE:

- Swelling of the ankles and legs. This usually occurs during the day when a person is standing or sitting up straight.

General swelling around the abdomen, waist and sacral areas.

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Weight gain (due to the extra weight of retained fluid).

- When both sides of the heart are affected, the term "bi-ventricular failure" (meaning both sides of the heart) is used.

OTHER COMMON SYMPTOMS OF HEART FAILURE INCLUDE:

- Palpitations (the sensation of a rapid pounding in the chest) are usually caused by irregularity in the heartbeat, called "atrial fibrillation". An irregular heartbeat can aggravate heart failure by making each heart beat weaker and reducing the amount of blood being pumped around the body.

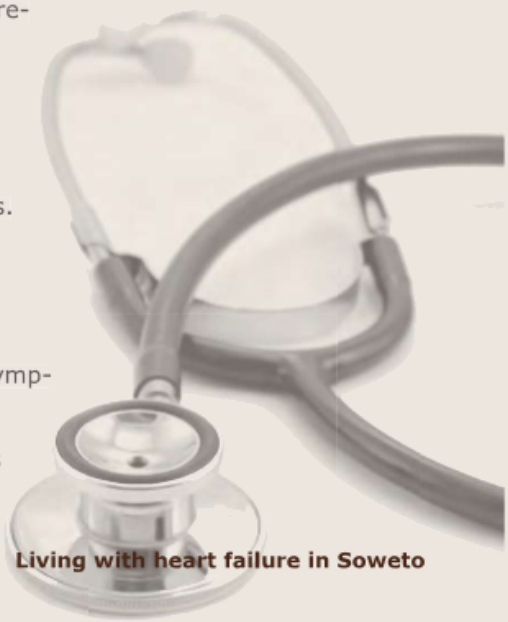
- In some cases, palpitations may be associated with dizziness or episodes of fainting. Fortunately, atrial fibrillation and other heart irregularities can be controlled with medication, especially if treated early.

It is extremely important to report any palpitations promptly to your doctor.

- Muscle wasting caused by a reduced supply of oxygen and nutrients. This is often due to a combination of poor appetite, a lack of blood supply to the digestive system where nutrients are absorbed and a lack of blood supply to the muscles themselves.

- General fatigue and lethargy caused by the overall lack of blood supply.

It is important to note that the symptoms of heart failure depend on many different factors, including how badly the right and left sides of the heart are affected.



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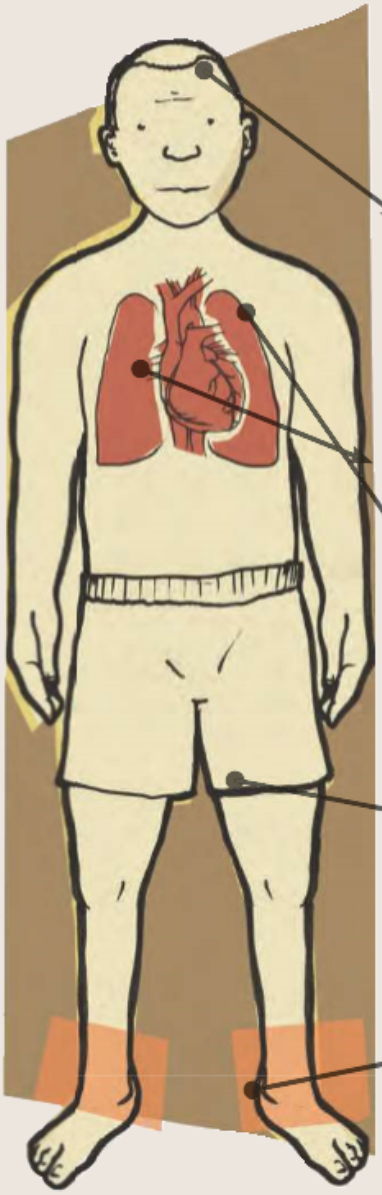

The symptoms of heart failure are related to the changes that occur in your heart and body.

Dizziness and weakness (especially when standing quickly) caused by less blood going to your brain.

Shortness of breath – even at rest – caused by fluid backing up in your lungs (congestion).

Awareness of heartbeat caused by the heart beating faster to pump enough blood to the body.

Tiredness, especially with activity, caused by less blood getting to your major organs and muscles.

Swelling (oedema) of feet, legs, and abdomen and rapid, unexplained weight gain caused by poor heart function and circulation, which causes water retention.

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Causes of heart failure



Heart failure most commonly occurs when the heart muscle is damaged by a heart attack (creating a scar). As a result, it cannot pump as strongly as it did before.

It can also occur as a result of too much stress on the inside walls of the heart (for example if your blood pressure remains too high). Too much stress causes the heart to stretch, lose its proper and most efficient shape and therefore begin to lose its ability to pump enough blood around the body.

Damage to any of the valves in the heart that normally ensure that blood is pumped in the right direction can also reduce how much blood leaves the heart. This can also happen when the heart is affected by a viral infection or by excessive alcohol intake.

Either side of the heart (the left or right side, or both) can be affected by the above, leading to heart failure.

Whatever the cause, the problem is the same – the heart is weakened and is unable to pump properly. Therefore, not enough blood is pumped around the body. To compensate for this problem, the heart attempts to work harder and faster. If nothing is done to reduce continual stress on the heart, its efforts become weaker and the signs and symptoms of heart failure worsen.



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How is heart failure diagnosed?



When blood circulation is affected by the "failure" of either side of the heart, there is increased pressure within the blood vessels. Like a garden hose that becomes leaky when it is blocked, fluid is forced out into the tissues of the body.

Heart failure usually becomes worse whenever the pressure within the blood circulation is increased. This can be caused by the following:

- When the heart's attempts to pump the blood faster become weaker. This can occur when the heart is put under more stress (for example during exercise or when the heartbeat becomes too fast or too irregular.)

- When the kidneys begin to fail. The kidneys normally regulate how much fluid is in the body (by producing urine that contains the body's waste products). Therefore, when they fail, too much fluid is retained in the body.

- When a person lies down and more blood than usual returns from the lower parts of the body.

- If the left side of the heart is affected, fluid builds up in the lungs. This extra fluid hinders the transfer of oxygen from the

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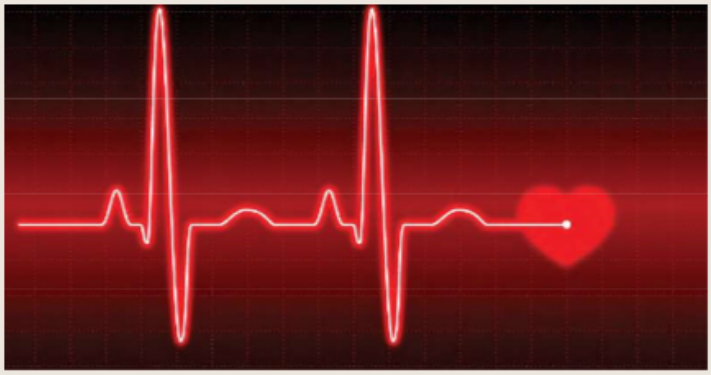

sacs of air in the lungs to the blood vessels and causes a person to become short of breath.

Your doctor will ask about your symptoms and examine your heart and body for signs of heart failure. You will undergo certain tests to help the doctor find out the extent of your heart failure and what has caused it.

BLOOD TESTS

Your doctor may test your blood for:

- Kidney function
- Levels of cholesterol

Depending on your symptoms, you may have other blood tests as well.

ECG

An ECG (electrocardiogram) is a test that picks up the electrical activity of your heart. It shows the doctor your heart's rhythm, or the timing of your heartbeats. It may also show changes due to a heart attack in the past, or to thickening of the heart muscle.

X-RAY

An x-ray can be used to show the size of your heart. An enlarged heart is a sign of heart failure. The heart grows bigger when it has to work harder to pump blood.

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GATED BLOOD POOL SCAN (HUG A)
This shows an x-ray test done in the Nuclear Medicine Department. A small amount of radioactive dye is injected into a vein, and pictures are taken as the dye fills the heart's chambers. Like echocardiography (see below), this test tells your doctor how much blood your heart can pump with each beat (the ejection fraction).

ECHOCARDIOGRAPHY
Echocardiography uses sound waves to safely show how your heart is working. The test shows:

- If the heart muscle is not working properly.
- If any of the heart valves are leaking.
- If the heart walls are thickened.

Any of these problems could cause your heart to work harder than normal.

STRESS TEST
You may be given a test that involves walking on a treadmill. The speed and slope of the machine are increased until you become tired or short of breath, or until your heart reaches a certain rate. This test does not diagnose heart failure. It indicates how well the heart functions when given extra work.



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ANGIOGRAM AND RIGHT HEART CATHETERISATION

Occasionally, doctors recommend a right-heart catheter with or without an angiogram. This procedure is done at a hospital, often on an outpatient basis.

You may be given a sedative to help you feel calm, and a local anaesthetic.

A needle will be inserted into a blood vessel and a thin tube will be carefully guided through the blood vessel into your heart.

This procedure allows your doctor to measure the pressure inside your heart. Dye may also be pumped into your heart to make it show up on a special type of x-ray film.

Occasionally a tiny sample of the heart muscle may be taken (this is known as a biopsy) to study under a microscope and look for a possible cause of your heart failure.



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How is heart failure treated?

HEART FAILURE IS TREATED BY:

- ❒ Making lifestyle changes
- ❒ Taking medication
- ❒ Seeing your family doctor for regular check ups
- ❒ Surgery if appropriate

TREATMENT AIMS TO:

- ❒ Prevent progression of your heart problem.
- ❒ Maintain or improve your quality of life.
- ❒ Help you live longer.

TREATMENT: A TEAM EFFORT

The success of your treatment plan will require team effort. Your family doctor and your specialist cardiologist will manage your medication and other medical problems. Other team members – nurses, dieticians, physiotherapists and social workers – will help you achieve success. It is up to you to take your medication, live a healthy lifestyle, keep your follow-up appointments and be an active member of the team.



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Making lifestyle changes: diet

DIET AND LIFESTYLE RECOMMENDATIONS

- Balance energy intake and physical activity to achieve or maintain a healthy body weight.

- Reach your healthy weight and stay there! Your goal is to achieve and maintain your ideal body weight (IBW). If you are overweight your heart has to work harder to pump. IBW can be achieved by exercising regularly and watching your diet. Your dietician can help you plan a diet which provides the proper amount energy for you.

- Consume a diet rich in vegetables and fruits.

- Choose whole-grain, high-fibre foods.

- Consume fish, especially oily fish, at least twice a week.
  Limit your intake of saturated fat to <7% of energy, trans fat to <1% and cholesterol to <300mg per day by:
  - ❒ Choosing lean meats and vegetable alternatives;
  - ❒ Selecting fat-free (skim), 1%-fat, and low-fat dairy products; and
  - ❒ Minimising intake of partially hydrogenated fats.

- Minimise your intake of beverages and foods with added sugars.

- Choose and prepare foods with little or no salt. Most people eat too much sodium (salt), which means the heart must work harder. One teaspoon of salt = 2 000mg sodium.

WATCH YOUR FLUID INTAKE

For severe heart failure you may need to limit the fluids (liquids) you drink throughout the day. If your doctor tells you to limit your fluid intake, you will need to watch how much fluid is in the foods you eat (soup, jelly, oranges, ice cubes). Your doctor will tell you how much fluid you are allowed.

If you take certain types of diuretics (water pills), you may need to eat foods that are high in potassium and magnesium. These foods include fresh fruit (bananas and strawberries), dried fruit (raisins), and fresh vegetables (spinach).

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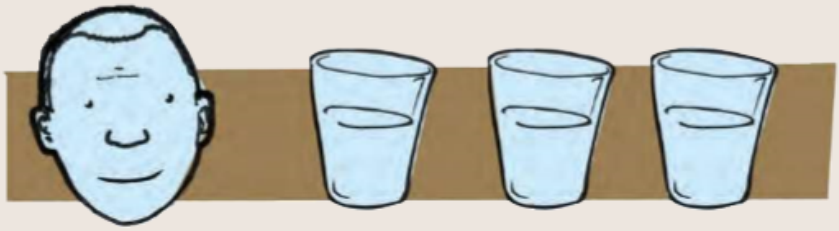

PRACTICAL HINTS TO CONTROL YOUR FLUID INTAKE

- Divide your fluid allowance evenly throughout the day.
- Avoid drinking sugary fluids.
- Use a small cup or glass.
- Take medication with a meal (unless instructed not to). Some tablets require little or no fluid to swallow if taken with food.
- Rinse your mouth with water and gargle if necessary, but do not swallow.
- Stimulate the production of saliva by sucking a lemon wedge or sweets like sherbet or chewing gum.
- Cool off by wiping your face, neck and under the arms with a wet towel. Alternatively, take a shower.

WEIGH YOURSELF EACH MORNING

Weigh yourself on the same scale each morning, after urinating and before eating. Write down your weight every day in a diary. Bring this to your doctor's visit. Call your doctor sooner if you gain 1kg in one day or 2.5kg in one week. Remember 1 litre of fluid weighs 1 kilogramme!

STOP SMOKING

Smoking causes abnormal heart rhythm, heart attacks, lung disease and lung infections.

LIMIT ALCOHOL

If you consume alcohol, do so in moderation. It can contribute to heart failure by further damaging the heart muscle. If you have heart failure you may be advised to have no alcohol at all.

American Heart Association 2006. Diet and Lifestyle Recommendations for Cardiovascular Disease Risk Reduction

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Making lifestyle changes – exercise

Muscles, particularly in the legs, may become weak due to heart failure. This is due to reduced blood flow and reduced activity. The weak muscles may slow you down as much as your heart does. A structured exercise programme will significantly increase your exercise capacity.

PACE YOURSELF

If your daily activities are too tiring, you will need to conserve your energy. You may need to cut down on some of the heavier activities or use energy-saving devices or techniques.

ENERGY TIPS

1. You will have good days and bad days. Try to minimise fluctuations by pacing your activities.
2. Do not schedule too many things to do in one day. Allow for adequate time so that you don't have to rush.
3. Rest before and after activities. Frequent short breaks are more effective than large rest periods when you are feeling very tired.
4. If you become tired during any activity, stop and rest.
5. Do not plan to do things immediately after having a meal.
6. Avoid extreme physical exertion. Do not push, pull or lift heavy objects that quickly tire you out or require you to strain yourself.
7. For more energy-saving tips, tell your doctor you would like to speak to an occupational therapist.



IS CARDIAC REHAB FOR YOU?

Cardiac rehabilitation can help you learn about your heart failure, lifestyle changes and exercise guidelines, while being supervised by health-care professionals. Your family doctor may also have information about cardiac rehabilitation programmes in your area.

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TO BE SAFE, FOLLOW THESE EXERCISE TIPS:

- Know the type and level of exercise that is right for you. Try and walk on a flat track, avoid stairs and hills.
- Try to exercise at least five days per week.
- Gradually increase your exercise from 10 minutes per day to 30–60 minutes per day. This may take 8–12 weeks to achieve.
- The right amount of activity should not exhaust you.
- Wear comfortable clothes and shoes.
- Avoid exercise in temperatures below 5°C and above 30°C or within an hour of eating.
- If walking is your exercise: Walking in one direction may take you far away from your starting point. Rather walk around a block or track. Try to walk continuously.
- Avoid heavy lifting.

A STRUCTURED EXERCISE PROGRAMME WILL HELP TO:

- Minimise symptoms.
- Give you more stamina to keep up with your daily activities.
- Help maintain weight by burning calories.
- Keep your muscles and bones strong and healthy.
- Control cholesterol levels, blood sugar levels and stress management.
- Give you a sense of well-being.
- Improve your quality of life.



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SIGNS OF EXERCISING TOO HARD

- ❒ Excessive shortness of breath and palpitations.
- ❒ Dizziness.
- ❒ Chest discomfort.
- ❒ Exhaustion after exercise.

If these symptoms occur, stop the activity and rest. Call your doctor if these symptoms last longer than 20 minutes or if they occur on a regular basis.

Medication

WHY DO YOU NEED TO TAKE MEDICINE?



The medicine you are given will help your heart to beat more strongly and slowly (beta-blocker eg: Carvedilol and ace-inhibitors eg: Enalapril).
It also helps you to lose extra fluids in your body (diuretics eg: Lasix).
You will not only need medicine. You will probably need to lose weight and will most likely need to change your diet. For these reasons you should attend the lectures offered to you.

It is important that you take your medicine exactly as you have been told.

WHY SHOULD YOU FOLLOW THE INSTRUCTIONS?

If you do not:

- ❒ Your heart will not get stronger.
- ❒ Your legs will swell.
- ❒ Water will be stored in your legs, lungs and abdomen.
- ❒ This can lead to chest infections such as pneumonia.
- ❒ You might die.

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SUMMARY

What can you do to improve your life when you have heart failure?

1. Take your medicine regularly.
2. Lose weight if you are overweight.
3. Correct your diet.
4. Do not smoke.
5. Do not drink alcohol.
6. Measure your weight daily and record it in a book.
7. Attend the clinic regularly.
8. If you don't feel well, contact us and come to our clinic.
9. If you follow these instructions you will improve your quality of life.

IT IS IMPORTANT TO KNOW:

- The names of your different types of medication.
- What each one is used for.
- How often and at what times to take them.
- Common side effects.

Your doctor or nurse will review this information with you. Medication needs vary for each person. Your doctor will work with you to find the best medication to relieve your symptoms and improve your sense of well-being.

Common medications and what they do

ACE INHIBITORS AND ANGIOTENSIN II BLOCKERS (EG: PERNDOPRIL)

Lower the blood pressure by relaxing the arteries, reducing the workload of the heart and increasing blood flow to the kidneys. They also block some of the body's harmful responses to heart failure.

DIURETICS (WATER PILLS)(EG: FRUSEMIDE)

Remove extra fluid from the body; lessen swelling of the ankles and abdomen (oedema) and make breathing easier.

POTASSIUM OR MAGNESIUM (EG: SLOW K)

Replace potassium or magnesium which can be lost due to increased urination when taking certain diuretics.

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BETA-BLOCKERS (EG: CARVEDILOL)
Block over-stimulation of the heart by adrenaline which occurs in people with heart failure, and allows the heart to work more easily.

VASODILATORS (EG: ISORDIL, HYDRALAZINE)
Similar to ACE inhibitors, lower the blood pressure by relaxing the arteries and reduce the work of the heart.

INOROPIC AGENTS (EG: DIGOXIN)
Improve the heart's pumping ability and regulate the heart's rate and rhythm.

ANTIARRHYTHMICS (EG: AMIODARONE)
Contol abnormal heart rhythm.

TIPS TO MANAGE YOUR MEDICATION

- It's important to keep a list of your medication and dosages with you at all times in case of an emergency.
- Always consult your doctor before you stop taking or change your medication.
- Ensure that you take your medication at the same time each day.
- If you forget to take a dose of your medication do not "catch up" by taking a double dose. Stick to your normal dosage.
- Keep your medication in its original and proper containers so that the name, dose and frequency is easy to see. This also helps in cases of emergency.
- Discuss with your doctor or pharmacist any options of using over-the-counter medications.
- Do not leave your medication in the car, as it may become too hot or too cold and this could affect its efficiency.
- Follow your doctor's orders in order to help yourself.

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Your action plan

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Dietary guidelines – protect your heart

Eat more:

FRUIT AND VEGETABLES: 5 PORTIONS PER DAY!



Apple, pears, bananas, oranges, pumpkin, spinach, tomatoes, cabbage, carrots, beetroot, green beans.

Whole-grain starches and high-fibre foods (oats, maltabella, All-Bran, samp and beans, brown rice, brown or wholewheat bread, lentils, dried beans, split peas, etc).

Meat and chicken (no fat, no skin) – grilled, roasted, boiled, steamed.

Fish – grilled, steamed, especially sardines and pilchards (in tomato sauce).

Low-fat milk, yoghurt, cheese.

IN MODERATION: MONO-UNSATURATED FATS/OILS: Olive oil, canola oil (for stir-fry salad dressings, etc), nuts, peanut butter.

IN MODERATION: POLY-UNSATURATED FATS/OILS: Sunflower oil and soft-tub margarine.

Herbs and spices instead of salt to flavour food.

DRINK MORE WATER – at least 1 – 2 litres per day!

Eat less:



- ☒ Fried foods – deep-fried potato chips, chicken, pizza, hamburgers, pies.
- ☒ Processed food – sausages, russians, polony, viennas, bacon.
- ☒ Salted snacks: potato crisps, salted peanuts, savoury biscuits, biltong.
- ☒ Soya sauce, Worcester sauce, stock cubes, packet soup, canned soup, Aromat, prepared salad dressings, pickles, atchar, olives.
- ☒ Don't add extra salt to food after food has been cooked.
- ☒ Foods with added sugar – cakes, biscuits, sweets, chocolate.
- ☒ Drink fewer sweetened cold drinks.
- ☒ Drink less alcohol.

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1.1 Eat less fat



❒ Keep overall fat intake low (one to two teaspoons a day of margarine, olive or canola oil).
❒ Avoid animal fats (also avoid coconut and palm kernel oil).
❒ Keep intake of foods high in cholesterol minimal, ie use a maximum of 2 – 3 eggs/week; have shellfish/organ meats no more than once a month.
❒ Use small quantities of mono-unsaturated fats (avocado, olive or canola oil, olives, small quantities of nuts – not cashews/brazils) daily.
❒ Use essential fatty acids (eg Salmon omega-3: 1000mg/day).
❒ Avoid trans fatty acids, often found in "hydrogenated" or "partially hydrogenated" oils (eg: in hard-brick margarines), also found in commercial bakery products (they are used to enhance stability and shelf-life of these products).

TIPS FOR REDUCING OVERALL FAT INTAKE:

❒ Buy lean cuts of meat and chicken (skinless) – trim off any visible fat BEFORE cooking.
❒ Read food labels – check the fat content: <5g fat per portion/serving.
❒ Fat-free cooking methods: grill, stew, roast, boil, stir-fry (1 tsp oil, cooking spray).
❒ Avoid take-aways (hamburgers, pies, pizza etc) most of the time (keep some frozen meals on standby for days when you're rushed for time or don't feel like cooking).
❒ Avoid chocolates and crisps (use fat-free sweets, eg wine gums, jelly tots, marshmallows etc – in small amounts, when necessary)
❒ When eating out: choose grilled fish, chicken (no basting sauce); salad (no dressing); vegetables (sauces to be served separately);

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pasta (tomato-based sauce); fruit salad or sorbet.

1.2 To limit saturated fats and trans fat and cholesterol (bad fat)all together:

- ❒ Use skim milk, preferably (or mix it with 2% fat milk).
- ❒ Use low-fat cheeses and fat-free cottage cheese.
- ❒ Use fat-free yoghurt.
- ❒ Use soft, tub margarines (Flora lite, Ole, Canola margarine).
- ❒ Avoid tropical oils (eg: coconut and palm kernel oil – used in coffee creamers and in commercially baked cakes and pastries) – these are extremely high in saturated fats.
- ❒ Avoid products whose labels read "hydrogenated" = hard, brick margarines.
- ❒ Avoid fatty red meat – remove all visible fat before cooking.
- ❒ Use red meat no more than three times a week, and small portions (± 60 – 90g cooked).
- ❒ Grill meat, fish and poultry – at least to the point where it is "medium-done".
- ❒ Avoid frying foods.
- ❒ Avoid processed meats (viennas, sausages, bacon etc).
- ❒ Eat plenty of fish (which provide the good type of fatty acids).
- ❒ Eat less commercially fried and baked products.



1.3 Eat more fibre

SOME GOOD SOURCES OF SOLUBLE FIBRE:

- ❒ Oat bran.
- ❒ Oats porridge.
- ❒ Hi-fibre bran cereal.
- ❒ High-fibre breads, eg: heavy rye bread, seed loaf, "health" bread.
- ❒ High-fibre grains, such as brown rice, pearl barley, durum wheat, wholewheat pasta.
- ❒ Legumes: beans, lentils and split peas.
- ❒ Potato with the skin, sweet potato.
- ❒ Fresh fruit and vegetables.

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EXTRA NOTES ON LEGUMES, INCLUDING BEANS, LENTILS ETC
Legumes include beans of every variety (green beans, baked beans, kidney beans, pinto beans, butter beans, sugar beans etc); also chick peas, lentils and split peas.

Legumes are:
- ❒ Rich in protein, and are therefore ideal in vegetarian dishes.
- ❒ Rich in fibre.
- ❒ Very low in fat.
- ❒ Contain some B vitamins, copper and zinc.
- ❒ Cheap.

THEREFORE LEGUMES HAVE MANY HEALTH ADVANTAGES:
- ❒ Due to their high fibre content, legumes help prevent, reduce colon-disorder symptoms (eg: irritable bowel syndrome, constipation etc).
- ❒ Legumes also help protect against heart disease.
- ❒ Legumes help lower fasting blood glucose levels.
- ❒ Legumes added to a meal help sustain energy levels after that meal is eaten.
- ❒ Legumes leave one feeling fuller, more satisfied after a meal (great in weight-reducing diets!)
- ❒ Legumes help stimulate the immune system in the colon.

BEANS AND LENTILS ARE EASY TO ADD TO MEALS
- ❒ Canned beans are fine to use – drain off the brine, rinse, and add to whatever dish you are preparing.
- ❒ Dried lentils reconstitute very easily – cook up for about 20 minutes in boiling water (like rice) – and then add to dishes, like mince, soups, stews etc.
- ❒ Chickpeas can be used in pasta dishes; or added to couscous (hot or cold as a salad).
- ❒ Don't forget about "baked beans on toast"!
- ❒ Baked beans in tomato sauce can also be puréed – and used as a gravy, topping.

ADD BEANS, LENTILS TO DISHES SUCH AS:
- ❒ Stews, casseroles, curry dishes.
- ❒ Mince dishes (lentils, baked beans in tomato sauce).
- ❒ Soups.
- ❒ Stir-fries.
- ❒ Pasta dishes and risottos.

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Hints to improve the digestion of beans

1. Wash beans thoroughly and place them in a bowl. Cover with water a few centimetres above the beans. Let stand at room temperature for eight hours.
2. Freeze beans, which will break up troublesome starch molecules.
3. Place frozen beans in a large pot with pleanty of water to double the volume of the beans. Bring water to boil. Boil uncovered for about 10 minutes. Drain off water. Replace with fresh water. Cook until done.
4. While cooking, add a pinch of ginger or fennel. These spices will further aid in minimising potential gas and bloating.
5. Be sure beans are cooked well, or until soft.

Example of a recommended daily diet and portions per day (AHA-Recommended Dietary goals at 8500 kj)

Food Group	Portions/serving per day	Serving sizes
Grains	6 – 8 servings	1 slice bread; or ½ cup cereal or cooked porridge; ½ cup cooked rice/pasta etc.
Vegetables	4 – 5 servings	½ cup cut up raw or cooked veg or 1 cup leafy/salad
Fruits	4 – 5 servings	1 medium fruit or ½ cup fruit salad or ½ cup fruit juice
Fat-free or low-fat milk and milk products	2 – 3 servings	1 cup milk or yoghurt or 30g cheese
Lean meats, poultry and fish	4 – 5 servings	30 – 40g meat or fish or chicken
Nuts, seeds and legumes	4 – 5 servings	1/3 cup, 2 tbsp peanut butter, 2 tbsp seeds, ½ cup dry beans
Fats and oils	2 – 3 servings	1 tsp soft margarine, 1 tbsp mayonnaise, 2 tbsp salad dressing, 1 tsp vegertable oil
Sweets and added sugars	5 or fewer servings per week	1 tbsp soft margarine, 1 tbsp jelly or jam, ½ sorbet and ices, 1 cup lemonade

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1.4 Hints to lower your sodium (salt) intake

- Remove the salt shaker from the table. Instead of using salt, try using garlic, herbs and spices.
- Avoid using salt in cooking. Start by using half the normal amount, and then cut that in half again. Your taste buds will adjust!
- Use less processed foods. Choose items that are labelled "salt free" or "reduced salt" or "low in salt". Foods such as tinned foods and soups, instant pasta or rice dishes, take-away foods, canned meats and snack foods like chips are all high in salt.
- Avoid MSG, often found in Chinese foods.
- Read stomach, cold and headache medication labels, as some of these can be high in sodium.
- Read food labels and choose items low in salt.

IN SUPERMARKETS BUY LOW-SALT AND NO-ADDED-SALT FOODS
Look for the per 100g column.
Look for sodium.
Buy it if sodium is not more than 120mg/100g (in some countries 120mg/100g is printed as 0.12g/100g).

THE KEY TO AVOIDING SALT
The key to avoiding salt is to realise that most of the salt you eat comes from the supermarket and take-away foods.
For most people:

- 10% of salt occurs naturally in fresh foods.
- 15% is cooking or table salt.
- 75% is in the supermarket and take-away foods.

One teaspoon of salt = 2 000mg sodium. Most of this salt comes from processed foods we eat, not the added salt you may use at the table or in cooking.

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1.5 Food guide pyramid

Each food group provides some, but not all, of the nutrients you need. Foods in one group can't replace those in another.



Eat a variety of foods in the right balance to obtain all the nutrients AND the energy you need to achieve and maintain a healthy weight.

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1.6 Herbs – A basic guide



Herbs can be used to flavour food, instead of adding extra salt to food/ dishes. They can be used fresh or dry.

❒ Grow your own herb garden; buy plants at your supermarket or nursery and put each one in its own container on your windowsill in a sunny spot, water regularly and use cuttings in food.
❒ Freeze whole herbs in plastic bags; you don't need to thaw them, simply cut off as much as you need and add to dishes.
❒ Dried herbs are more concentrated than fresh herbs; for every teaspoon of dried herbs, use one tablespoon of fresh herbs.
❒ Make your own herbal oils and vinegar; add favourite herbs and spices to olive oil or vinegar and leave to flavour, then use in salad dressings.



HERB	USE IN FOOD/RECIPIES
Basil	All tomato dishes.
Bay	Soups, casseroles, stews, rice.
Borage	Add to salads.
Chervil	Add to salads.
Chives	Add to potato, egg dishes, soups, stews.
Coriander	Add to curries, salads and sauces.
Dill	Pickles, soups, and fish dishes.
Fennel	Tastes like aniseed, add to sauces, fish.
Mint	Savoury dishes such as lamb, also desserts.
Oregano	Stuffing, pizza, soups and stews.
Parsley	Garnishes, salads, soups, stews.
Rosemary	Lamb and chicken dishes, potatoes.
Sage	Stuffing for meat, pork.
Thyme	Lamb, chicken, soup, stews etc.
Garlic	Meat, chicken, potato, pasta, soup, stews etc.

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1.7 Spices – A basic guide



- Allspice: Used in fruit cakes, mince pies and Christmas puddings.
- Anise: Used in confectionery and baking.
- Fennel: Used in curries, vegetables and bean casseroles (liquorice flavoured).
- Cayenne pepper: Used for giving heat to curries, and seasoning cheese and fish dishes.
- Chilli: Used to give heat and flavour to curries.
- Cinnamon: Ground cinnamon is used for desserts, cakes and biscuits, while cinnamon sticks are used in curries, soups and casseroles.
- Cloves: Used in baking, pickling and marinades, apple dishes, fruit punches.
- Coriander (also called dhania or cilantro): These spicy dried seeds are used in curry pastes and powders, marinades and pickling.
- Cumin (jeera): Used in cheese, bread, sauces and curries.
- Ginger: Combines well with garlic. Also used in baking, herbal teas.
- Mixed spice: Used for biscuits, puddings and cakes.
- Mustard seed: Casseroles, sauces.
- Nutmeg: Sprinkled on milk puddings, pumpkin, spinach and pasta.
- Paprika: Made from dried red pepper, it goes well with beef, chicken and fish.
- Saffron: Used with rice and fish dishes, as well as in cakes and biscuits.
- Turmeric: Often used instead of saffron to colour food yellow. Its warm and spicy taste makes it good for use in curries, pickles, chicken and fish stews.



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Recipes

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2. Healthy and refreshing summer drinks Page 34
3. Salads Page 36
4. Healthy bread and muffins Page 38
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1. Breakfast and healthy lunch box ideas

Breakfast

To get a good start to the day, breakfasy is vital. This meal will give you fuel for the day and kick start the brain into motion. Without breakfast, your concentration will dwilndle and eventually, by lunch-time, you could struggle to stay awake. Some ideas for healthy breaksfasts in the home:

- ❒ Whole-wheat breakfast cereal with chopped up fresh fruit and low-fat yoghurt.
- ❒ Whole-wheat/brown toast and cottage cheese/peanut butter.
- ❒ Scrambled egg on whole-wheat/brown toast with baked beans.
- ❒ Fruit smoothie made with low fat yoghurt and fresh fruit, sprinkled with muesli or rolled oats and chopped nuts.
- ❒ Oats or maltabella cooked porridge with low-fat milk and fresh fruit.

Healthy lunch box ideas

It is preferable to have home-packed food, as convenience and pre-prepared foods are often fairly high in fat and sugar.

The following are some suggestions for a healthy lunch box:
Sandwich, roll, crackers, pasta or pita.
Use whole-wheat or brown bread.
Some healthy toppings: cottage cheese, tuna, pilchards, mashed-up egg with low-fat mayonnaise, baked beans, peanut butter, avocado pear with lemon juice, lean chicken slices, fish paste and sliced to-mato.
Make a pasta salad with chopped up vegetables, lean chicken and some plain yoghurt.
Left-over food from supper.

Other snacks for the day

Fresh or dried fruit salad.
Vegetable sticks with some low fat cottage cheese as a dip.
Rice cake with peanut butter or jam.
Peanuts and raisins.

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2. Healthy and refreshing summer drinks

Fruit punch

Ingredients

1 litre black Rooibos tea
1 litre fresh pineapple (or granadilla) juice, unsweetened
1 pineapple (or pulp of 6 granadillas), chopped
honey to taste
mint leaves



Prepare

1. Add the fresh pineapple (or granadilla) juice to the black Rooibos tea.
2. Sweeten with a little honey if desired.
3. Add the finely chopped pineapple (or granadillas).
4. Add fresh mint leaves.
5. Put in the fridge to chill and add ice cubes before serving.

Refreshing and healthy iced tea

Ingredients

1 – 2 litres Rooibos tea OR other herbal teas
1 lemon, sliced
honey or artificial sweetener



Prepare

1. Sweeten the rooibos tea with honey or artificial sweetener to taste.
2. Add slices of lemon.
3. Put in fridge and drink ice cold.

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Fruity herbal cup

Ingredients

2 litres of boiling water
4 cups mint
1 cup lavender flowers
1 litre fresh, unsweetened apple juice
honey to taste



Prepare

1. Pour the boiling water over the mint leaves and the lavender flowers.
2. Leave to stand overnight.
3. Next day pour off through a strainer and add the apple juice.
4. Sweeten with honey.
5. Refrigerate and serve with slices of lemon.

Other combinations
Rosemary and lemon juice. Lemon thyme and grape juice. Lemon grass and lemon juice.

Herbal teas

Ingredients

¼ cup fresh herbs (lavender, mint, lemon verbena, thyme etc)
1 cup boiling water



Prepare

1. Put the herbs into the boiling water.
2. Let it stand for 2-5 minutes, then strain.
3. Sweeten with honey and a squeeze of lemon juice, or drink plain, hot or cold.

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Fruity herbal cup

Ingredients

2 litres of boiling water
4 cups mint
1 cup lavender flowers
1 litre fresh, unsweetened apple juice
honey to taste



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3. Sweeten with honey and a squeeze of lemon juice, or drink plain, hot or cold.

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3. Salads

Stokvel three bean salad

Ingredients

1 x 410g tin butterbeans, drained
1 x 410g tin beans in tomato sauce
1 x 410g tin green beans, French cut, drained
15ml (1 tbsp) brown sugar
2ml (½ tsp) mustard powder
15ml (1 tbsp) canola or olive oil
100ml (2/5 cup) brown or balsamic vinegar
5ml (1 tsp) basil
½ green pepper, diced
1 onion, diced
salt and pepper to taste

Prepare

1. Mix together all the beans, diced green pepper and onion.
2. Put sugar, mustard, oil, vinegar and basil into a pot and heat until sugar has dissolved, stirring continuously.
3. Pour sauce over the beans.
4. Add salt and pepper to taste.
5. Refrigerate overnight or for at least three hours.
6. Serve cold.

(Will keep for up to two weeks in a sealed container in the fridge.)



Variation
Use lite fruit/sweet chilli chutney instead of sugar, oil and vinegar.

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Soweto salad with a twist



Ingredients

2kg beetroot, small to medium sized
1kg red onions
100ml orange juice
50ml balsamic vinegar
25ml (2 tbsp) brown sugar
25ml (2 tbsp) olive oil
pinch ground ginger
salt and pepper to taste



Prepare

1. Wash beetroot and trim, leaving 5cm of stalk. Place in boiling salted water and cook until almost done.
2. Drain, cool and roll skins off with fingers.
3. Cut onions into quarters. Cook in boiling salted water until just soft.
4. Place beetroot and onions in oven baking pan (coat pan with cooking spray).
5. Mix orange juice, vinegar, sugar, oil, ginger, salt and pepper together.
6. Pour sauce over beetroot and onion and toss together.
7. Roast in preheated oven at 180°C for 20 minutes.

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4. Healthy bread and muffins

Quick and easy wholewheat bread

Ingredients

1 cup oats
3 cups nutty wheat flour
1 ½ tsp salt
1 ½ tsp cream of tartar
1 ½ tsp bicarbonate of soda
4 tbsp honey
2 cups sour milk (*Inkomazi*)

Prepare

1.Preheat oven to 180°C.
2. Mix all the ingredients together and stir.
3. Pour mixture into a 23cm greased loaf pan.
4. Bake for one hour at 180°C.
5. Remove from pan and cool on a cooling rack.

Bran muffins

Ingredients

Note: Batter has to stand overnight
2 large eggs
1 cup soft brown sugar
4 tbsp canola oil
1 cup oat bran
1 ½ cups flour, sifted before measuring
2 cups digestive bran
½ tsp salt
1 tbsp bicarbonate of soda
1 large apple, grated
1 cup raisins
1 tsp cinnamon
2 cups plain low-fat yoghurt
1 tsp vanilla essence

Prepare

1. Beat together eggs, sugar and oil.
2. Add all dry ingredients, grated apple and raisins.
3. Mix thoroughly.
4. Mix yoghurt and vanilla and add to flour mixture.
5. Stir until well blended.
6. Leave overnight in fridge.
7. When ready to bake, stir and put spoonfuls in muffin pans.
8. Bake at 180°C for 15 minutes.
9. Cool and remove from pan.

A good idea for a healthy lunch box. Makes 24 large muffins.

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Microwave maize-meal bread

Ingredients

4 eggs
½ cup (125ml) low-fat milk
60ml (4 tbsp) sugar
1 ½ tsp baking powder
5 tsp cake flour
1 cup (250ml) coarse maize meal
1 x 410g tin creamed corn
6 tsp canola oil
salt to taste
paprika (optional)



Prepare

Spray microwave loaf pan with Spray and Cook.

1. Beat together the eggs, milk and sugar.
2. Add maize meal, cake flour, salt and baking powder.
3. Beat well.
4. Add corn and oil and mix well.
5. Pour into loaf pan.
6. Sprinkle a little paprika over (optional).
7. Put a plastic plate upside down in microwave and put the loaf pan on top.
8. Bake for 15 minutes on medium = 70% = 7.
9. Bake for four minutes on high = 100% = 9 or 10.
10. Let it stand for another 10 minutes in the microwave before serving.



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Curried pumpkin soup

Ingredients

2 cloves garlic, peeled, chopped
1 medium onion, peeled, chopped
3 large carrots, peeled and sliced
2 tbsp olive oil
500g pumpkin pieces
500ml chicken stock (homemade)
1 bay leaf
2 tsp curry powder
1 tsp turmeric
pinch of cayenne pepper
1 ½ tsp salt
freshly ground pepper
2 tbsp chopped flat-leaf parsley
1 tbsp plain low-fat yoghurt (optional)

Prepare

1.Heat 1 tbsp of the olive oil in a medium stockpot over medium heat. Add the garlic and onion and sauté, stirring occasionally, until onion is translucent, (about six minutes). Add carrots and sauté for five minutes. Add the pumpkin, chicken stock, bay leaf, curry, turmeric, cayenne, 1 tsp of the salt, and pepper to taste, and bring to a boil. Reduce heat and cook until the vegetables are tender (about eight minutes). Remove from heat and add parsley.
2.Place two cups of the cooked vegetables and about ½ cup of the liquid in a bowl and purée until smooth. Stir purée back into the soup. Adjust seasonings, and stir in the plain yoghurt, if desired.



Bean and vegetable soup

Ingredients

30ml (2 tbsp) olive oil
3 garlic cloves, chopped
1 onion, peeled and chopped
250g carrots, peeled and chopped
250g cabbage leaves, cleaned and chopped
3 large red fresh tomatoes, chopped
250ml (1 cup) each: sugar beans, butter beans, kidney beans, soaked overnight and cooked
1 x 410g tin of tomatoes in tomato sauce
30ml (2 tbsp) fresh oreganum, chopped (optional)

Prepare

1. Heat oil in a large pot.
2. Fry onion and garlic lightly.
3. Add rest of the ingredients and simmer until well cooked, thick and tasty.
4. Season with salt and pepper and serve hot.

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6. Healthy meat, chicken and fish dishes

Sweet chilli chicken

Ingredients

4 skinless chicken breasts (chopped)
1 cup butternut (chopped)
1 cup cabbage or spinach (chopped)
2 carrots (diced)
2 – 3 tomatoes (diced)
1 onion (diced)
1 sweet red pepper (diced)
1 chilli (remove pips and dice) – optional
1 – 2 garlic cloves, crushed
1 tin (410g) chickpeas (OR 1 cup dry chickpeas, soaked overnight)
1 tbsp olive oil or canola oil
30ml lemon juice
30ml tomato paste
30ml sweet chilli chutney
salt and pepper to taste

Prepare

1. Heat olive oil in a pan. Add chopped onion and chicken, and brown lightly.
2. Add all chopped vegetables and stirfry for a few minutes.
3. Add chickpeas, as well as fluid from tin OR add a little water.
4. Leave to cook for further 5 minutes.
5. Season with lemon juice, tomato paste and sweet chilli chutney.
6. Add salt and pepper to taste.
7. Serve with brown rice or samp.

Recipe by: Sandra Pretorius (Registered Dietician)

DIETICIAN'S REMARKS

❒ Choosing skinless chicken breasts and using controlled amounts of olive oil or canola oil are good ways to decrease saturated fat (bad fat) and to increase use of the more healthy polyunsaturated fats.
❒ By adding vegetables and chickpeas, the soluble fibre content is increased.
❒ Add salt to taste so you limit the salt content of the recipe.
❒ Fresh or dried herbs can also be added, eg oreganum, rosemary, thyme or basil.
❒ Use any leftovers as a healthy lunch for work or school, with an added fruit.

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Hearty beef stew

Ingredients

1.5kg topside beef, cubed
4 large carrots, peeled and diced
4 medium baby marrows

Marinade

2 onions, peeled and diced
750 ml vegetable stock
250 ml balsamic vinegar
100 ml olive oil
4-6 cloves garlic, crushed
5 bay leaves
½ tsp dried thyme
½ tsp dried oreganum
½ tsp dried parsley
salt and ground black pepper

Prepare

1. Combine all the marinade ingredients and marinate meat in a glass dish for 12 – 24 hours.
2. Coat pan with olive oil and brown meat.
3. Put meat in a cast iron pot or casserole dish.
4. Add vegetables.
5. Pour marinade over and simmer until very soft OR leave in oven at 110°C in casserole dish overnight.
6. Serve with samp and tomato salad.
7. Serves 3 – 4.

Fish cakes

Make 6 large or 12 small cakes

Ingredients

1 x 410g tin of pilchards in tomato sauce
1 onion, grated
250ml (1 cup) oats
1 egg
15ml (1 tbsp) canola oil
10ml (2 tsp) parsely, chopped

Prepare

1. Remove the fish from the sauce, flake fish and add onion, parsley and oats.
2. Mix with egg and some of the sauce until it forms a stiff mixture.
3. Make into 6 or 12 fish cakes.
4. Heat oil in a pan and fry fish cakes quickly.

Serve with potato wedges baked in the oven.

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Sweet potato casserole

Ingredients

1kg of sweet potato (finely sliced)
1 large apple, sliced
3 tomatoes, sliced
2 onions, sliced
4 rashers lean bacon
1 tsp prepared mustard
grated cheese



Prepare

1. Grease the sides of a casserole dish with a little vegetable oil.
2. Arrange layers of sweet potato, apple, tomato, onion and bacon (spread with mustard).
3. Finish with a layer of tomatoes.
4. Pour over half a cup of water, then sprinkle with grated cheese.
5. Bake at 180°C (350°F) for 1½ hours.

Grilled sweet potato salad

Ingredients

½kg of sweet potatoes (peeled, sliced)
1 tbsp vegetable oil
¼kg salad leaves (eg lettuce, rocket)
100g tomatoes, sliced
2 tbsp pumpkin seeds

Dressing:
2 tsp vinegar or lemon juice
2 tbsp vegetable oil
1 tsp honey

Prepare

1. Grill sweet potato slices until tender.
2. Put salad leaves, tomatoes and pumpkin seeds together in a dish.
3. Combine ingredients for the dressing in a small jug and whisk together with a fork.
4. Sprinkle the dressing over the salad leaves.
5. Add the hot sweet potatoes on top and serve.

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7. Healthy dips and sauces

Tomato onion gravy/sauce



Ingredients

4 – 6 tomatoes (chopped)
1 large onion (chopped)
1 – 2 garlic cloves, crushed
1 green pepper
1 tbsp olive oil
1 tsp brown sugar
salt and pepper to taste
fresh or dried basil (to taste)

Prepare

1. Heat olive oil in pan, add onion and brown lightly.
2. Add garlic and heat with onion.
3. Add green pepper and stirfry lightly.
4. Add chopped tomatoes and brown sugar and let simmer for 5 – 10 minutes.
5. Add salt and pepper to taste, and lastly add the basil.
6. Serve with stiff maize porridge or samp or pasta.

❒ Can also be used as a dip with low-fat, low-salt snacks.
❒ A healthy spread on sandwiches with cold meat or low-fat cheese.

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Hummus

Ingredients

2 cups chickpeas (cooked)
1/3 cup tahini (sesame paste)
1/4 cup lemon juice
2 garlic cloves
salt and pepper to taste

Prepare

1. Combine all the ingredients in a food processor and blend until very smooth. Add liquid as needed.
2. Taste. Add additional lemon juice, garlic, salt and pepper if desired.

Serve as dip for pita bread and veggies or serve on bread.

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Chakalaka

Ingredients

4 tbsp olive oil
1 large onion, peeled and diced
3 cloves garlic, peeled and crushed
1 large red pepper, diced
1 large yellow pepper, diced
1 large green pepper, diced
4 large carrots, peeled and grated
1 – 2 small red chillies, seeded and diced
1 x 215g tin baked beans in tomato sauce
salt and ground black pepper to taste

Prepare

1. Heat olive oil in a pan and fry onion until transparent.
2. Add garlic and cook for a few minutes.
3. Add peppers, carrots and chilli and stir fry.
4. Add the baked beans and cook for another 5 – 10 minutes.
5. Season with salt and pepper.
6. Serve with mieliepap or samp.



Low-fat yoghurt sauce/dressing

Ingredients

1 cup low-fat plain yoghurt
1 tbsp lemon juice
salt and pepper to taste



Prepare

1. Use this dressing instead of mayonnaise, to lower saturated and total fat intake in the diet.
2. Mix all the ingredients together and use as a salad dressing on green salad or on a baked potato, or on potato or pasta salad.
3. Use as a healthy sauce with cold meat or chicken.
4. Use as a dip with low-fat, low-salt snacks.

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8. Desserts

Rainbow fruit salad

Ingredients

4 oranges
2 apples, peeled and sliced
2 ripe bananas, sliced
½ medium pawpaw, sliced
½ medium pineapple, diced
6 small guavas, peeled and quartered
1 mango, peeled and diced
1 cup melon or watermelon cubes

Prepare

1. Squeeze juice from the oranges.
2. Put all the slices and diced fruit pieces into a large serving dish.
3. Pour orange juice over.
4. Serve with plain low-fat yoghurt and mint leaves OR low-fat custard.

Crunchy baked apples

Ingredients

4 large green apples
4 tbsp oats
4 tbsp chopped peanuts
4 tbsp raisins
2 tbsp brown sugar or honey
2 tbsp soft margarine
cinnamon
4 tbsp plain low-fat yoghurt



Prepare

1.Preheat oven to 180°C.
2. Core the apples and slice the bottom and the top off the apples.
3. Place the apples in a greased ovenproof dish.
4. Combine the oats, peanuts, raisins, sugar and margarine.
5. Divide the mixture evenly between the apples and scoop into each apple, pushing it down into the apple.
6. Sprinkle cinnamon over the top.
7. Bake in oven at 180°C for 20 – 30 minutes.
8. Serve warm with yoghurt or low-fat custard.

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