

The analysis of a student-led university screening and testing programme for cardiovascular disease and diabetes



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DECLARATION

I, Umara Bibi Qureshi, student number [733160], declare that this dissertation is my own work and that I contributed adequately towards research findings published in the article stated below which is included in my dissertation.

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Agreement by co-authors: By signing this declaration, the co-authors listed below agree to the use of the article by the student as part of his/her Dissertation.

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DEDICATION

In the name of Allah, The Most Gracious, The Most Merciful

To my beloved parents, Muhammad Ashraf and Zaitoon, your unwavering motivation and steadfast support have been the guiding light on this challenging journey. Your sacrifices, encouragement, and boundless belief in me have been the cornerstone of my success. May Allah reward you abundantly for your endless kindness and love.

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ABSTRACT

Non-communicable diseases (NCDs) have become the primary cause of both mortality and morbidity globally. Due to their insidious progression, regular screening and monitoring is imperative. The notable surge in these diseases may be attributed to the ongoing global and epidemiological transitions, leading to changes in people's behaviours and lifestyles. Typically, these diseases remain undetected until they manifest clinically, often leaving limited opportunity for prevention or reversal of damage. Hence, the goal is to prevent, delay the onset and treat these diseases before irreversible end-organ damage occurs.

As NCDs typically develop over decades, the presymptomatic phase is often undetected by individuals, with individuals unknowingly exacerbating their conditions through lifestyle choices, such as physical inactivity, unhealthy diets, tobacco consumption and harmful use of alcohol. The university environment, with its academic demands and stressors, often fosters these habits, thus contributing to the proliferation of NCDs.

To address this NCD epidemic, empowering students to conduct screening and health promotion initiatives within the academic environment could prove beneficial in building a health enabling environment. Providing students with opportunities to practice their clinical skills and complement their theoretical knowledge with practical experience through work-based learning initiatives could be mutually beneficial to the public and the students. Students gain valuable skills and experience, while the public receives free screening, lifestyle advice, and early detection of CVD risk factors.

This study aims to identify the occurrence of CVD related risk factors at a student-led screening event. The Wits university clinical pharmacy department initiated a work-based learning program for the fourth-year pharmacy students to improve their clinical skill set. After training in the clinical skills required to conduct Point-Of-Care Testing (POCT) services, understanding the clinical threshold values and the lifestyle advice regarding each condition, the students underwent competency assessment before participating in the screening event.

There were 767 participants in this study, with their medical histories and demographical information collected using a questionnaire, followed by relevant tests such as blood pressure, blood glucose, blood cholesterol and their anthropometric measurements. Additional tests such as the glycated haemoglobin A1c (HbA1c) test and full lipid panel testing was offered to some

participants. Following the screening, results were explained to the participants, who were then referred or offered appropriate lifestyle education. Those that were referred for CVD-related risk factors, were telephonically surveyed about their clinical findings and their interventions post-screening.

The occurrence of self-reported hypertension (6.5%), diabetes (2.09%), cholesterol (2.87%) and obesity (3.91%) were lower in comparison to the measured results. Screening results show that there were 18.25% abnormal blood pressure readings, 2.83% had hyperglycaemia, and 11.36% had high cholesterol readings. Control levels amongst participants with self-reported diagnosed conditions were suboptimal, with 56% potentially having uncontrolled hypertension, 18.75% uncontrolled diabetes, 18.18% uncontrolled cholesterol and 50% confirmed obesity. In this sample, tobacco and alcohol consumption did not significantly influence CVD risk factors. However, the age and designation were significantly ($P < 0.05$) associated with disease occurrence, while obesity was strongly associated with all demographic characteristics (gender, ethnicity, age range and designation).

Follow-up surveys revealed significant findings among 35% of the participants. Among them, three participants (43%) were diagnosed with hypertension or diabetes, two participants (29%) had uncontrolled conditions which required upscaling treatment and the remaining two participants were advised to monitor their conditions and implement lifestyle modifications to prevent disease progression.

Most participants cited reasons such as the lack of perceived need, cost, and time constraints for not pursuing routine screening. Those who utilized this service appreciated the convenience offered by a screening event held at their working and study environment. It was found that most people are unlikely to pursue screening services unless they are offered screening at their education and working environment. This highlights the importance of creating a health enabling environment, encouraging proactive health behaviours among participants.

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As I reflect, I am grateful for the role this journey has played in providing a sense of purpose and direction during a period of difficulty. The pursuit of knowledge served as a sanctuary, offering solace from life's trials. This research has been more than an academic endeavour; it has been a source of growth, and transformation.

LIST OF ABBREVIATIONS

AA	Atomic Absorption
ABPM	Ambulatory Blood Pressure Monitoring
ACC	American College of Cardiology
ADA	American Diabetes Association
AFRICOS	African Cohort Study
SAGE	Study on global AGEing and adult health
AHA	American Heart Association
AIDS	Acquired Immuno Deficiency Syndrome
ANOVA	Analysis of variance
ART	Anti-retroviral therapy
BMI	Body Mass Index
BP	Blood pressure
CDC	Centres for Disease Control and Prevention
CVD	Cardiovascular disease
CVJA	Cardiovascular Journal of Africa
DALY	Disability Adjusted Life Years
DASH	Dietary Approaches to Stop Hypertension
DBP	Diastolic Blood Pressure
DCCT	Diabetes Control and Complications Trial
DM	Diabetes mellitus
DTG	Dolutegravir
DYSIS	Dyslipidaemia International Study
EML	Essential Medicines Lists
ESC	European Society of Cardiology
FBG	Full Blood Glucose
FOSCE	Formative Objective Structural Clinical Examination
GBD	Global Burden of Disease
GDP	Gross Domestic Product
GPP	Good Pharmacy Practice
HAALSI	Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa
HBPM	Home Blood Pressure Monitoring
HDL-C	High-Density Lipoprotein Cholesterol
HIV	Human Immunodeficiency Virus
HPU	Health Promoting Universities
HSFSA	Heart and Stroke Foundation of South Africa
ICP	Inductively Coupled Plasma
IDF	International Diabetes Federation
IHD	Ischaemic Heart Disease
INSTI	Integrase Strand Transfer Inhibitors
ISH	International Society of Hypertension

IVD	<i>in vitro</i> diagnostics
KAU	King Abdul Aziz University
KSA	Kingdom of Saudi Arabia
LDL-C	Low-Density Lipoprotein Cholesterol
LMIC	Low-and Middle- Income Countries
MMM	May Measurement Month
NBD	National Burden of Disease
NCD	Non-Communicable Disease
NDoH	National Department of Health
NDP	National Drug Policy
NGSP	National Glycohemoglobin Standardization Program
OBPM	Office Blood Pressure Monitoring
OGTT	Oral Glucose Tolerance Test
PHC	Primary Health Care
POCT	Point-Of-Care Testing
RBG	Random Blood Glucose
SA	South Africa
SADHS	South African Demographic and Health Survey
SAHPRA	South African Health Products Regulatory Authority
SBP	Systolic Blood Pressure
SEMDSA	Society for Endocrinology, Metabolism and Diabetes
SSB	Sugar Sweetened Beverages
STEPPS	Screening and Testing Programme for Pharmacy Students
STG	Standard Treatment Guidelines
TB	Tuberculosis
TC	Total Cholesterol
TG	Triglycerides
UK	United Kingdom
USA	United States of America
UWC	University of Western Cape
WBL	Work-Based Learning
WC	Waist Circumference
WHF	World Health Federation
WHO	World Health Organization
WHR	Waist to Hip Ratio

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DISSERTATION STRUCTURE

A dissertation by publication was undertaken and comprises of the following chapters:

- Chapter One introduces the study and explains the design
- Chapter Two provides a literature review
- Chapter Three provides the publication entitled “Identification and follow-up of participants with CVD risk factors at a pharmacy-student-led screening and testing programme”
- Chapter Four concludes the study.

CHAPTER 1: Introduction

1.1 Non-communicable diseases

Non-communicable diseases (NCDs) have been recognized as the leading cause of death worldwide (Lopes Ibanez-Gonzalez *et al.*, 2014; Nojilana *et al.*, 2016; Samodien *et al.*, 2021). According to the World Health Organization (WHO), 74% of all deaths are caused by NCDs, of which 77% occur in low-and middle- income countries (LMIC) (WHO, 2022b). Previously, NCDs were more common in developed nations; however, research indicates that NCDs are also increasingly prevalent in developing nations (Mayosi *et al.*, 2009; Stern *et al.*, 2010; Lopes Ibanez-Gonzalez *et al.*, 2014; Roomaney *et al.*, 2020). The epidemic of NCDs in LMIC has been attributed to the epidemiological transition occurring in these nations (Mayosi *et al.*, 2009; Stern *et al.*, 2010; Nojilana and Pillay-van Wyk, 2017; Wilson *et al.*, 2020).

Globally, mortality and morbidity due to NCDs pose a major health challenge, initiating a resolution in 2011, to control and prevent NCDs (WHO, 2018b). To address this health challenge, the WHO developed the WHO Global Action Plan for the Prevention and Control of NCDs 2013–2020 (Global NCD Action Plan) (WHO, 2018b). This plan aims to curtail the NCD-related mortality by 25%, while also targeting the reduction of modifiable and metabolic NCD risk factors (WHO, 2018b). Disability Adjusted Life Years (DALY) describe the mortality and morbidity to effectively evaluate disease burden (Roser *et al.*, 2016). One DALY represents the loss of one year of good health due to premature death or disease-related disability (Roser *et al.*, 2016). Findings from the Global Burden of Disease (GBD) study indicate that non-communicable diseases (NCDs) account for the greatest percentage (63.84%) of DALYs lost in 2019 (Roser *et al.*, 2016).

Increased urbanization and globalization have resulted in a change in the lifestyle and behaviour of the population, affecting disease patterns (Stern *et al.*, 2010; Wagner and Brath, 2011). The misconception that the burden of disease in sub-Saharan Africa is largely due to communicable diseases is refuted by Mayosi *et al.* (2009). South Africa is currently struggling with a quadruple burden of disease i.e. non-communicable, communicable, perinatal and maternal, and injury-related (Van Straten *et al.*, 2017). The WHO estimates that by 2030, NCDs will be the leading cause of death in sub-Saharan Africa (Nojilana *et al.*, 2016). This is further established by the 2nd

South African National Burden of Disease study which demonstrated that NCDs accounted for 43.4% of all deaths in 2012, greater than the combined mortality from Human immunodeficiency virus/Acquired immunodeficiency syndrome (HIV/AIDS) and Tuberculosis (TB) at 33.6% (Nojilana and Pillay-van Wyk, 2017). This is especially concerning since NCDs in LMIC impact the population differently than in developed nations, where about 30% of deaths occur before the age of 60 as opposed to 13% in developed nations (Wagner and Brath, 2011; Nojilana *et al.*, 2016). Furthermore, the WHO has placed the severity of the burden two to three times higher in LMIC than in developed nations (Mayosi *et al.*, 2009).

The South African National Department of Health (NDoH) describes NCDs as chronic illnesses that are non-infectious (NDoH, 2020). Genetic, physiological, socio-environmental (poverty and rapid urbanization), and behavioural risk factors have been identified as contributing factors to the development of NCDs (Samodien *et al.*, 2021). The most prevalent NCDs that South Africa is currently combating are cardiovascular disease, cancer, diabetes mellitus (DM), obesity, respiratory illnesses, and mental health disorders (Kluge *et al.*, 2020; Samodien *et al.*, 2021). In South Africa, the cumulative loss of gross domestic product (GDP) between 2006 and 2015 from stroke, diabetes, and coronary heart disease is estimated to cost ZAR 28.88 billion (USD 1.88 billion) (Hofman, 2014; Hunter-Adams and Battersby, 2020).

It is essential to have a healthy population for the sustainable economic growth of a country. Chand *et al.* (2020) explains that NCDs have a detrimental effect on the economy by depleting the labour force and the capital of a country. Decreased productivity, absenteeism, and early retirement due to poor health caused mainly by NCDs led to an estimated loss of 6.7% of GDP in 2015 and this is predicted to increase by 2030 (NDoH, 2020). Investing in the prevention and control of NCDs may prove to be cost-effective and result in improved health outcomes (Hofman, 2014; NDoH, 2020).

The NDoH has adopted the cost-effective interventions known as the “Best Buys” suggested by the WHO (2020) in the Global Action Plan to target NCDs (NDoH, 2020). As there are multiple factors contributing to the cause of NCDs, the NDoH deems it necessary to adopt a multi-sectoral approach with a “whole-of-government” and “whole-of-society” attitude toward NCD morbidity

and mortality (NDoH, 2020). There is consensus that urgent and effective interventions are required to target the prevention and treatment of all NCDs at all levels of healthcare (Nyaaba *et al.*, 2017; Gouda *et al.*, 2019; NDoH, 2020). Malcolm *et al.* (2019) explains that innovative methods for efficient screening and diagnosis, such as Point-Of-Care Testing (POCT) are required, to screen for NCDs and the management of risk factors by 2030 to meet the target of 2030 Agenda Sustainable Development.

1.2 Point-Of-Care Testing (POCT)

Point-Of-Care Testing (POCT), conducted at or near the site of patient care, is crucial in the diagnosis and management of NCDs by measuring critical biochemical markers that define disease prevalence (Malcolm *et al.*, 2019; Jalavu *et al.*, 2020). The aim of POCT for NCDs is to provide accurate information timeously on the patient's medical condition, screen to identify underlying risk factors, regulate management, and improve the quality of care (Klug *et al.*, 2018; Jalavu *et al.*, 2020). This is especially convenient for patients as it consolidates the test-and-treat cycle into a single patient encounter (Engel *et al.*, 2015). Moreover, the portability and ease of use of the POCT devices make them viable in resource-limited settings, thereby improving the accessibility of screening services (Motta *et al.*, 2017; Malcolm *et al.*, 2019). Furthermore, an example of improved accessibility to POCT screening services is the strategic integration of a student-directed community cardiovascular disease (CVD) screening programme into community gatherings (Crump *et al.*, 2021). Besides improved accessibility and convenience, Hess *et al.* (2012) reported substantial improvements in participants' comprehension of healthy parameters for total cholesterol, blood pressure, blood glucose, and body mass index (BMI) following participation in a pharmacist- and student-led health screening and educational program. The program assessed participants' knowledge of specific diseases both before and after the screenings, revealing marked enhancements in their understanding.

1.3 Health promotion initiatives and disease prevention

Although there have been increased efforts to identify and target the social determinants of NCDs (Stern *et al.*, 2010; Lopes Ibanez-Gonzalez *et al.*, 2014; WHO, 2018b), McQueen (2013) argues that there are ideological challenges that are overlooked and identifies health promotion to be an important component of public health as it is based on the principles of justice, equity, and health

as a fundamental right. Health promotion refers to the steps taken to help people manage and improve health, enabling them to choose healthy behaviours (Ahlstrand *et al.*, 2022).

Determining the burden of non-communicable diseases is crucial to the growth and functioning of a country (Hofman, 2014; Freeman *et al.*, 2020). It is essential to prevent and delay the onset of NCDs in high-risk individuals to reduce the burden of NCDs by providing prompt treatment and lifestyle recommendations (Juchli *et al.*, 2021a). This is reinforced by the idea that prevention is more efficient and cost-effective compared to treatment (Hofman, 2014; Nojilana *et al.*, 2016). Freudenberg (2007) advocates for universities to be more proactive in the prevention of NCDs by involving students in a range of initiatives, including health promotion and research. The population in a university setting consists of both the working population and tertiary-level students from different socioeconomic and cultural backgrounds (Schouw *et al.*, 2018). Suárez-Reyes and Van den Broucke (2016) believe that these individuals may have or will have significant roles in different societies; therefore, the habits, perspectives, and attitudes they hold will influence society.

Contrary to the common assumption, which holds that NCDs exclusively affect older age groups, research reveals that in LMIC, the younger population is not immune to them (Wagner and Brath, 2011; Nojilana *et al.*, 2016; Schouw *et al.*, 2018; Kamkuemah *et al.*, 2020). Tafireyi and Grace (2022) report that students at the university level lead unhealthy and sedentary lifestyles. Considering all these facts, researchers suggest that the conduction of health promotion and screening initiatives be targeted at younger age groups (Dadlani *et al.*, 2013; Kamkuemah *et al.*, 2020). Kamkuemah *et al.* (2020) reasons that most of the NCDs' risky behaviours are adopted during adolescence and youth; hence, promoting the development of healthy behaviours during this period is crucial, as these habits are more likely to persist into adulthood. Similarly, Dadlani *et al.* (2013) emphasize that CVD risk factors may be identified as early as adolescence, which may be managed before CVD develops in adulthood.

With the aid of POCT, screening aims to detect abnormal biochemical parameters that may be indicative of NCDs while also facilitating the monitoring and assessment of disease management (Malcolm *et al.*, 2019; Jalavu *et al.*, 2020). Within screening programmes, pharmacists assume an

essential role by providing POCT services, interpreting test results, educating the participants about the health status and referring them for further care (Hess *et al.*, 2012). This is noteworthy as Zolezzi *et al.* (2016) explain that pharmacists are transitioning into more direct patient care roles where they are expected to perform a physical examination and utilise POCT devices for health screening.

Accredited bodies of Pharmacy schools from the UK, Canada, and the USA have recommended the attainment of clinical skills through Work-Based Learning (WBL) and community outreach programs (Kehrer and James, 2016; Nazar *et al.*, 2021). Furthermore, screening programmes providing POCT is a method of training student pharmacists to apply concepts from the classroom to real-life situations (Hess *et al.*, 2012). Thus, these healthcare promotion and screening initiatives may be used to supplement academic training, bridging healthcare gaps by extending services to marginalized communities (Banack *et al.*, 2012; Bastianelli *et al.*, 2017). Remarkably, the public's response to these community outreach events has been predominantly positive, underscoring the acceptance and value within underserved populations (Bastianelli *et al.*, 2017).

The clinical pharmacy division of University of the Witwatersrand, Department of Pharmacy and Pharmacology has a preventative health screening and education programme as part of the WBL initiative called the *Screening and Testing Programme for Pharmacy Students* (STEPPS). This programme was established in 2017, where fourth year pharmacy students are taught how to screen for chronic conditions, using POCT devices. A range of tests and assessments are offered including obesity measurement, blood pressure, blood cholesterol, and blood glucose measurements.

The STEPPS event as depicted in Figure 1, is advertised throughout the university campus inviting all the University of the Witwatersrand staff and students to an opportunity to screen for NCDs. The screening sessions are conducted at the Main (Solomon Mahlangu House), Education (Bohlaneng Concourse), and Health Sciences campuses of the University of the Witwatersrand (Wits) in Johannesburg.

Fourth-year pharmacy students are provided intensive and comprehensive training on screening and the equipment used. After training, students are assessed using a summative theory test and

then a formative objective structural clinical examination (FOSCE) to determine the students' competence. Any student not successful in meeting the competence requirements, must reattempt the FOSCE following a revision session. The students are facilitated and observed by the Wits Pharmacy department lecturers at each of the STEPPS sessions to ensure the reliability of the results and technique.

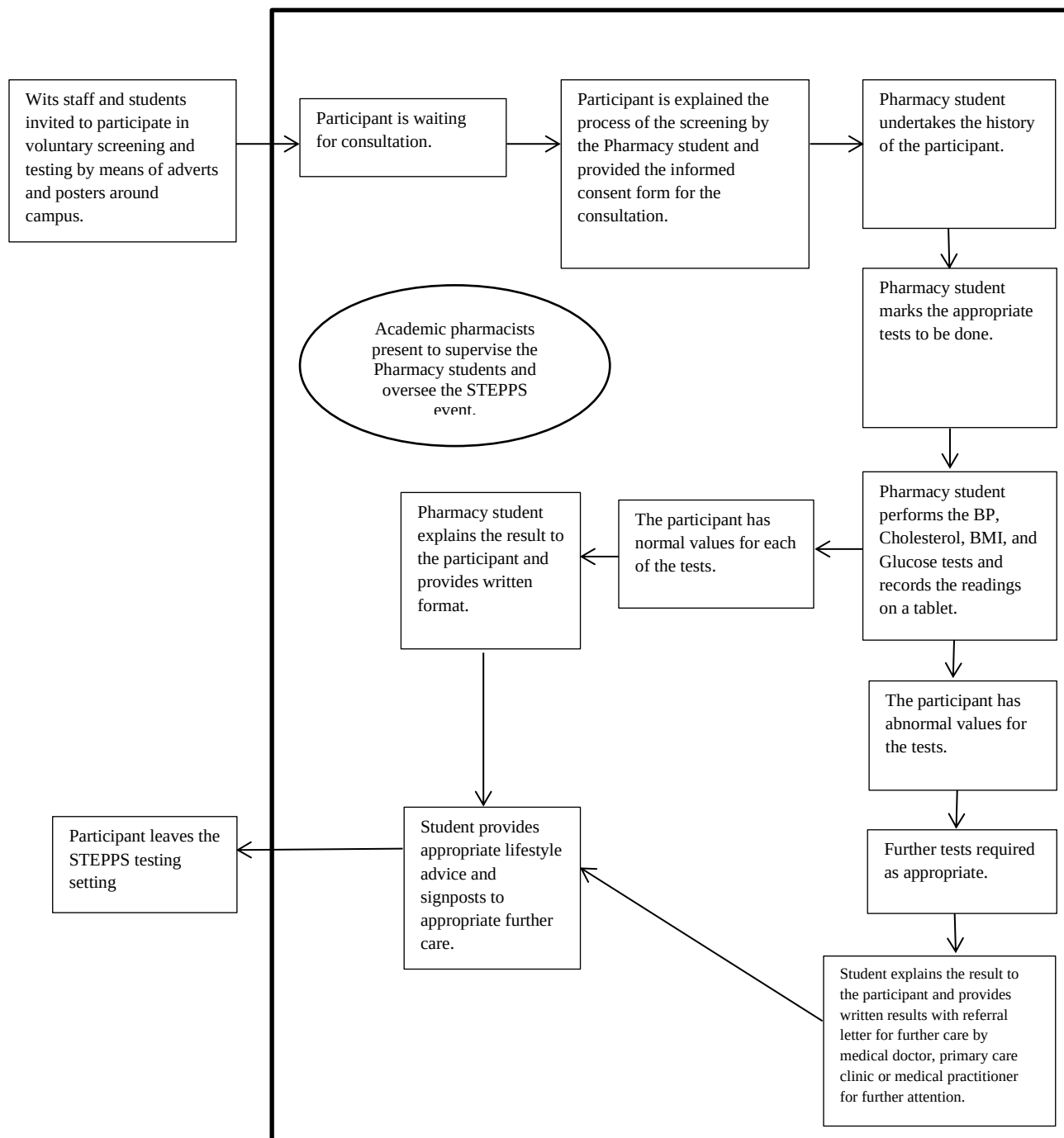


Figure 1: STEPPS screening and testing event

On the screening day event, participants are informed about the procedure of the screening and once the participant grants consent, the consultation process may begin. The student will conduct the screening and take the history of the participant; this determines the types of tests that are relevant and specific to each participant. The student will advise and encourage the participant on the baseline tests: blood pressure, blood glucose, and blood cholesterol. They will then be directed for the relevant tests. The necessary weight and height measurements are completed for the BMI calculations. Based on the results of the tests and the initial screening, the participant may be directed for further tests. If the results are in the normal range, the results are explained to the participant along with the necessary lifestyle advice. Participants with abnormal test results for total cholesterol are provided the full lipid panel test. Similarly, participants with abnormal test results for blood glucose and diabetic risk factors are provided the haemoglobin A1c (HbA1c) test. Findings outside of the normal criteria are discussed with participants and they are provided with referral letters, to either the university medical doctor, a primary care clinic or preferred medical practitioner, for further investigation. The participants are given appropriate lifestyle advice by the pharmacy students before being directed to the selected further care facility/practitioner. The entire process is conducted under the supervision of academic pharmacists/ lecturers. The study operator conducts follow-up calls on the referred participants to ensure the continuity of the care process. The follow-up process involves a telephonic survey to determine the effectiveness of the screening event and to determine if the participant made any health-enabling decision since the STEPPS screening event.

Initiatives like the STEPPS screening events will foster a more health-conscious environment by enabling students and staff to monitor health status on the university campus without having to take undue time away from work or studies, which would be more convenient. This inculcates the idea of health promotion and wellness instead of visiting a clinic only when sick.

1.4 Problem statement

Non-communicable diseases arise from a complex interplay of multiple factors, necessitating a comprehensive exploration of all potential factors contributing to their development (NDoH, 2020). Unlike infectious diseases, where targeted identification and treatment of causative agents is feasible, NCDs progress insidiously over the years without any evident symptoms, leaving

individuals unaware of the condition until a significant event leads to the detection of the disease. At this point, significant damage may have already occurred to the body decreasing the chances of averting life-threatening complications. This highlights the need for early detection of CVD risk factors to facilitate the implementation of lifestyle modifications and initiate appropriate pharmacological therapy.

The benefits of screening and testing services in clinical settings have been established and supported by research; however, there is limited structured research on the benefits of such screening sessions in non-clinical settings. It has been suggested that student-led screening sessions conducted in non-clinical or academic environment are advantageous to both the students and the public; however, evidence of patient outcomes from such screening sessions is limited and the effectiveness of such sessions on the patient outcomes has not been quantified. It is worthwhile to target the student population as risky behaviours linked to CVD are usually adopted during the earlier life stages (Kamkuemah *et al.*, 2020). This study intends to determine the impact of the STEPPS screening sessions in an academic environment by examining the occurrence of NCD risk factors and investigating the subsequent health choices of the participants.

1.5 Research question

What is the occurrence of cardiovascular diseases identified at the STEPPS screening events during 2022, and does a university-based screening programme have an impact on the health intervention of referred patients?

1.6 Aims and objectives of the study

Aim

The purpose of this study was to identify the occurrence of underlying or uncontrolled cardiovascular diseases from a convenience sample of participants who attended the STEPPS screening events at the University of the Witwatersrand for the year 2022. The study then determined whether the referral of the identified patients led to a diagnosis and intervention.

Objectives

1. To determine the occurrence of abnormal readings of blood cholesterol, blood pressure, and blood glucose in the sample population.
2. To determine the occurrence of the abnormal readings of blood pressure, blood glucose, and cholesterol from the 2022 reviewed data in participants using tobacco and alcohol.
3. To determine the co-occurrence of abnormal results with and without a previous diagnosis.
4. To identify any correlations between demographics and cardiovascular disease occurrence.
5. To establish the proportion of referred participants that sought further care.
6. To determine whether participation in the STEPPs programme led to a diagnosis and/or an intervention.

This study seeks to establish the occurrence of CVD risk factors, explore the demographical correlations, ensure appropriate referral and follow-up procedures and to examine the factors that may potentially influence an individual's CVD risk profile. It explores the influence an individual has in enhancing one's health, alongside the pivotal role the governmental policies and the healthcare sector play in shaping the population health and behaviours. Moreover, it advocates the notion of empowering students to conduct screening events, offering a mutually beneficial approach for both the public and the students, while potentially contributing to early detection efforts and community health education.

Chapter 2: Literature review

2.1 Trends of non-communicable diseases and their risk factors in South Africa

Globally, disease patterns have changed, with a distinct decline seen in communicable diseases whereas NCDs are now accountable for the majority of the deaths (WHO, 2023a). However, within the South African context, although there has been a drastic increase in NCD cases, communicable diseases persist as the leading cause of death (Mayosi *et al.*, 2009; WHO, 2020a). Cardiovascular disease and diabetes are among the leading causes of NCD-related deaths, accounting for two-thirds of all global mortality (Lopes Ibanez-Gonzalez *et al.*, 2014; Nojilana *et al.*, 2016; Hopkins *et al.*, 2021).

2.2 Cardiovascular disease (CVD)

The WHO describes CVDs as a group of disorders of the heart and blood vessels commonly caused by the accumulation of fatty deposits on the inner walls of the blood vessels that supply the heart or brain (WHO, 2021a). They include cerebrovascular disease, coronary heart disease, and peripheral arterial disease (WHO, 2021a). The World Health Federation (WHF) reports that CVDs including, ischaemic heart disease and stroke, account for approximately 33% of all fatalities worldwide (WHF, 2023b).

Ischaemic Heart Disease (IHD), the most prevalent form of heart disease, develops when the arteries become hardened and narrowed due to Atherosclerosis - a condition characterised by the accumulation of fatty substances within the arteries - resulting in ischaemia, insufficient supply of oxygen-rich blood to an organ or tissue (HSFSA, 2023b; WHF, 2023a). This progression increases the risk of a potential blockage in the blood supply to either the heart or the brain, leading to the deprivation of oxygen and essential nutrients, which may ultimately cause a myocardial infarction (heart attack) or a stroke, respectively (WHF, 2023a). The findings of the GBD reveal an estimated 197 million prevalent cases of IHD followed by 101 million prevalent stroke survivors (Roth *et al.*, 2020). Notably, IHD accounts for a loss of 182 million DALYs, highlighting the substantial burden imposed by this condition, while stroke contributes 143 million DALYs lost to the global health burden (Roth *et al.*, 2020).

These diseases may not present any symptoms indicating underlying disease, however, may result in an acute event such as a stroke or a heart attack (WHO, 2021a). Cardiovascular disease risk factors may be categorized into non-modifiable risk factors such as genetic risk factors and modifiable risk factors including behavioural, metabolic, and environmental risk factors (WHF, 2023b). Pioneering studies such as the Framingham Heart Study have identified major risk factors influencing the development of CVD, which later served as the basis of the creation of multivariable 10-year and 30-year risk prediction algorithms and further research (Andersson *et al.*, 2019). Similarly, additional studies such as the INTERHEART study and the SCORE-Project of the European Society of Cardiology (ESC) have been instrumental in determining CVD risk factors across diverse populations and creating risk assessment tools for screening purposes (Juchli *et al.*, 2021b; Teo and Rafiq, 2021). These collective studies have identified common modifiable CVD risk factors, including diabetes, hypertension, dyslipidaemia, obesity, tobacco consumption, unhealthy diet, and a sedentary lifestyle (Teo and Rafiq, 2021).

2.3 Non-modifiable risk factors

Genetic factors

Increasing age, sex, family history, and ethnicity are considered to be non-modifiable risk factors associated with cardiovascular disease and diabetes (Huma *et al.*, 2012; International Diabetes Federation, 2021). An age greater than 65 years increases the chances of heart disease (Huma *et al.*, 2012). In terms of sex, men have higher chances of heart disease compared to women; however, metabolic risk factors such as obesity are more likely to affect women (Mayosi *et al.*, 2009; Huma *et al.*, 2012). There is an increased risk of CVDs if there is a family history of heart disease before the age of 55 years for male relatives and 65 years for female relatives (Huma *et al.*, 2012).

South Africa has a diverse population with a variety of ethnicities, which presents different risk factors (Samodien *et al.*, 2021). There has been evidence of a very high prevalence of protective HDL cholesterol in over 80% of the black African population which may have resulted in a low prevalence of ischaemic heart disease in the population (Mayosi *et al.*, 2009; Nojilana and Pillay-van Wyk, 2017). Similarly, obesity in black women is found to be less harmful when compared to

obesity in white women (Kruger *et al.*, 2001). In contrast, the South Asian (Indian) population has an unfavourable predisposition as they are found to be more insulin resistant compared to other ethnic groups, thus increasing the risk of diabetes mellitus type 2 and ischaemic heart disease (Mayosi *et al.*, 2009; Nojilana and Pillay-van Wyk, 2017).

Although genetic factors influence the development of NCDs, some conditions will develop regardless of personal behaviours and the environment that moulds these behaviours (NDoH, 2020). It is crucial to target modifiable risk factors, such as behavioural risk factors which are physical inactivity, unhealthy diet, tobacco use, and harmful use of alcohol (WHO, 2018b; Kluge *et al.*, 2020), and metabolic risk factors which are raised blood cholesterol, raised blood pressure, raised blood glucose, and obesity (WHO, 2018b). The interplay between behavioural and metabolic risk factors is significant, often leading from behavioural to metabolic factors, consequently contributing to the development of major NCDs (Wagner and Brath, 2011; WHO, 2018b). Recognizing the importance of preventative measures, the South African guidelines prioritize NCDs prevention through the implementation of lifestyle modifications (Stern *et al.*, 2010).

2.4 Metabolic risk factors

The metabolic risk factors contributing to the development of NCDs which will be discussed are diabetes, hypertension, dyslipidaemia, and obesity. Ntusi *et al.* (2019) mentions that many South Africans who are diagnosed with these conditions are unaware of the disease and its subsequent complications. Furthermore, few individuals undertake the appropriate lifestyle or pharmacological interventions to treat or manage the disease (Ntusi *et al.*, 2019). Lopes Ibanez-Gonzalez *et al.* (2014) attributes the low healthcare utilization due to poor trust in formal healthcare services, misconceptions, and lack of information about NCDs.

Diabetes

Diabetes mellitus is a chronic metabolic disease where the pancreas fails to produce sufficient insulin due to autoimmune destruction of the β -cell of the pancreatic islets of Langerhans (Type 1) or there is a non-autoimmune progressive loss of insulin secretion by the β -cells of the pancreatic islets of Langerhans, usually accompanied by insulin resistance and metabolic syndrome (Type 2),

resulting in elevated blood glucose levels or hyperglycaemia (American Diabetes Association, 2023).

Diabetes is diagnosed based on the plasma glucose levels (Table 1), either the fasting plasma glucose value (no caloric intake for at least eight hours), the 2-h plasma glucose value during a 75-g oral glucose tolerance test (OGTT), or the HbA1c (American Diabetes Association, 2023). The diagnostic criteria for diabetes as defined by the Society for Endocrinology, Metabolism and Diabetes (SEMDSA) is the presence of any one of the following: fasting plasma glucose ≥ 7 mmol/L, a glycated haemoglobin A1c test with a level $\geq 6.5\%$, or a 2-hour post-load glucose (OGTT) ≥ 11.1 mmol/L. For patients presenting with hyperglycaemic symptoms (polyuria, polydipsia, blurred vision, weight loss) or diabetic ketoacidosis, any one of the mentioned tests or the random plasma glucose ≥ 11.1 mmol/L are sufficient for diagnosis. However, for asymptomatic individuals, the tests need to be repeated on separate days within two weeks (SEMDSA, 2017).

Table 1: Criteria for diagnosis of diabetes

Indicator	Range
Fasting plasma glucose (No caloric intake for at least 8 hours)*	≥ 7.0 mmol/L
2-hour post-load glucose during OGTT* The test should be performed as described by WHO, using a glucose load containing the equivalent of 75 g anhydrous glucose dissolved in water.	≥ 11.1 mmol/L
HbA1c* The test should be performed in a laboratory using a method that is NGSP certified and standardized to the DCCT assay.	$\geq 6.5\%$
Random plasma glucose along with symptoms of hyperglycaemia and diabetic ketoacidosis	≥ 11.1 mmol/L
DCCT – Diabetes Control and Complications Trial NGSP - National Glycohemoglobin Standardization Program *In asymptomatic individuals any one of these tests need to be repeated within 2 weeks Table adapted from SEMDSA (2017) and (American Diabetes Association, 2023)	

Hyperglycaemia results in the damage of the nerve and blood vessels leading to micro-vascular (retinopathy, nephropathy, and neuropathy) and macro-vascular complications (coronary artery disease, peripheral arterial disease, and stroke) (Fowler, 2008; Aikaeli *et al.*, 2022). These complications, encompassing both micro-vascular and macro-vascular issues, are the primary contributors to morbidity and mortality among individuals with diabetes (Fowler, 2008; Aikaeli *et al.*, 2022). Notably, diabetes significantly contributes to visual impairment and blindness in developed nations, necessitating two to three times more healthcare resources for diabetic individuals compared to those without diabetes (Wagner and Brath, 2011). Duro *et al.* (2023) mentions that LMIC aren't immune to these complications as visual impairment is increasing and diabetes – induced blindness is the third most common cause of blindness after cataracts and glaucoma in South Africa. Additionally, Erzse *et al.* (2019) quantifies the economic burden, estimating that patients with diabetes-induced blindness incur an estimated annual cost of ZAR 12 120 (USD 662) per disabled individual.

The global prevalence of diabetes is on the rise, evident in the escalating rates over the years as highlighted in various studies (Pheiffer *et al.*, 2018; Erzse *et al.*, 2019; Hirst *et al.*, 2021). Currently, 9.3% of the total global population (734 million) is diagnosed with diabetes (Sifunda *et al.*, 2023). The WHO has established that the number of people with diabetes has nearly quadrupled from 1980 to 2014 (WHO, 2018b). In comparison, the International Diabetes Federation (IDF) reports the prevalence of diabetes in South Africa as 10.8% (International Diabetes Federation, 2021), which has almost doubled since the year 2000 when the prevalence was reported as 5.5% (Pheiffer *et al.*, 2018). This substantial increase underscores its standing as the second most common NCD following CVD in South Africa (Hirst *et al.*, 2021).

This escalation is a cause of concern as it fails to account for the undiagnosed population, which the International Diabetes Federation (2021) estimated at 53.6% in Africa. Approximately 90-95% of the population with diabetes have diabetes mellitus type 2 (Wagner and Brath, 2011; WHO, 2021b; Aikaeli *et al.*, 2022) which is mainly due to excess body weight (approximately 90%) (Wagner and Brath, 2011; Pheiffer *et al.*, 2018) and physical inactivity (WHO, 2021b). Addressing the factors contributing to the development of NCDs is a critical step in preventing the diseases.

Hypertension

Hypertension, or raised blood pressure, is a condition in which the force exerted by circulating blood against the walls of the arteries is elevated (WHO, 2021c). The European Society of Cardiology (ESC) has defined both office and out-of-office diagnostic criteria for monitoring blood pressure (Williams *et al.*, 2018). The ESC defines hypertension office blood pressure monitoring (OBPM) as systolic and/or diastolic blood pressure $\geq 140/90$ mmHG (Table 2). Out-of-office blood pressure measurement refers to the home blood pressure monitoring (HBPM) and ambulatory blood pressure monitoring (ABPM) systems (Williams *et al.*, 2018). Compared to the OBPM, both the HBPM and the ABPM are on average lower, hence, the diagnostic threshold for hypertension is $\geq 130/80$ mmHG (Williams *et al.*, 2018). This is similar to the American College of Cardiology/American Heart Association (ACC/AHA) which classifies Hypertension stage 1 in the range ≥ 130 -139 mmHG systolic and ≥ 80 -89 mmHG diastolic (Whelton *et al.*, 2022). Although, the diagnostic criteria differ for hypertension, both guidelines recommend lifestyle modification and the addition of an antihypertensive drug only in high risk patients with CVD or increased risk profile when the average hypertension falls in the range 130-139 mmHG systolic and/or 80-89 mmHG diastolic (Whelton *et al.*, 2022).

Table 2: Diagnostic criteria for Blood pressure according to ESC (Office and Out-of-office) and AHA/ACC

Category	Systolic blood pressure, mmHG		Diastolic blood pressure, mmHG
ESC Office BP	≥ 140	and/or	≥ 90
ESC Ambulatory BP	≥ 130 -139	and/or	≥ 80 -89
Daytime (or awake) mean	≥ 135	and/or	≥ 85
Night-time (or asleep) mean	≥ 120	and/or	≥ 70
24 h mean	≥ 130	and/or	≥ 80
Home BP mean	≥ 135	and/or	≥ 85
ACC/AHA	≥ 130 -139	and/or	≥ 80 -89
Table adapted from Whelton <i>et al.</i> (2022)			

Hypertension is a major risk factor for coronary heart disease, chronic kidney disease, and ischaemic and haemorrhagic stroke (WHO, 2018b). Recent WHO prevalence data states that there are about 1.8 billion people diagnosed with hypertension globally (WHO, 2022a). Furthermore, hypertension complications are responsible for 9.4 million deaths (WHO, 2013). A study conducted across six countries - China (N=13,157), Ghana (N=4,305), India (N=6,560), Mexico (N=2,318), the Russian Federation (N=3,938) and South Africa (N=3,836) - based on the findings of SAGE (Study on global AGEing and adult health) wave 1, revealed South Africa to exhibit the highest prevalence of hypertension among these countries (Wu *et al.*, 2015). Notably, people living with hypertension typically do not present with symptoms, hence, the disease is known as a silent killer (WHO, 2013). People need to be aware of blood pressure readings to prevent life-threatening complications such as CVD events, kidney failure and stroke (WHO, 2013). A cross-sectional study determining the prevalence of uncontrolled hypertension among South African adult hypertensive residents of Mkhondo municipality in the Mpumalanga Province, found that the overall prevalence of uncontrolled hypertension was 56.83%, the author attributes the high prevalence to the non-adherence to treatment and occurrences of obesity, and dyslipidaemia (Masilela *et al.*, 2020). Berek *et al.* (2021) notes that in LMIC, individuals often forgo treatment for hypertension due to its unaffordability. Consequently, they incur higher costs associated with hospitalization and care for hypertension-related complications.

Dyslipidaemia

Dyslipidaemia, a major risk factor for CVD, is described as abnormalities of serum lipid levels that indicate an increased risk of cardiovascular events (Reiger *et al.*, 2017). Abnormal serum lipid values are defined as total cholesterol > 5.0 mmol/L, LDL-cholesterol >3.0 mmol/L, HDL-cholesterol <1.2 mmol/L, and triglycerides >1.7 mmol/L (Reiger *et al.*, 2017). Based on findings from the Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa (HAALSI) study, a study aimed to assess the prevalence, awareness, control and treatment in rural South Africa, Reiger *et al.* (2017) revealed concerning statistics. Despite 67.3% of participants meeting the criteria for dyslipidaemia, only 1.05% of those with dyslipidaemia were aware of the condition, and only 0.73% of them were on treatment, emphasizing the need for screening and education on dyslipidaemia within the population (Reiger *et al.*, 2017). Klug *et al.*

(2018) recommends the use of POCT for cholesterol screening and cautions that the generalized statin therapy is insufficient to reduce low-density lipoprotein cholesterol (LDL-C) in many patients in South Africa. This is supported by the findings of the Dyslipidaemia International Study (DYSIS) report, an observational study of lipid control, where South African patients did not achieve desired lipid levels despite statin therapy (Ntusi, 2018).

High cholesterol levels increases the chances of developing atherosclerotic diseases due to the accumulation of cholesterol esters in the arteries resulting in an atherosclerotic plaque which may lead to IHD which can present as coronary heart disease, ischemic stroke or peripheral artery disease (Félix-Redondo *et al.*, 2013; Leuschner, 2022). Atherosclerosis is a major risk factor for mortality and morbidity associated with CVD (Garg *et al.*, 2015; Leuschner, 2022). Individual abnormal lipid components are individually associated with increased coronary heart disease (Masvosva, 2021). Such that, the LDL-C/HDL-C ratio is a traditional lipid index used to predict coronary heart disease (Wakabayashi and Daimon, 2019). However, the TG/HDL-C ratio is a more recent and effective predictor of cardiovascular disease, particularly myocardial infarction, and is linked to insulin resistance and metabolic syndrome (Wakabayashi and Daimon, 2019).

Obesity

The WHO describes overweight and obesity as the accumulation of abnormal or excessive fat which may be detrimental to one's health (WHO, 2021a). According to the WHO (2021a), obesity has nearly tripled and most countries have a greater number of deaths from obesity compared to being underweight. South Africa struggles with the co-existence of malnutrition and obesity within the population (NDoH, 2020). More than half of the population of South Africa is at risk of starvation, even though it is recognized as the most food-secure country on the African continent (Samodien *et al.*, 2021). Samodien *et al.* (2021) estimate that obese people account for 27% of the population, with South African women having the highest obesity rates in the world at 42% (Samodien *et al.*, 2021). Findings from the Global Burden of Disease 2015 and other studies have found that there is a higher prevalence of under-nutrition and stunted growth in children while adults are more at risk of obesity (Min *et al.*, 2018; Melaku *et al.*, 2019).

On account of urbanization (Stern *et al.*, 2010), there has been increased availability of foods high in fats and sugar; and lower physical activity due to mechanization (Lopes Ibanez-Gonzalez *et al.*, 2014). Bosire *et al.* (2020) describes this type of environment as ‘obesogenic’ which limits physical activity, and has excessive marketing and availability of unhealthy foods, thus resulting in people making poor health choices. Additionally, it was found that personal and cultural beliefs are instrumental in the existence of obesity (Kruger *et al.*, 2001; Lopes Ibanez-Gonzalez *et al.*, 2014). Being overweight or obese is valued as it is linked to dignity and wealth in certain cultures; in contrast, weight loss is considered a stigma and a sign of diseases such as HIV/AIDS, TB, or cancer (Lopes Ibanez-Gonzalez *et al.*, 2014; Samodien *et al.*, 2021). This is reinforced through obesity trends where increased income exhibited an increased risk of obesity (Wu *et al.*, 2015; WHO, 2018b). Moreover, HIV/AIDS is characterised by severe wasting which is a different clinical presentation compared to most NCDs (Puoane and Hughes, 2005). Bosire *et al.* (2020) conducted a study to determine the influence of socio-cultural customs on obesity normalization among black South Africans. The findings of this study explain that people have a misperception about obesity which results in them being unwilling to adopt healthier habits (Bosire *et al.*, 2020). The misperceptions range from socio-cultural norms of bigger bodies being healthier and beautiful, to the idea that fat and overweight is normal, however, obesity is a disabling condition (Bosire *et al.*, 2020). To resolve South Africa’s obesity problem, it is necessary to shift social norms and address ‘obesogenic’ food environments (Bosire *et al.*, 2020).

It is evident that obesity is a major risk factor in the development of NCDs (Lopes Ibanez-Gonzalez *et al.*, 2014; Nojilana *et al.*, 2016) hence; it is a critical preventative and/or therapeutic target (Reiger *et al.*, 2017; Samodien *et al.*, 2021). Furthermore, excess body weight is thought to be the cause of more than 90% of type 2 diabetes mellitus and 68% of hypertensive cases in South Africa (Samodien *et al.*, 2021). There are anthropometric measurements that may be calculated to determine the NCD risk (Shisana *et al.*, 2014). These include the Body Mass Index (BMI), calculated as weight (kg)/height (m)², waist circumference (WC), and Waist to Hip ratio (WHR) (Shisana *et al.*, 2014). A value ≥ 25.0 kg/m² indicates that a person is overweight and a value ≥ 30.0 kg/m² indicates obesity (SEMDSA, 2017; WHO, 2021d). For Asians, a value ≥ 25.0 kg/m² indicates obesity (SEMDSA, 2017).

According to Kruger *et al.* (2001), visceral adiposity is linked to impaired glucose tolerance and hyperlipidaemia (Kruger *et al.*, 2001). Central obesity was found to be associated with hypertension (Kruger *et al.*, 2001). Research has shown that WC is a better predictor of NCD risk compared to the WHR, primarily due to WC's strong association with BMI and its function as a simple measure of central obesity. However, other studies comparing the association of WC and WHR with CVD risk have found that while both are linked to CVD risk, WHR has a stronger correlation with CVD risk than WC (Kruger *et al.*, 2001; De Koning *et al.*, 2007; Lam *et al.*, 2015). A waist circumference > 88 cm in women and > 102 cm in men and WHR values > 0.8 for women or > 1.0 for men are regarded as indicative of central obesity (Shisana *et al.*, 2014).

2.5 Behavioural risk factors

The WHO has recognized four leading behavioural risk factors that contribute toward CVD: unhealthy diets, physical inactivity, tobacco use, and harmful use of alcohol (WHO, 2018b). Behavioural patterns such as alcohol use and smoking are more common in men compared to women (Mayosi *et al.*, 2009). Kamkuemah *et al.* (2020) explain that globalization has resulted in the adoption of the Western diet and lifestyle, thus making these practices more prominent in both rural and urban settings in Africa (Maredza *et al.*, 2011; Samodien *et al.*, 2021). These raise the likelihood of complications in people with NCDs and are responsible for more than two-thirds of all new cases of NCDs (Wagner and Brath, 2011). The SAGE wave 1 study found that the occurrence of multiple risk factors was prevalent in South Africa (Wu *et al.*, 2015). Consequently, the South African guidelines focus on implementing lifestyle changes to prevent NCDs (Stern *et al.*, 2010; Klug *et al.*, 2018).

Unhealthy diets

One of the first symptoms of obesity and metabolic disease is the diet-induced hypothalamic inflammation that occurs due to unhealthy diets (Samodien *et al.*, 2021). The leading dietary risk factors for NCD mortality are diets high in sodium, low in fruit and vegetables, low in nuts and seeds, low in omega-3 fatty acids, and low in whole grains (NDoH, 2020). The biggest risk factors from the dietary ingredients for NCDs are salt, sugar, and saturated fat (NDoH, 2020).

Salt

Excess salt consumption causes about 30% of hypertension cases (Wagner and Brath, 2011). International guidelines recommend < 5 g of salt/day, which is difficult to attain as most modern diets have sodium in the form of packaged foods and restaurant meals (Maredza *et al.*, 2011; WHO, 2018b). South Africans are unable to meet international guidelines as about 50% of the intake comes from non-discretionary sources such as bread (Maredza *et al.*, 2011). Interventions such as the reduction of salt content in processed foods are required to adhere to this international guideline (Maredza *et al.*, 2011). This has been put into effect by Woolworths by reformulating its brand recipes with reduced salt content (Maredza *et al.*, 2011).

Sugar

Concerning sugar consumption, the recommendation is to limit the intake of foods high in added sugar such as foods and snacks (cakes, desserts, sweets); and sugar-sweetened-beverages (SSB), including fruit juice, flavoured water, sweetened tea and coffee. (Klug *et al.*, 2018; Nakhooda and Wiles, 2020). Studies show that SSB promote weight gain due to the high sugar content and incomplete compensation for total energy (Manyema *et al.*, 2014). An average South African is potentially consuming about 400 ml of SSBs daily (Manyema *et al.*, 2014). In the theory-based qualitative study conducted by Bosire *et al.* (2020), it is demonstrated that SSB consumption is common amongst South Africans, with the participants drinking SSB for breakfast and as a coping strategy to manage stress or psychological disturbances, as these beverages provided a sense of happiness.

Dietary fats

Fats provide texture, taste and promote satiety (Klug *et al.*, 2018). A healthy diet consists of polyunsaturated fats instead of saturated fats (Klug *et al.*, 2018). Dietary polyunsaturated fat provides the two essential fatty acids that cannot be synthesized in the body (Klug *et al.*, 2018). The omega-6 linoleic acid is derived from sunflower and soybean oils whilst omega-3 alpha-linoleic acid is derived from green leafy vegetables, canola oil, and flaxseeds (Klug *et al.*, 2018). Saturated fats are primarily solid and comprise both animal and vegetable solid fats such as the visible fat on meat and poultry, lard and dairy cream, and food items that contain vegetable fats (Klug *et al.*, 2018). *Trans*-unsaturated fatty acids are available in the meat and milk of ruminant

animals such as sheep and cattle and are produced for use in partially hydrogenated vegetable oils (Klug *et al.*, 2018). Due to the affordability and durability, commercial *trans*-unsaturated fatty acids are used in the production of processed foods such as margarine, deep-fried foods, and baking goods (Klug *et al.*, 2018). Where the consumption of polyunsaturated fats promotes the reduction of LDL-C and cardiovascular risk, saturated fats display the highest increase in LDL-C, as much as 0.02 - 0.04 mmol/L LDL-C increase for every additional 1% energy coming from saturated fats (Klug *et al.*, 2018). Similarly, *trans*-unsaturated fatty acids raise LDL-C, apolipoprotein B, TG, and lipoprotein (a), and lower the levels of high-density lipoprotein cholesterol (HDL-C) and apolipoprotein A1 thereby increasing cardiovascular risk. (Klug *et al.*, 2018). The consumption of foods high in saturated and *trans*-unsaturated fatty acids is discouraged (Klug *et al.*, 2018).

Diets that have a high consumption of wholegrain products, fruit and vegetables, regular intake of fish, poultry, nuts, and legumes and restricted intake of red meat, sweets, and SSB are associated with long-term reduction in CVD risk. Diets such as the Dietary Approaches to Stop Hypertension (DASH), Mediterranean diets, and the South African food-based dietary guidelines are in line with these recommendations (Klug *et al.*, 2018). Research has found that the limitations to promoting a healthy diet are the affordability of a quality diet (NDoH, 2020; Samodien *et al.*, 2021). Healthier foods generally cost between 10% and 60% more when compared to less healthy and nutritionally poor food (NDoH, 2020; Samodien *et al.*, 2021).

Physical inactivity

The WHO recommends that adults (> 18 years) participate in at least 150 - 300 minutes of moderate-intensity physical activity per week to be considered physically active (WHO, 2018b; WHO, 2020b). Many studies have shown that physical inactivity is a major risk factor contributing to NCD risk (De Villiers *et al.*, 2012; WHO, 2013; Butler *et al.*, 2015; Wu *et al.*, 2015; Nojilana and Pillay-van Wyk, 2017; Schouw *et al.*, 2018). In 2016, approximately 28% of adults (>18 years) worldwide, were classified as physically inactive, a concerning statistic that hasn't shown improvement since 2001 (WHO, 2018b). The significance of physical activity in mitigating health risks is underscored by its role in lowering the likelihood of conditions such as hypertension, depression, and stroke (WHO, 2018b). This correlation is supported by De Villiers *et al.* (2012) study, which demonstrated that heightened physical activity not only promotes cardiovascular

health but also contributes to a reduction in stress levels. The SAGE wave 1 study found physical inactivity to be highest in South Africa compared to other LMICs at 59.7% (Wu et al., 2015).

An analysis of the 2012 nationally representative population-based household survey found that 57.4% of the individuals were physically inactive (Mlangeni *et al.*, 2018). Mlangeni *et al.* (2018) attributes this high level of inactivity to urbanization and socio-economic changes, which reduce the need for physical labour and lead to less intensive physical work. This is significant as the physical activity of the working class often involves walking for transportation or work-related activities (Mlangeni *et al.*, 2018). Personal factors such as age and gender also influence activity levels, with elderly individuals and females being less active (Mlangeni *et al.*, 2018). Additionally, living environment and socio-economic status impact activity levels; those in higher socio-economic status and urban formal settlements are more likely to engage in moderate to vigorous physical activity due to the availability of recreational parks, neighbourhood streets, and malls. Higher educational attainment is also associated with greater physical activity compared to lower or primary education levels (Mlangeni *et al.*, 2018).

Tobacco use

Tobacco contains nicotine which is a highly addictive substance (WHO, 2024). Tobacco smoking and the use of smokeless tobacco are harmful to cardiovascular health in both adults and children (Klug *et al.*, 2018; WHO, 2018b). Electronic cigarettes (e-cigarettes, vaping) may be considered less harmful and a healthier alternative to traditional smoking, however, the long-term health implications are unknown (Klug *et al.*, 2018). The national average smoking rate in South Africa is 16.2% (WHO, 2023c). Tobacco has been linked to the initiation and exacerbation of atherosclerosis due to the damage caused to the vascular intima (Klein, 2022). Smoking activates the immune system, leading to increased serum levels of cytokines which enhances inflammation (Klein, 2022). This contributes to the development and instability of atherosclerotic plaques (Klein, 2022). Other mechanisms that may be linked to CVD risk include the lipid abnormalities (higher LDL-C, TG and TC) among the smokers (Klein, 2022). Smoking also promotes a procoagulant environment and raises the fibrinogen levels and blood viscosity, which increases the risk of thrombosis, MI, and stroke (Klein, 2022).

The use of the waterpipe also known as hookah pipe, shisha, hubbly bubbly, or narghile has become a social phenomenon (Senkubuge *et al.*, 2012; Daniels and Roman, 2013). Formerly, the use of the waterpipe was restricted to cultural gatherings in the Middle East but now it has become popular in social gatherings of youngsters in restaurants, cafes, and hookah bars (Daniels and Roman, 2013). In the study by Daniels and Roman (2013), the usage of the waterpipe among first-year university students in the Western Cape, South Africa, is explored. The percentage of the waterpipe users was 40%, most of whom use it on daily (Daniels and Roman, 2013). This is an alarming number and much higher than the 18.6% of users in a study conducted at the medical campus of a university in Pretoria (Senkubuge *et al.*, 2012). Multiple researchers mention that the users believed the waterpipe is less harmful than smoking as it contains less nicotine and the toxins are filtered by the water (Senkubuge *et al.*, 2012; Daniels and Roman, 2013). This belief is further reinforced by the lack of prohibitions in the current Tobacco policy, easy accessibility, attractive and various flavours of tobacco, thus making it socially acceptable (Senkubuge *et al.*, 2012; Daniels and Roman, 2013; Roman *et al.*, 2019). However, this perception is refuted by research that shows cigarette and waterpipe smoking have similar health risks, with waterpipe smoking displaying increased carbon monoxide and smoke exposure (Eissenberg and Shihadeh, 2009; Daniels and Roman, 2013). Direct tobacco use kills more than seven million people while 1.2 million people die from exposure to second-hand smoke (WHO, 2022c). Over 80% of the world's tobacco users are in LMIC, this is concerning as the household spending is directed to tobacco instead of basic needs (WHO, 2022c).

Harmful use of alcohol

Alcohol is a psychoactive substance with addictive properties (WHO, 2018a). The consumption pattern and the level of alcohol-related harm is dependent on individual and societal factors (WHO, 2018a). The Centres for Disease Control and Prevention (CDC) state that a person of legal drinking age may abstain from drinking or limit the daily intake to not exceed two drinks for men and one drink for women (CDC, 2022). Both the WHO and CDC consider less drinking or no drinking of alcohol to be more healthy (WHO, 2014; CDC, 2022). In fact, the WHO is resolutely opposed to alcohol consumption and cautions that there are no safe levels of alcohol consumption. The harmful use of alcohol is more likely in individuals with increased vulnerabilities (such as individuals with poor health status and high-risk alcohol consumption patterns) (WHO, 2018a)

and has been associated with premature deaths and disabilities and may cause a range of mental and behavioural disorders, NCDs, and communicable diseases (WHO, 2018b).

The CDC describes the excessive use of alcohol as heavy drinking (more than 15 drinks per week for men and more than eight (8) drinks per week for women), binge drinking (drinking on a single occasion that raises the Blood Alcohol Concentration (BAC) level to 0.08% or more), underage drinking and any alcohol use by pregnant women (CDC, 2022). Studies have observed a link between increased alcohol consumption with cancer, and cardiovascular outcomes such as hypertension, stroke, and also diabetes (WHO, 2018b; Yamamoto-Moreno *et al.*, 2020). It is vital to address the high rate of heavy episodic drinkers (25.6%) in South Africa (NDoH, 2020).

Incidences of heavy episodic drinking have been attributed to the easy availability of alcohol and the lack of stringent regulations regarding its marketing, distribution, and production (Davis *et al.*, 2017; Trangenstein *et al.*, 2018; Parry *et al.*, 2023). Apartheid led to the establishment of informal and unlicensed sale outlets, known as shebeens, which operate outside the formally regulated sector. Owners of these informal outlets are not deterred by regulatory consequences, while consumers, facing limited recreational activities, often engaged in alcohol consumption as a primary social activity (Ataguba, 2012; Trangenstein *et al.*, 2018). A household survey employing a multi-stage stratified cluster random sampling design found that heavy drinking in South Africa may also be linked to the use of above-average sized containers by the liquor industry for alcohol distribution (Trangenstein *et al.*, 2018). Survey respondents who consumed alcohol from these larger containers were nearly eight times more likely to engage in heavy drinking compared to those who drank from average-sized containers (Trangenstein *et al.*, 2018). Alcohol consumption is closely associated with sexually transmitted infections (STIs), interpersonal violence, and foetal alcohol spectrum disorders, and it may lead to long-term societal problems such as unemployment, financial difficulties, and family issues (Davis *et al.*, 2017; Trangenstein *et al.*, 2018; WHO, 2018a).

2.6 Healthcare Disparities in South Africa

South Africa is identified as an upper middle-income country with different living conditions ranging from affluent and middle-class suburbs, deprived peri-urban areas, and underdeveloped

rural areas (Nojilana and Pillay-van Wyk, 2017). In the past few decades, there have been epidemiologic transitions occurring in the nation, which have been attributed to rapid urbanization and globalization, coupled with the political transition after democracy (Mayosi *et al.*, 2009; Nojilana and Pillay-van Wyk, 2017). The abolishment of the ‘influx control’ legislation has allowed the black African population from rural areas to migrate to urban areas (Nojilana and Pillay-van Wyk, 2017). The negative effects of urbanization, migration, and globalization exceed the capacity of the government to deliver the healthcare needs of the population (Stern *et al.*, 2010; Wagner and Brath, 2011).

In addition to experiencing epidemiological transitions, South Africa also endured apartheid, which exacerbated healthcare disparities that persist to this day (Stuckler *et al.*, 2011; McLaren *et al.*, 2014; Maphumulo and Bhengu, 2019). During apartheid, spatial segregation was used to maintain inequality, providing high-quality care to the elite white population while relegating poor healthcare infrastructure to the black populations (Stuckler *et al.*, 2011; Maphumulo and Bhengu, 2019). Post apartheid, basic healthcare was declared a constitutional right, and efforts were made to redistribute health resources based on need (Stuckler *et al.*, 2011). However, economic challenges around the year 1998 and increasing healthcare demands hindered the government's ability to equitably redistribute resources (Stuckler *et al.*, 2011). Poorer regions struggled to manage the funds allocated to them, thus receiving criticism and decreasing fund allocation, while wealthier regions effectively utilized their resources to meet healthcare needs (Stuckler *et al.*, 2011). As a result, poorer regions became largely dependent on conditional disease-specific grants to address their healthcare demands (Stuckler *et al.*, 2011). South Africa has fallen victim to the inverse care law, wherein regions with the greatest needs receive the fewest resources (Stuckler *et al.*, 2011). This has led to an infrastructure-inequality trap that exacerbates healthcare disparities, as funding is determined by existing capacity rather than disease burden (Stuckler *et al.*, 2011). Consequently, healthcare inequalities are rooted in historical context and continue to influence current resource allocations (Stuckler *et al.*, 2011).

McLaren *et al.* (2014) asserts that residential areas in South Africa remain racially defined, with non-white neighborhoods often situated in remote areas far from healthcare facilities. This geographic separation affects access to healthcare, as time and financial constraints hinder

residents' ability to seek medical care, thereby influencing their health-seeking behaviour. McLaren *et al.* (2014), through a multivariate regression analysis investigating the role of distance to the nearest facility on the likelihood of having a health consultation or an attended birth, found that 14% of Black African adults live more than five km from the nearest facility, compared to only 4% of Whites. Additionally, Black African adults are 16 percentage points less likely to report a recent health consultation (McLaren *et al.*, 2014).

Progressive health policies such as free primary health care for all have been ineffective (Mayosi *et al.*, 2009). This is due to the inequity between the rich and the poor resulting in unequal distribution of resources and low quality of healthcare (Mayosi *et al.*, 2009; Stern *et al.*, 2010). Although the burden of disease is dominated by communicable diseases such as HIV/AIDS, TB, and malaria, the increased prevalence of NCDs requires the need for the South African health system to change from an acute care model to a chronic care model (Mayosi *et al.*, 2009; Gouda *et al.*, 2019; Samodien *et al.*, 2021).

This issue is particularly relevant in South Africa, where an aging population necessitates increased support and care (Goodrick, 2013). An aging population presents significant healthcare challenges such as a higher prevalence of chronic diseases, greater demand for health services, and increased healthcare costs for the government, families, and society (Goodrick, 2013). As the elderly population grows, largely economically inactive and dependent, this support becomes crucial (Goodrick, 2013). (Goodrick, 2013) also notes that it is not age per se that drives healthcare costs, but rather an individual's proximity to death. Historically, South African policies have focused more on younger cohorts, while the challenges faced by older cohorts have received less attention (Goodrick, 2013). Of particular concern is the lack of training and prioritization of geriatric care in institutional planning (Goodrick, 2013). South Africa is expected to experience substantial aging soon and must adapt its policies prioritizing care for individuals with long-term, chronic diseases, and NCDs (Goodrick, 2013). Although the South African government has implemented policies aimed at improving the well-being of the older population, these efforts are often only partially successful due to a lack of awareness regarding the specific challenges posed by an aging population (Goodrick, 2013).

This also applies to the chronic care required for the ageing HIV/AIDS population with increased life expectancy due to the suppression of the disease (Mayosi *et al.*, 2009; NDoH, 2020). The health transition is placing a burden on an already under-resourced and overburdened healthcare system (Nojilana and Pillay-van Wyk, 2017). Besides the mortality due to NCDs, there is significant morbidity (presence of a chronic disease in an individual) which leads to disability (NDoH, 2020). HIV/AIDS, diabetes and COPD are among the top ten conditions that lead to disability (NDoH, 2020).

The healthcare system would be able to provide better quality care if there were fewer sick people to support (Hofman, 2014). To address the quality of the public healthcare system, the NDoH created a Ten Point Plan Strategic Framework, as part of the Hospital Revitalization Programme. This initiative aims to enhance hospital infrastructure, health technology, administrative management, and service quality in public settings (Maphumulo and Bhengu, 2019). Strategies that have been suggested to improve the quality of care include decentralization that strengthens the ability of local organisations to negotiate with the government for resource allocation to underserved communities, the implementation of policies and legislation such as the Patients Rights Charter and free-health policies and the district-based primary health care system (Maphumulo and Bhengu, 2019).

Multi-morbidity

The WHO (2016) explains multi-morbidity as the co-occurrence of two or more chronic conditions in an individual. The prevalence of multi-morbidity increases as the individual ages (Du *et al.*, 2023). Patients with multi-morbidity have increased safety concerns such as a higher probability of adverse health outcomes, reduced quality of life, and higher use of health care services (Du *et al.*, 2023). Multi-morbidity complicates the treatment regimens and increases the chances of polypharmacy (WHO, 2016). This makes it difficult for the healthcare workers at the primary healthcare (PHC) level to treat and manage the disease as they lack the skills or may only have the capacity to deal with a subset of symptoms (Mayosi *et al.*, 2009). Consequently, resulting in untreated and undiagnosed chronic diseases (Mayosi *et al.*, 2009).

To address the healthcare deficiencies, the government established the National Drug Policy (NDP) (Govender *et al.*, 2021). The primary goal of the NDP was to ensure a reliable supply of safe, cost-effective, and high-quality drugs to all South Africans, while promoting the rational use of medicines by prescribers, dispensers, and consumers (Govender *et al.*, 2021). The NDP developed the Essential Medicines Lists (EML), guided by the Standard Treatment Guidelines (STGs), which were subsequently distributed throughout the public healthcare system (Govender *et al.*, 2021). However, challenges regarding the accessibility and utilisation of the STGs remain unresolved (Govender *et al.*, 2021). (Govender *et al.*, 2021) found that STGs/EML were more accessible to doctors in urban hospitals than to nurses in rural clinics at the PHC level. Initially distributed as hardcopies every three years, the guidelines frequently became outdated (Govender *et al.*, 2021). To address this, the NDoH introduced soft copies only of the guidelines on the NDoH website and as a mobile application for the guidelines in 2015, which improved accessibility for doctors but not for many nurses, who faced challenges such as lack of technological skills, data costs, and limited access to smartphones or computers (Govender *et al.*, 2021). Additionally, poor internet access in rural areas further hindered nurses' ability to use the application. Many healthcare workers at primary healthcare facilities were unaware of the mobile app and continued to rely on outdated hardcopies (Govender *et al.*, 2021).

Very few prescribers received training on the STGs, however, most prescribers felt they were knowledgeable enough to use the guidelines (Govender *et al.*, 2021). In comparison, nurses were found to be inadequately trained with less than 60% having sufficient knowledge to access and utilise the STGs (Sooruth *et al.*, 2015). This is further established with Govender *et al.* (2021)'s findings on the implementation of EMLs/STGs at a public tertiary institution and its associated PHCs, there were 94.4% nurses that requested further training on STGs/EML use as they had never received formal training.

Non-communicable diseases (NCDs) and other communicable diseases

Patients living with NCDs, and other risk factors are at an increased risk of contracting other communicable diseases such as TB and COVID-19 (Kluge *et al.*, 2020; NDoH, 2020). People living with NCDs have been found to experience more serious sequelae and even death (NDoH, 2020). The NDoH (2020) emphasizes that the co-occurrence of communicable and non-

communicable disease enhance the risk or effect of the other, exemplified by the fact that diabetes has been shown to triple the risk of TB.

Human Immuno-deficiency Virus (HIV) and NCDs

There is an increased prevalence of HIV and NCDs co-occurrence (Kamkuemah *et al.*, 2020). As HIV-positive individuals have longer life expectancies, they are more vulnerable to NCDs due to the infection and long-term complications of anti-retroviral therapy (ART) (Kamkuemah *et al.*, 2020; NDoH, 2020; Roomaney *et al.*, 2020; Esber *et al.*, 2022). There are conflicting reports on the effect of ART, specifically protease inhibitors, on HIV/AIDS patients with a risk of dyslipidaemia. Ntusi (2018) reports that the difference in the prevalence of dyslipidaemia was insignificant between ART-naïve and treated HIV patients. This is reinforced by Klug *et al.* (2018) who mention that the HIV-negative patients exhibited similar cardio-metabolic risk as compared to HIV-positive patients. Additionally, any change in the lipid profile due to ART was minor, thus not requiring further evaluation (Klug *et al.*, 2018). In contrast, Reiger *et al.* (2017) suggest that protease inhibitors increase lipid levels by 25% and increase the risk of cardiovascular events. All things considered, it is evident that it is essential to make enhanced efforts to prevent multi-morbidity (Kamkuemah *et al.*, 2020; Du *et al.*, 2023).

Following reports on the safety and efficacy of the integrase strand transfer inhibitors (INSTIs), specifically dolutegravir (DTG), the WHO recommends DTG as an alternative to efavirenz (EFV) as first-line ART for all populations, including pregnant women and women of childbearing potential (WHO, 2019b; Brennan *et al.*, 2023). However, there are reports on increased weight gain being associated with the INSTIs, particularly DTG (Taramasso *et al.*, 2020; Esber *et al.*, 2022; Brennan *et al.*, 2023). Generally, there has been a ‘return-to health’ phenomenon observed with HIV-positive individuals who are responding well to therapy, however, weight gain beyond the healthy ranges is of concern (Taramasso *et al.*, 2020; Esber *et al.*, 2022; Brennan *et al.*, 2023). There are health implications of excess weight gain, as it increases the risk of HIV-positive individuals developing NCDs (Esber *et al.*, 2022; Brennan *et al.*, 2023).

The African Cohort Study (AFRICOS), conducted in routine care settings across Uganda, Kenya, Tanzania, and Nigeria, revealed that before transitioning to a DTG-based regimen, patients experienced an average weight change of 0.35 kg/year (Esber *et al.*, 2022). However, this rate escalated significantly, increasing fourfold to an average weight change of 1.46 kg/year after one year of the transition to a DTG-based regimen (Esber *et al.*, 2022). Other studies support the findings on weight gain being associated with DTG, however, researchers caution that longer follow-up is needed as there may be other confounders that may be attributed to the weight gain such as the prior regimen, BMI at transition, CD4 count that may influence the body dynamics (Taramasso *et al.*, 2020; Brennan *et al.*, 2023). Additionally, there are suggestions of the weight gain being sustained after a certain period following the initial short-term weight gain (Taramasso *et al.*, 2020; Brennan *et al.*, 2023). Nevertheless, the WHO (2019a) recommends that whilst on DTG therapy, physical activity should be increased along with a healthy diet to combat the detrimental effects of weight gain.

2.7 Health sector interventions and recommendations to combat NCDs:

The NDoH has developed policies and interventions under the guidance of the WHO to combat NCDs in South Africa (Mayosi *et al.*, 2009). Many researchers have advocated the use of population-wide interventions that are independent of the healthcare system such as taxation to be effective in the control of NCDs (Mayosi *et al.*, 2009; Maredza *et al.*, 2011). The former director of WHO, Margaret Chan, explicitly stated that the health sector cannot manage NCDs on its own and needs government-directed interventions (Hofman, 2014).

Taxation

Tobacco

South Africa has implemented mandatory policies to prevent NCDs. This includes the implementation of comprehensive Tobacco legislation with the passing of the Tobacco Products Control Act of 1993 (Mayosi *et al.*, 2009; Maredza *et al.*, 2011). The Act regulates the marketing and sale of tobacco products, enforces warning labels on tobacco products, and assures the rights of non-smokers and children to a smoke-free environment (Mayosi *et al.*, 2009; Maredza *et al.*,

2011). Additionally, any smoking-related death information is included in the death certificate, allowing the burden due to tobacco to be monitored (Mayosi *et al.*, 2009). The tobacco tax has increased yearly (American Cancer Society, 2012), currently, it is at ZAR 10.89 per ten cigarettes (SARS, 2024), making it less affordable and discouraging youth initiation (WHO, 2020b). The prevalence of smoking has decreased among adults from 32% in 1993 (American Cancer Society, 2012) to 20% in 2016 (WHO, 2018b). Similarly, Maredza *et al.* (2011) state that there has been a decline in smoking-related CVD deaths. However, there has been an increase in novel tobacco products, which the tobacco industry has developed to evade tax (Egbe, 2022). Egbe (2022) explains the need for a new bill that includes the regulation of novel tobacco products (electronic cigarettes and heated tobacco products) and any other future products that the tobacco industry may invent. Currently, the government has implemented an excise duty rate R2.90/ml from 1 June 2023 on novel products (SARS, 2023).

Alcohol

Similar to tobacco products, alcohol is taxed to reduce alcohol misuse (Mayosi *et al.*, 2009). The Liquor Act prohibits the advertising of alcohol to children and supports the responsible use of liquor (Mayosi *et al.*, 2009). Research indicates that excise duty on alcohol has been ineffective in changing consumption patterns (Ataguba, 2012; Storom, 2013). Poor or non-existent alcohol policy places an unnecessary burden on the economy (Ataguba, 2012). This includes increased healthcare costs to treat alcohol-related illnesses, social welfare costs due alcohol misuse, increased alcohol-related crimes, and decreased productivity due to absenteeism and impaired performance (Ataguba, 2012). Ataguba (2012) explains that the current laws are regressive and place a greater burden on the poor, thus exacerbating health inequalities. Poorer populations tend to consume cheaper alcoholic beverages, such as traditional African sorghum beer, which are taxed at relatively high rates (Ataguba, 2012). In contrast, wealthier individuals consume more expensive beverages, such as wine and spirits, which are taxed at lower rates relative to their price (Ataguba, 2012). The regressive nature of alcohol taxes means that the poor pay a higher proportion of their income in taxes compared to the rich (Ataguba, 2012). The development of a comprehensive alcohol policy is complex, and consideration should be given to the socioeconomic environment and the consumption patterns of the drinkers (Ataguba, 2012).

Sugar

The government implemented a 10% excise tax on SSB in 2018, which is expected to decrease the number of obese people by 220 000 in 3 years (Hofman, 2014; Nojilana *et al.*, 2016). The health promotion levy aims to decrease the sugar content in SSB and decrease the consumption of SSB among South Africans (Koen *et al.*, 2022). Although there was a reduction in the consumption of SSB in the lower-income group, the impact of this levy will only be measurable in a few years (Koen *et al.*, 2022).

Salt

A salt reduction policy has been implemented since 2016 to address hypertension (Nojilana and Pillay-van Wyk, 2017). The policy entails the phased reduction of sodium content in certain food stuff to reduce salt intake to less than 5g a day (Factssa, 2021). This was achieved by dividing the food stuff into 13 categories and setting maximum targets of sodium content measured in either the Atomic Absorption (AA) or the Inductively Coupled Plasma (ICP) method (Factssa, 2021). Since voluntary action has largely been proven ineffective, Hofman and Tollman (2013) strongly advocate for mandatory salt regulations. This is expected to decrease hospital costs by ZAR 300 million yearly, saving a total of 6 400 lives from stroke and 4300 lives from non-fatal stroke (Hofman, 2014). Noteworthy voluntary actions taken by the food industry have been proven to be effective (Maredza *et al.*, 2011). In South Africa, Woolworths has reformulated the recipes of its brand products to reduce the salt content (Maredza *et al.*, 2011). Likewise, the ‘Tick’ initiative by the Heart Foundation in Australia focuses on having food with lower saturated fat, *trans*-fat, salt, and kilojoules (Maredza *et al.*, 2011; NSWFA, 2023).

Trans-fatty acids

As *trans*-fatty acids increase the risk of cardiovascular disease, the WHO advises the content of *trans*-fatty acids should be less than 1% of daily energy consumption (Maredza *et al.*, 2011). The policy on *trans* fatty acids aims to reduce *trans*-fats in processed foods in South Africa (Maredza *et al.*, 2011). The policy prohibits the sale, production, and importation of any oils and fats, alone or as a component of processed products with the *trans*-fat content exceeding 2 g per 100 g of oil or fat (NDoH, 2011). Additionally, for any product with the “*Trans*-fat free” claim on the label or

advertisement, the content of the *trans*-fat must be less than 1 g per 100 g of the total fat or oil in the final product (NDoH, 2011).

Other regulations include more transparent food labelling indicating the levels of all nutrients especially salt, fat, saturated fat, and sugar content (Maredza *et al.*, 2011; Samodien *et al.*, 2021). Maredza *et al.* (2011) recommend a front-of-pack labelling system where red would indicate unhealthy/bad and green would indicate healthy/good. This would make it easier for consumers to make healthy choices and will be more convenient to explain in educational initiatives (Maredza *et al.*, 2011). This is similar to The Heart and Stroke Foundation of South Africa (HSFSA)'s Heart Mark programme (HSFSA, 2020). The programme was developed to create a health-enabling environment where the consumers associate the logo with healthy eating (HSFSA, 2020). The logo is a red circle with a white heart, fork, and knife inside (Figure 2), with the text stating that the food item is approved by the HSFSA (HSFSA, 2020). Only food manufacturers that meet the set criteria are allowed the opportunity to use this logo (HSFSA, 2020). A healthcare provider suggested the introduction of a weight tax, similar to Japan, whereby the obese individuals are taxed based on BMI and waist circumference (Hunter-Adams and Battersby, 2020).



Figure 2: Heart and Stroke Foundation's Heart Mark logo (HSFSA, 2023a)

Storom (2013) explains the main aim of sin tax is to create income for the government and to influence consumer behaviour. Fat tax is considered a part of sin tax due to it being considered a vice in society (Storom, 2013). Countries with lower obesity rates compared to South Africa have already implemented fat taxes in different forms. Most countries implemented fat tax by taxing foods rich in sugar and fats (Storom, 2013). However, Japan's implementation of the fat tax differs in that people are fined for obesity (Retief, 2017; Hunter-Adams and Battersby, 2020). Japan's 'metabo' law requires the measurement of waist sizes intending to reduce the waist sizes over the

years (Retief, 2017). There are financial penalties for companies and local governments that fail to meet the specified targets (Retief, 2017).

South Africa has implemented a fat tax to a certain extent by taxing trans-fat and SSB. Storom (2013) found in his study that the consumers were sensitive to the pricing in terms of the food choices they make; this was proven when 32% of the participants chose the healthier option when the price of the unhealthy option increased. The cost was further emphasised when 98% of the participants indicated that they considered price when purchasing food. Although, most participants ate fast-food regularly, most (71%) showed that they would make better choices if presented with nutritional information about the food (Storom, 2013). Storom (2013) emphasizes the need for awareness and educational campaigns to target obesity as tax alone cannot be feasible in a developing country.

Whilst most researchers advocate for population-wide interventions, many healthcare professionals have mentioned the limitations of a centralized decision-making process (Mayosi *et al.*, 2009). Healthcare professionals may not make independent decisions to act as they are controlled by a hierarchical chain of control (Mayosi *et al.*, 2009). This is problematic as the authority managers are unaware of local needs and may cause diagnostic delays (Mayosi *et al.*, 2009). Similarly, there is a centralized system for laboratory testing, where samples are sent to a central laboratory with skilled healthcare staff and specialized equipment (Sharma *et al.*, 2021). Sharma *et al.* (2021) suggest a decentralized POCT system for HIV monitoring which may be implemented to increase testing coverage and improve clinical outcomes by reducing turnaround time for results and decreasing the loss to follow-up. This is consistent with the views of Hirst *et al.* (2021), who mention that POCT may be used for HbA1c testing and enable the patient to connect lifestyle behaviour with HbA1c control. There is consensus on the requirement of an effective national NCD surveillance system that will facilitate the monitoring of NCD-related morbidity and mortality and also provide relevant information for the formation of policies (Mayosi *et al.*, 2009; Nojilana *et al.*, 2016; Gouda *et al.*, 2019).

There have been suggestions to integrate NCD care at the primary care level with other healthcare services, especially with chronic communicable diseases such as HIV/AIDS (NDoH, 2020;

Hopkins *et al.*, 2021). A cascading model, similar to the HIV model, has been suggested for NCD prevention and management (NDoH, 2020). Cases of cardiovascular disease and diabetes in South Africa are higher when compared to other NCDs, thus the government has implemented a 90/60/50 model target for the year 2025 which will be applied to blood pressure and blood glucose. This model outlines that 90% of the population (>18 years) will be tested for hypertension and/or raised blood glucose, 60% of these people positive for the diseases will receive treatment and 50% of the population receiving the treatment will be controlled (NDoH, 2020).

2.8 Point-Of-Care Testing (POCT)

Point-Of-Care Testing (POCT) services have been identified as a solution to the current healthcare disparities (Hirst *et al.*, 2021). They can be used to provide pathology services in disadvantaged settings and improve the accessibility to testing thus bridging the gap in health equity (Motta *et al.*, 2017).

Point of care testing challenges

Despite there being multiple benefits to POCT, there are a few concerns that need to be addressed (Dyhdalo *et al.*, 2014). Firstly, the POCT devices that are used for clinical decision-making, need to be evaluated and approved by government regulatory bodies (Kehrer and James, 2016). The product is considered safe and effective, if the clinical benefits outweigh the risks associated with the product and the results are proven to be clinically significant (Kehrer and James, 2016). In South Africa, medical devices and *in vitro* diagnostics (IVD) are classified depending on the risk to the individual and the public as per regulations of Act 101 of 1965 (SAHPRA, 2023a). Any medical device in the category B, C, and D requires the approval of the South African Health Products Regulatory Authority (SAHPRA) before it may be manufactured or distributed by the holder of the licence (SAHPRA, 2017; SAHPRA, 2023b). This raises the issue of quality control measures such as device evaluation, calibration, and validation which ensures accurate results. Quality patient care is dependent on accurate results (Dyhdalo *et al.*, 2014), however, the audit at Tygerberg Hospital shows that the staff is not aware of the quality control procedures that are required (Jalavu *et al.*, 2020).

Secondly, the reliability of the POCT device needs to be considered. It is concerning that the POCT results may not be comparable to the results from a laboratory (Kehrer and James, 2016). According to the systematic literature review conducted to evaluate the effectiveness and analytical quality of POCT performed in the community pharmacy, it was found that POCT was of acceptable quality compared to laboratory standards with a few challenges (Buss *et al.*, 2019). Thus, POCT may be used for screening, however, not diagnostic purposes (Buss *et al.*, 2019).

Thirdly, it is crucial to have trained clinical healthcare workers conducting the tests. Currently, South Africa has no formal national policy on POCT and training of personnel for healthcare facilities (Jalavu *et al.*, 2020). Jalavu *et al.* (2020) mentions that most of the staff participants (Consisting of 91% of the Nursing staff and the rest medical doctors) at Tygerberg Hospital indicated the need for formal training in POCT. This impacts staff confidence and increases the chances of error resulting in poor patient outcomes (Jalavu *et al.*, 2020). In conjunction with the POCT, the staff must be knowledgeable about the correct posture, the abnormal values, and situations when the devices may display inaccurate results by under/overestimating the results (Jalavu *et al.*, 2020). Thus, there should be formal training provided to all POCT operators followed by assessments (Jalavu *et al.*, 2020). As per the Good Pharmacy Practice in South Africa, all pharmacists performing the services of screening and monitoring are required to have sufficient training and competence, to perform the tests and interpret the results (SAPC, 2010). The pharmacists should have knowledge on sample collection and maintenance, record keeping and equipment maintenance and quality assurance (SAPC, 2010).

2.9 Student-led health screening initiatives

This formal training required to conduct POCT may be provided while healthcare practitioners are still in school. During student years, pharmacy professionals undergo training in accordance to the Good Pharmacy Practice (GPP) requirements, on the minimum standards for screening and monitoring services (SAPC, 2010). This involves training on the theoretical aspect as well as the practical assessments on conducting these tests. The training also incorporates all complementary aspects including the quality control procedure of the equipment, documentation, and record-keeping (SAPC, 2010). Student-led initiatives have a dual purpose, first to provide healthcare practitioner students with the opportunity to develop professional skills through delivering services

and additionally to fulfil a service delivery gap in the healthcare system (Suen *et al.*, 2020). Similarly, Nazar *et al.* (2021) suggest work-based learning (WBL) initiatives as an effective strategy to offer students an opportunity to develop professional identities and competencies under the supervision of facilitators and receive instant feedback without compromising the safety of the patients.

In a university setting, screening may encourage healthy behaviours and create awareness of NCDs, additionally guide the design of health promotion and wellness programmes (Ahlstrand *et al.*, 2022). This commitment is comparable to the Health Promoting Universities concept described by WHO in the Edmonton Charter (WHO, 2005; Suárez-Reyes and Van den Broucke, 2016). Effective wellness programmes influence health, safety, and risk behaviour and may act as an accelerator or preventer of chronic disease (Schouw *et al.*, 2018).

Student-led health screening initiatives have yielded positive results for both students and the participants (Hess *et al.*, 2012; McConaha *et al.*, 2013; Bastianelli *et al.*, 2017; Suen *et al.*, 2020). The students hosting such events reported having increased ability and confidence in performing POCT and communication in providing health education (Hess *et al.*, 2012; Bastianelli *et al.*, 2017; Nazar *et al.*, 2021). The participants of pharmacy student-led events have experienced various benefits including, increasing the participants' knowledge of disease states, increasing the intent to see a healthcare provider for further evaluation (Hess *et al.*, 2012), implementing lifestyle modifications such as a healthy diet, and joining an exercise and smoking cessation programs (McConaha *et al.*, 2013).

A pharmacy student led initiative that has demonstrated improved clinical outcomes include a pharmacy student-led interprofessional diabetes clinic that witnessed a significant improvement in the HbA1c values of the uncontrolled diabetics from 9.3% to 7.6%. During the sessions, the pharmacy students engaged in discussions with the patients regarding medication adherence, provided recommendations for medication therapy management to the primary care provider and conducted a follow-up telephone call with the patients to address any queries (Martin *et al.*, 2015). Likewise, another study demonstrated the effectiveness of incorporating pharmacy students to conduct follow-up intervention to discuss the diabetic medication adherence and address any

queries of the patients (Peasah *et al.*, 2020). As a result, the intervention group exhibited improved HbA1c levels compared to the control group (Peasah *et al.*, 2020). Remarkably, a study on the feasibility of a pharmacy student-led blood pressure and healthy lifestyle clinic, called ‘Young@Heart’ demonstrates that 45% of the participants were identified with high blood pressure. Among them, 23.7% of these cases had not received a prior diagnosis and were consequently referred to their physician for further assessment (Nazar *et al.*, 2021). Studies conducted in the USA found that the level of care that student-led initiatives provide is comparable to the national standards and professional-led initiatives (Suen *et al.*, 2020).

POCT outside traditional settings/ POCT in non-clinical settings

As most CVD and its associated diseases such as hypertension, diabetes mellitus type 2 and hypercholesterolemia have no symptoms until they result in an acute event (WHO, 2013; Ferrières, 2019; Juchli *et al.*, 2021a; Aikaeli *et al.*, 2022), offering screening services in non-clinical settings allows asymptomatic individuals an opportunity to test their biochemical markers for CVD risk (Kehrer and James, 2016). Ntusi *et al.* (2019) emphasize that student-led initiatives outside the hospital can facilitate access to pathways to care.

University setting

Globally, university students are known to be leading sedentary and unhealthy lifestyles (Dietz *et al.*, 2022; Tafireyi and Grace, 2022). The health promoting universities (HPU) concept was developed in response to the need to provide students with health promotion and physical activity interventions (Tafireyi and Grace, 2022). The WHO describes a health promoting school/university as a healthy setting for living, learning, and working (WHO, 2023b). The objectives of a health promoting university include the promotion of healthy and sustainable policies for the university, the provision of a healthy working and studying environment, to provide primary care, to encourage academic interest and development in health promotion, and also to develop links with the community (Tafireyi and Grace, 2022).

Suárez-Reyes and Van den Broucke (2016) assert that a university is a setting where many people spend a significant amount of time which makes it an ideal environment to promote health and wellbeing. A systematic review conducted on the implementation of the HPU concept in different

cultural contexts revealed that most universities had the main theme of promoting healthy lifestyle behaviours and other specific interventions adapted to the needs of the population (Suárez-Reyes and Van den Broucke, 2016). According to Ahlstrand *et al.* (2022), improving students' health and health status is essential to ensure good academic performance. It is further emphasised that knowledge of health promoting behaviour will help manage stress and relieve the negative load associated with studies (Ahlstrand *et al.*, 2022).

Other non-clinical settings

Work

Just as the university is a place of learning it is also the workplace of people including professors, administrative staff, and technicians, etc. (Suárez-Reyes and Van den Broucke, 2016). Schouw *et al.* (2018) explains that the workplace influences the health behaviours of individuals through physical and psycho-social methods. A healthy workplace environment can promote the productivity of a business (Schouw *et al.*, 2018). According to the perspective of Schouw *et al.* (2018), the choice of architecture and environmental design predominantly influences the decision of an individual. This highlights the importance of designing interventions that make the healthier choice an easier choice. This is consistent with the ideas of Maredza *et al.* (2011), which elucidate that effective interventions involve making the default choices healthy. As has been shown in the participatory action research by Schouw *et al.* (2018) at a commercial power plant in the Western Cape, South Africa, these innovative suggestions require the involvement of managers and decision-makers to be effective. The managers incorporated healthy meals, extended breaks once a week for physical activity (with demarcated areas for running, cycling, and walking), and a monthly sports day (Schouw *et al.*, 2018).

Community

Research advocates for student-led health interventions to fulfil a service delivery gap in the healthcare system and decrease the burden of healthcare professionals by providing screening and health promotional initiatives in the community and other settings (Banack *et al.*, 2012; Yamamoto-Moreno *et al.*, 2020; Nazar *et al.*, 2021). Participants can conveniently and cost-effectively undergo health testing, thus initiating the continuum of care. This would be per the

objectives of a health promoting university which advises creating links with the community for health promotion (Tafireyi and Grace, 2022).

A systemic review conducted by Suen *et al.* (2020) has revealed that student-led interventions based in “free clinic” settings in the USA have improved cardiovascular markers in patients with cardiovascular disease and its associated risk factors. Furthermore, other student-led health interventions by medical and pharmacy students have led to the improvement of HbA1c values and weight loss (Suen *et al.*, 2020). Moreover, pharmacy student-led discharge counselling led to a better comprehension of medication in about 90% of patients (Suen *et al.*, 2020).

Other screening and health promotion initiatives

Many screening and awareness initiatives have been developed to promote health and facilitate early detection of NCDs and associated risk factors (Yamamoto-Moreno *et al.*, 2020). The International Society of Hypertension (ISH) developed the campaign May Measurement Month (MMM) to create awareness and detect hypertension (Yamamoto-Moreno *et al.*, 2020).

The Rhodes University has a student-led community engagement programme that provides tutoring and screening services to marginalized communities (Rhodes University, 2021). Similarly, the University of the Western Cape has a community engagement programme aimed at the Genadendal community (Plaatjies, 2019). The third-year students from various disciplines provided health, wellness, and wellbeing screening services in Genadendal (Plaatjies, 2019).

The University of Cape Town Cardiac Society launched the Healthy Hearts initiative (Ntusi *et al.*, 2019). The Healthy Hearts initiative aims to create awareness of cardiovascular disease among students and the public in addition to providing screening services to asymptomatic members of the public (Ntusi *et al.*, 2019).

It is evident there should be increased screening and health promotion initiatives in the country. To elicit a behavioural change, it is necessary to have educational programmes that would improve the knowledge of the population on NCDs and their risk factors. The combination of screening and health promotion has the potential to improve the cardiovascular profiles of individuals.

CHAPTER 3: PUBLICATION

At the time of this submission, this article is awaiting submission to the journal: Research in Social and Administrative Pharmacy and is formatted for the journal.

Identification and follow-up of participants with CVD risk factors at a pharmacy-student-led screening and testing programme

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Abstract

Background: The increased prevalence of cardiovascular disease (CVD) and associated risk factors like hypertension, type 2 diabetes, dyslipidaemia, and obesity underscores the need for proactive screening. Given the insidious progression of these conditions, early detection is paramount. Sedentary and unhealthy lifestyles among academic populations are risk factors for CVD. The Screening and Testing Programme for Pharmacy Students (STEPPS), a preventive health screening programme, is a work-based learning initiative at the University of the Witwatersrand that is available to staff and students.

Methodology: Fourth-year pharmacy students conducted screenings for risk factors and measured blood pressure, blood glucose, blood cholesterol, and anthropometric measurements. A retrospective review of the STEPPS 2022 results was conducted. Participants identified with CVD risks were followed up telephonically.

Results: At the time of participation in the STEPPS initiative, participants self-reported diagnoses included hypertension (6.5%), diabetes (2.09%), dyslipidaemia (2.87%), and obesity (3.91%). Elevated readings were observed among 136 (18.25%) participants for blood pressure, 13 (2.83%) participants for blood glucose and 50 (11.36%) participants for blood cholesterol. Among the CVD-related referrals based on abnormal screening results (33 participants), 75% complied. Of these 35% exhibited significant findings, including those with a new diagnosis (43%), escalation of disease (29%) and lifestyle modifications (29%).

Conclusion: The student-led initiative effectively identified the occurrences of undiagnosed and uncontrolled cases at the university. Among follow-up participants, 16 (80%) participants reported undergoing interventions post-screening.

Keywords: cardiovascular, hypertension, pharmacy student, student-led screening, university, diabetes, non-communicable diseases

1. Introduction

Globally, non-communicable diseases (NCDs) such as cardiovascular diseases (CVDs) and diabetes have become the leading cause of morbidity and mortality^{1, 2}. The World Health Organization (WHO) attributes 74% of total mortality to NCDs³. Most of these deaths occur in low-and middle-income countries (LMIC)³. This is concerning as Wagner and Brath (4) explain that the NCDs impact differently in LMIC with earlier morbidity and mortality compared to more developed nations. As a large part of the population in LMICs live in poverty and harsh conditions, the effect of the socioeconomic environment results in heightened susceptibility to disease and poor health prognosis^{1, 5}.

South Africa is struggling with a quadruple burden of diseases which include communicable, non-communicable, perinatal, and maternal and injury-related disorders^{1, 6}. The National Department of Health (NDoH) of South Africa describes NCDs as chronic non-infectious diseases that are of long duration and slow progression⁷. The CVDs and their associated conditions are also known as 'silent killers' as they present with little to no symptoms⁸⁻¹⁰. Merolla *et al*, (11) mentions that screening allows for the identification and staging of undiagnosed diseases during its presymptomatic phase before its clinical manifestation. Thus, it is crucial to make screening and monitoring services accessible to asymptomatic individuals^{12, 13}. Creating a health-enabling

environment allows the opportunity for asymptomatic individuals to screen themselves for CVD risk^{12, 13}.

The university and workplace settings have been identified as an ideal environment for implementing health promotion and prevention strategies¹⁴⁻¹⁷. This is because people from different socio-economic and cultural backgrounds spend a significant amount of time at their places of learning and working^{14, 15}. Researchers report that university students tend to adopt sedentary and unhealthy lifestyles due to academic demands^{17, 18}. Likewise, the working population was found to have underlying risky behaviour and multiple risk factors for NCDs¹⁴. Furthermore, a pedometer-based worksite wellness programme at a university campus by Butler *et al*, (16) successfully improved the fitness levels of the employees. Thus, Butler *et al*, (16) recommend the implementation of worksite wellness programmes which will improve CVD risk factors as they have the potential to decrease the burden of CVD. Moreover, improving the health and well-being of the population at the university and the workplace would result in good academic performance by the students and enhanced productivity of the employees^{14, 18}. It, therefore, presents a valuable opportunity to influence risk behaviour and promote the health of the population^{14, 15}.

Consensus that the prevention of CVD is more effective and less costly to the economy than to treat the people who become sick is evident^{19, 20}. Non-communicable diseases (NCDs) are largely preventable and are identified as lifestyle diseases with few modifiable risk factors that may be targeted, including physical inactivity, unhealthy diet, and harmful use of alcohol and tobacco use^{21, 22}. Hofman (19) asserts that South Africa could enhance the quality of healthcare provided to its population if the number of individuals requiring medical support were reduced. The increasing morbidity and mortality due to NCDs affect the service delivery of healthcare services, quality of life, and the economy^{6, 21}. Abegunde *et al*, (23) estimated the cumulative loss of gross domestic product (GDP) between 2006 and 2015 from stroke, diabetes, and coronary heart disease is ZAR 28.88 billion (USD 1.88 billion). More recently, in 2018, the public sector costs for diagnosed diabetes patients amounted to approximately ZAR 2.7 billion (USD 146 million), and the total costs, including both diagnosed and undiagnosed diabetes patients, were ZAR 21.8 billion (USD 1.1 billion)²⁴. The total cost of all diabetes mellitus type 2 cases is projected to reach ZAR 35.1 billion (USD 1.9 billion) by 2030²⁴.

To effectively prevent, delay the onset, treat, and manage NCDs, there is a need for increased screening and monitoring services^{11, 19, 20}. Initiatives directed at individuals in healthcare settings are limited by lack of access and inconsistent adherence patterns²⁵. Similarly, Ntusi *et al*, (13) explain that many South Africans struggling with CVD are unaware of their diagnosis, and the associated complications and lack the knowledge of both the lifestyle modifications and pharmacological interventions to treat these conditions. This is evidenced by the high proportion of undiagnosed diabetes (53.7%) in South Africa, with 80.6% of people with diabetes having unmet needs²⁶.

There is consistent emphasis on the importance of early detection of NCDs and NCD risk factors, as the earlier they are detected, the sooner the individual can implement lifestyle modifications and/or initiate pharmacological treatment to manage the condition^{10, 27-29}. This is especially important to prevent end-organ damage resulting in morbidity and premature mortality^{19, 30, 31}.

Mayosi *et al*, (6) advocate for national initiatives by the government in collaboration with academic communities to target NCDs in rural and urban settings in South Africa. This is comparable to Hofman (19)'s suggestion of a Health Promotion Foundation (HPF) that would work with the government, research institutions, and society to raise awareness and monitor the NCD burden. As there are healthcare inequalities and the healthcare system is already overburdened, there are suggestions to allow medical students to conduct screening and monitoring of NCDs^{31, 32}. Similarly, a study conducted by Banack *et al*, (29) mentions that pharmacists in community pharmacies are unable to incorporate health promotion and CVD prevention initiatives in daily practice due to time constraints. Suen *et al*, (32) emphasize that student-led interventions allow the students to develop professional skills and competencies but also address the healthcare gaps by providing services to underserved and overlooked communities^{29, 32, 33}.

Pharmacy schools in the UK, Canada, and the USA advocate for the development of clinical skills through work-based learning (WBL) and community outreach events^{12, 34}. This sentiment is shared by pharmacy students as there are insufficient experiential learning opportunities available to practice clinical skills³⁵. Health promotion and screening initiatives providing Point of Care Testing (POCT) allow the students to practice clinical skills in real-life controlled environments under the supervision of facilitators with minimal risk to the patients^{34, 36}.

Health promotion and screening initiatives should be hosted at universities, workplaces and extend to community outreach events/public spaces where the public frequents for daily tasks to make screening more accessible. To facilitate the hosting of the screening event, Crump *et al*, (37) effectively employed a "steering committee" made up of local leaders who guided when the target group was gathered for another purpose. Thus, screening is being made accessible to both overlooked and underserved communities. Furthermore, Yamamoto-Moreno *et al*, (38) highlight how these events allow the opportunity for those people who don't perform regular health screening or have limited access an opportunity to test CVD biochemical markers. Essentially, it is the student-led initiatives outside the hospital that facilitate access to pathways to care ¹³.

Considering the benefit of reaching previously overlooked communities, the clinical pharmacy division at the University of the Witwatersrand launched a preventative health screening and education programme as part of the work-based learning initiative for pharmacy students called Screening and Testing Programme for Pharmacy Students (STEPPS). This programme was established in 2017, where fourth-year pharmacy students are taught how to screen for chronic conditions, using point-of-care testing. This study aims to determine the occurrence of cardiovascular disease risk factors of the STEPPS participants and to determine the effectiveness of the student-led screening initiative.

2. Methodology

2.1. Study design, study population and study setting

A mixed methods study was conducted at the University of Witwatersrand. A total of 911 participants were screened at the STEPPS screening events, 767 participants (>18 years of age) were included in the convenience sample. A retrospective review of the STEPPS 2022 results was conducted. Incomplete records were excluded from the sample. For gender-based health analysis, participants who did not disclose their gender were excluded. Records that had unreliable/erroneous readings were excluded from the analysis to prevent inaccurate analysis and interpretation. Follow-up surveys were conducted with participants that were referred for cardiovascular risk factors.

2.2. Biochemical markers, anthropometric measurements, and demographics

Each participant was screened for risk factor occurrence (medical history and demographical data) using a questionnaire (S1) completed with assistance by a student. The occurrence of hypertension,

diabetes, dyslipidaemia, and obesity was self-reported. Blood pressure (BP) was recorded three times, and the average was used for analysis. A systolic blood pressure (SBP) ≥ 140 mmHg and/or a diastolic blood pressure (DBP) ≥ 90 mmHg were considered abnormal or uncontrolled³⁹. Blood glucose (Fasting Blood Glucose (FBG)/Random Blood Glucose (RBG)) was recorded as abnormal if FBG ≥ 5.6 mmol/l and RBG ≥ 11.1 mmol/l was observed^{40, 41}. Abnormal blood cholesterol was recorded as total cholesterol (TC) ≥ 5.0 mmol/l⁴². A HbA1c and a full lipogram were offered to participants displaying abnormal values for FBG/RBG and/or TC or having family history of these conditions. All participants exhibiting abnormal values were referred for further care to either the university medical doctor, a primary care clinic or preferred medical practitioner, for further investigation. Anthropometric measurements were recorded to determine Body Mass Index (BMI). The BMI values ≥ 30.0 kg/m² were considered obese while Waist Circumference (WC) ≥ 94 cm for men and ≥ 80 cm for women were considered as abdominal (central) obesity and increased risk for the development of NCDs^{40, 43}.

2.3. Follow-up surveys

Twenty participants were telephonically surveyed using a questionnaire (S2). All participants provided consent. Figure 1 depicts the selection process of the follow-up participants. The questionnaire employed in the telephonic interviews primarily consisted of closed-ended questions. The questionnaire was designed to collect a broad range of information relevant to the study objectives including the demographic information, health status, health interventions post-STEPPS screening event, and feedback on the screening event.

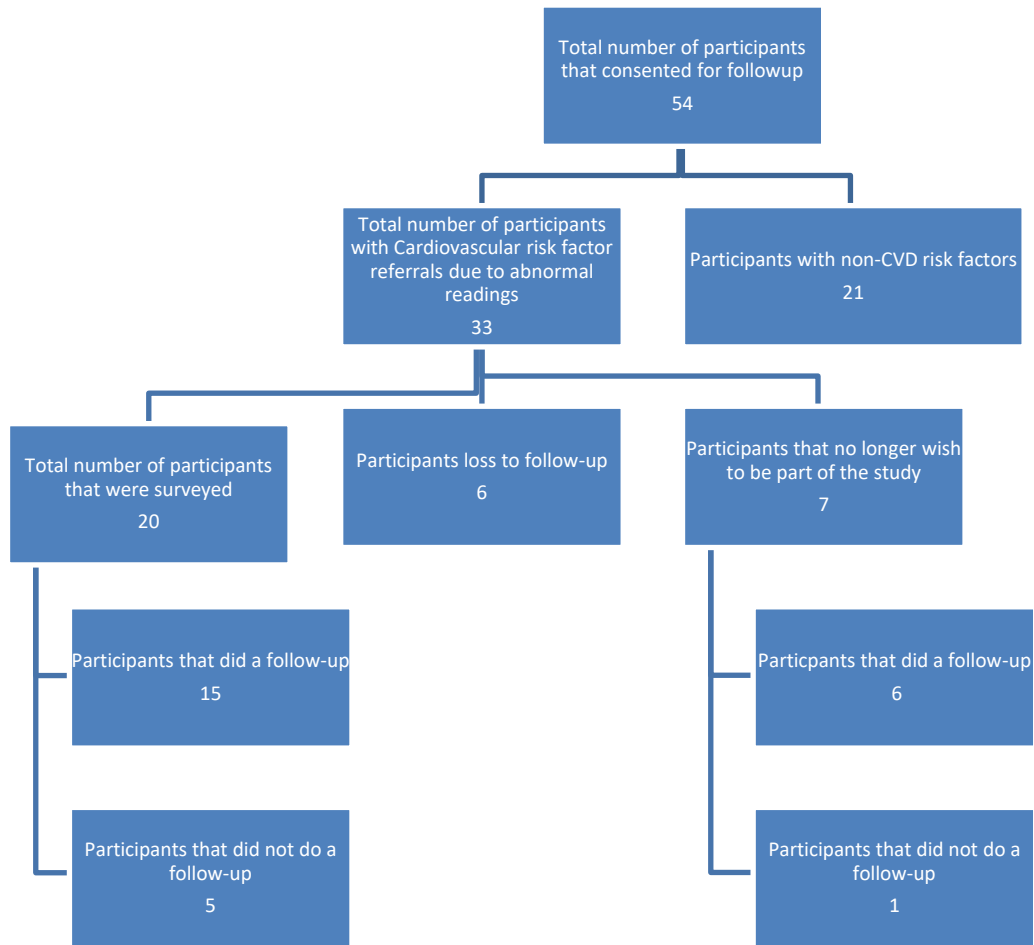


Figure 1: STEPPS CVD referral sample selection

2.4. Statistical analysis

Data were collected and stored in the REDCap® 14.1.4 software. The data were downloaded from the REDCap® system, cleaned, and stored in Microsoft Excel Office® 365 on a password-protected computer and prepared for analysis using STATA/SE® 18.0. The biochemical markers were categorized as abnormal and normal values using the clinical thresholds described in S3 which were compared by demographic characteristics using ANOVA, t-test, and Kruskal-Wallis test as per data distribution. All tests were considered significant at $P < 0.05$. Post hoc testing was conducted using Bonferroni's test and Dunn's test.

2.5. Ethics and consent

Ethics approval was obtained from the Human Research Ethics Committee (Medical) of University of the Witwatersrand (M220918) and consent was obtained from each participant to conduct the study.

3. Results

3.1. Study population

A total of 767 university staff and students participated in the study (Table 1). Out of the total participants, 511(66.62%) identified as females, with 544 (70.93%) of the participants being students. A significant number of participants fell within the age range of 18-24, with 633 (82.53%) of the participants being of African origin/ethnicity. Among the participants, 348/734 (47.41%) stated that they only do screening if it is available as a screening event, while 330/734 (44.96%) participants reported first-time participation in screening.

Table 1: Socio-demographic characteristics and family history of participants

		N=767 (Freq.)	Percent %
Gender	Female	511	66.62
	Male	235	30.64
	Unknown	21	2.74
	Total	767	100
Age range	18-24	512	66.75
	25-34	96	12.52
	35-44	66	8.6
	45-54	55	7.17
	55-64	26	3.39
	65 and above	3	0.39
	Unknown	9	1.17
	Total	767	100
Ethnicity	African	633	82.53
	Asian	29	3.78
	Indian	53	6.91
	Mixed	21	2.74
	White	23	3
	Unknown	8	1.04

		N=767 (Freq.)	Percent %
Total		767	100
Designation	Staff	180	23.47
	Students	544	70.93
	Other	11	1.43
	Unknown	32	4.17
Total		767	100
Medical aid	Yes	286	37.29
	No	457	59.58
	Unknown	24	3.13
Total		767	100
Positive family history (self-reported)	Hypertension	276	35.98
	Diabetes	275	35.85
	Cholesterol	115	14.99
	Obesity	69	9
Alcohol Consumption	1-3 times per month	252	32.86
	1-6 times per week	42	5.48
	Daily	2	0.26
	Never or rarely	464	60.5
	Unknown	7	0.91
	Total	767	100
Smoking	No	574	74.84
	No, but I used to	52	6.78
	Only socially	78	10.17
	Yes	52	6.78
	Unknown	11	1.43
Total		767	100

3.2. Biochemical markers, anthropometric measurements, and demographics

Results of the screening tests are listed in Table 2. Abnormal blood pressure readings were recorded in 136 (18.25%) participants. Hyperglycaemia was found in 13 (2.83% (fasting 2.17 % and random 0.65%)) of the participants. Three of the participants with hyperglycaemia underwent HbA1c testing, two of the participants were found to have an HbA1C $\geq$ 6.5 %. High cholesterol readings were observed in 50 (11.36%) of the participants. Participants that underwent further lipid

panel testing, six were found to have high LDL-C (≥ 3.0 mmol/l), four with high TG (≥ 1.7 mmol/l) and one had high HDL-C. Eligible participants underwent complete lipid profile assessment, however, not all details were recorded, resulting in missing data for the HDL-C, LDL-C and TG.

Table 2: Screening results

Screening results and measurements	Frequency (n)	Percentage (%)
Blood pressure readings		
Normal (<130 mmHG systolic and <85 mmHG diastolic)	294	38.33
High Normal (130-139 mmHG systolic and 85-89 mmHG diastolic)	315	41.07
Isolated Diastolic (< 140 mmHG systolic and ≥ 90 mmHG diastolic)	84	10.95
Isolated Systolic (≥ 140 mmHG systolic and < 90 mmHG diastolic)	16	2.09
Elevated blood pressure reading (≥ 140 mmHG systolic and ≥ 90 mmHG diastolic)	36	4.69
Not measured	22	2.87
Total	767	100
Blood Glucose readings		
Random Hypoglycaemia (<4.0 mmol/L)	84	10.95
Random Normal (5.6-11.0 mmol/L)	306	39.9
Random Hyperglycaemia (≥ 11.1 mmol/L)	3	0.39
Fasting Hypoglycaemia (<4.0 mmol/L)	17	2.22
Fasting Normal (< 5.6 mmol/L)	40	5.22
Fasting Hyperglycaemia (≥ 5.6 mmol/L)	10	1.3
Not measured	307	40.03
Total	767	100
Blood Cholesterol readings		
High Cholesterol (TC ≥ 5.0 mmol/L)	50	6.52
Normal Cholesterol (TC <4.9 mmol/L)	390	50.85
Not tested	327	42.63
Total	767	100
Body Mass Index (BMI)		
Underweight (<18.5 kg/m ²)	37	4.69
Normal weight (<18.5 kg/m ² – 24.9 kg/m ²)	230	29.07
Overweight (25.0 kg/m ² – 29.9 kg/m ²)	134	16.95
Obese (≥ 30.0 kg/m ²)	100	12.39
Not measured	266	36.9
Total	767	100
Waist circumference		
Increased risk Females (≥ 80 cm)	138	17.99
Increased risk Males (≥ 94 cm)	34	4.43
Normal Waist Circumference Females (< 80 cm)	212	27.64
Normal Waist Circumference Males (< 94 cm)	108	14.08
Not measured	275	35.85
Total	767	100

Among the screened individuals 50 (6.50%) reported having hypertension, 16 (2.09%) reported diabetes, 22 (2.87%) reported dyslipidaemia and 30 (3.91%) reported obesity. Among those with hypertension (Table 3), 28 (56.00%) exhibited uncontrolled blood pressure readings. Among participants with diabetes, 3 (18.75%) had hyperglycaemia, while among those with dyslipidaemia, 4 (18.18%) had abnormal cholesterol readings. For individuals reporting obesity, 15 (50.00%) were confirmed to have obesity.

Among participants without pre-existing hypertension (Table 3), 105 (15.51%) displayed blood pressure values ≥ 140 mmHg for systolic and/or ≥ 90 mmHg for diastolic. Among participants without pre-existing diabetes, 9 (2.05%) had FBG values > 5.6 mmol/l. Among participants without pre-existing dyslipidaemia, 45 (10.74%) had high TC values. In participants without self-identified obesity, 79 (16.88%) were identified as having obesity, while 128 (27.35%) were classified as overweight.

Table 3: Screening results and diagnosis of NCD

Results of the screening tests and measurements*	History of Hypertension						History of Diabetes						History of Cholesterol						History of Obesity					
	No		Yes		Total		No		Yes		Total		No		Yes		Total		No		Yes		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Blood Pressure readings																								
Normal (<130 mmHG systolic and <85 mmHG diastolic)	283	41.8	3	6	286	39.3	283	39.9	3	18.8	286	39.4	286	40.6	3	13.6	289	39.8	278	40.2	7	24.1	285	39.6
High Normal (130-139 mmHG systolic and 85-89 mmHG diastolic)	289	42.7	19	38	308	42.4	303	42.7	5	31.2	308	42.4	296	42	10	45.5	306	42.1	298	43.1	8	27.6	306	42.5
Isolated Diastolic (< 140 mmHG systolic and ≥ 90 mmHG diastolic)	70	10.3	13	26	83	11.4	81	11.4	3	18.8	84	11.6	82	11.6	1	4.5	83	11.4	75	10.9	8	27.6	83	11.5
Isolated Systolic (≥ 140 mmHG systolic and < 90 mmHG diastolic)	12	1.8	4	8	16	2.2	14	2	2	12.5	16	2.2	13	1.8	3	13.6	16	2.2	15	2.2	1	3.4	16	2.2
Elevated BP (≥ 140 mmHG systolic and ≥ 90 mmHG diastolic)	23	3.4	11	22	34	4.7	29	4.1	3	18.8	32	4.4	28	4	5	22.7	33	4.5	25	3.6	5	17.2	30	4.2
Total	677	100	50	100	727	100	710	100	16	100	726	100	705	100	22	100	727	100	691	100	29	100	720	100
Blood Glucose readings																								
Random Hypoglycaemia (<4.0 mmol/L)	81	11.7	1	2	82	11	82	11.3	0	0	82	11	81	11.2	1	4.5	82	11	79	11.2	3	10	82	11.1
Random Normal (5.6-11.0 mmol/L)	279	40.2	23	46	302	40.6	294	40.4	8	50	302	40.6	292	40.4	8	36.4	300	40.3	284	40.1	14	46.7	298	40.4
Random Hyperglycaemia (≥11.1 mmol/L)	1	0.1	1	2	2	0.3	0	0	3	18.8	3	0.4	0	0	2	9.1	2	0.3	2	0.3	0	0	2	0.3
Fasting Hypoglycaemia (<4.0 mmol/L)	15	2.2	2	4	17	2.3	17	2.3	0	0	17	2.3	17	2.4	0	0	17	2.3	15	2.1	2	6.7	17	2.3
Fasting Normal (< 5.6 mmol/L)	38	5.5	2	4	40	5.4	38	5.2	1	6.2	39	5.2	39	5.4	1	4.5	40	5.4	38	5.4	1	3.3	39	5.3
Fasting Hyperglycaemia (≥ 5.6 mmol/L)	7	1	2	4	9	1.2	9	1.2	0	0	9	1.2	9	1.2	0	0	9	1.2	9	1.3	0	0	9	1.2
Not tested	273	39.3	19	38	292	39.2	288	39.6	4	25	292	39.2	285	39.4	10	45.5	295	39.6	281	39.7	10	33.3	291	39.4
Total	694	100	50	100	744	100	728	100	16	100	744	100	723	100	22	100	745	100	708	100	30	100	738	100
Blood Cholesterol readings																								
High Cholesterol (TC ≥ 5.0 mmol/L)	44	6.3	6	12.2	50	6.7	47	6.5	1	6.2	48	6.5	45	6.2	4	18.2	49	6.6	44	6.2	3	10	47	6.4
Normal Cholesterol (TC <4.9 mmol/L)	360	51.9	24	49	384	51.7	375	51.6	10	62.5	385	51.8	374	51.8	11	50	385	51.7	367	51.9	15	50	382	51.8
Not tested	290	41.8	19	38.8	309	41.6	305	42	5	31.2	310	41.7	303	42	7	31.8	310	41.7	296	41.9	12	40	308	41.8
Total	694	100	49	100	743	100	727	100	16	100	743	100	722	100	22	100	744	100	707	100	30	100	737	100
Body Mass Index (BMI)																								
Underweight (<18.5 kg/m ²)	36	7.73	0	0	36	7.33	35	7.29	1	8.3	36	7.32	36	7.50	0	0	36	7.35	36	7.69	0	0	36	7.39
Normal weight (<18.5 kg/m ² – 24.9 kg/m ²)	225	48.28	2	8	227	46.23	224	46.67	3	25	227	46.14	226	47.08	2	20	228	46.53	225	48.08	1	5.3	226	46.41

Overweight (25.0 kg/m² – 29.9 kg/m²)	123	26.39	8	32	131	26.68	131	27.29	1	8.3	132	26.83	130	27.08	1	10	131	26.73	128	27.35	3	15.8	131	26.90
Obese (≥ 30.0 kg/m²)	82	17.60	15	60	97	19.76	90	18.75	7	58.3	97	19.72	88	18.33	7	70	95	19.39	79	16.88	15	78.9	94	19.30
Total	466	100	25	100	491	100	480	100	12	100	492	100	480	100	10	100	490	100	468	100	19	100	487	100
Waist circumference																								
Increased risk females (≥ 80 cm)	118	25.6	16	76.2	134	27.8	130	27.4	3	50	133	27.7	128	27	4	66.7	132	27.5	118	25.4	14	87.5	132	27.5
Increased risk males (≥ 94 cm)	30	6.5	3	14.3	33	6.8	33	6.9	0	0	33	6.9	32	6.8	1	16.7	33	6.9	32	6.9	1	6.2	33	6.9
Normal waist circumference females (< 80 cm)	208	45.1	0	0	208	43.2	205	43.2	3	50	208	43.2	208	43.9	1	16.7	209	43.5	206	44.4	1	6.2	207	43.1
Normal waist circumference males (< 94 cm)	105	22.8	2	9.5	107	22.2	107	22.5	0	0	107	22.2	106	22.4	0	0	106	22.1	108	23.3	0	0	108	22.5
Total	461	100	21	100	482	100	475	100	6	100	481	100	474	100	6	100	480	100	464	100	16	100	480	100
Supplementary material S3 provides the parameters for analysis																								

Abnormal blood pressure readings were observed in 51/284 (17.96%) of the participants who consume alcohol and 17/127 (13.39%) of the participants who smoke (Table 4). Among participants who consume alcohol, 6/296 (2.02%) participants had hyperglycaemia while among those who smoke, 4/130 (3.08%) participants had hyperglycaemia. High cholesterol readings were observed in 19/295 (6.44%) participants who consume alcohol and 5/130 (3.8%) participants who smoke.

Table 4: Results of the screening tests and measurements amongst consumers of tobacco and alcohol

Results of the screening tests and measurements	Alcohol consumption								Tobacco consumption					
	1-6 times per week		1-3 times per month		Never or rarely		Total		No		Yes		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Blood Pressure readings														
Normal	15	35.7	94	38.8	184	40.5	293	39.7	226	37.2	62	48.8	288	39.2
High Normal	16	38.1	108	44.6	187	41.2	311	42.1	262	43.2	48	37.8	310	42.2
Isolated Diastolic	8	19	21	8.7	53	11.7	82	11.1	74	12.2	10	7.9	84	11.4
Isolated Systolic	1	2.4	8	3.3	7	1.5	16	2.2	15	2.5	1	0.8	16	2.2
Elevated Blood Pressure reading	2	4.8	11	4.5	23	5.1	36	4.9	30	4.9	6	4.7	36	4.9
Total	42	100	242	100	454	100	738	100	607	100	127	100	734	100
Blood Glucose readings														
Random Hypoglycaemia	8	18.2	23	9.1	51	11	82	10.8	69	11	13	10	82	10.8
Random Normal	8	18.2	88	34.9	208	44.8	304	40	270	43.1	31	23.8	301	39.8
Random Hyperglycaemia	0	0	1	0.4	2	0.4	3	0.4	3	0.5	0	0	3	0.4
Fasting Hypoglycaemia	0	0	4	1.6	13	2.8	17	2.2	16	2.6	1	0.8	17	2.2
Fasting Normal	1	2.3	12	4.8	27	5.8	40	5.3	31	5	9	6.9	40	5.3
Fasting Hyperglycaemia	3	6.8	2	0.8	5	1.1	10	1.3	6	1	4	3.1	10	1.3
Not tested	24	54.5	122	48.4	158	34.1	304	40	231	36.9	72	55.4	303	40.1
Total	44	100	252	100	464	100	760	100	626	100	130	100	756	100
Blood Cholesterol readings														
High Cholesterol	1	2.3	18	7.2	31	6.7	50	6.6	45	7.2	5	3.8	50	6.6
Normal Cholesterol	21	47.7	115	45.8	253	54.5	389	51.3	327	52.3	59	45.4	386	51.1
Not tested	22	50	118	47	180	38.8	320	42.2	253	40.5	66	50.8	319	42.3

Total	44	100	251	100	464	100	759	100	625	100	130	100	755	100
Body Mass Index (BMI)														
Underweight	0	0	13	7.9	24	7.7	37	7.4	31	7.4	6	7.6	37	7.5
Normal weight	15	65.2	59	35.8	155	49.8	229	45.9	182	43.6	46	58.2	228	46.0
Overweight	8	34.8	57	34.5	68	21.9	133	26.7	112	26.9	20	25.3	132	26.6
Obese	0	0	36	21.8	64	20.6	100	20.0	92	22.1	7	8.9	99	20.0
Total	23	100	165	100	311	100	499	100	417	100	79	100	496	100

A statistically significant association was found between the occurrence of diabetes, cholesterol, and obesity across the different ethnic groups, age ranges, and designations with $p < 0.05$ (Table 5). Suggesting that an individual's age, ethnicity, and designation influence the likelihood of the individual developing these conditions. While as in the occurrence of hypertension, a statistically significant association was found only among the different age ranges and designations. Gender distribution of obesity occurrence was statistically significant.

Table 5: Association between diagnosis and demographic factors

History of Hypertension								History of Diabetes								History of Cholesterol								History of Obesity							
	No		Yes		Total		P value	No		Yes		Total		P value	No		Yes		Total		P value	No		Yes		Total		P value			
	N	%	N	%	N	%		N	%	N	%	N	%		N	%	N	%	N	%		N	%	N	%	N	%				
Gender																															
							P=0.274							P=0.123							P=0.086							P=0.003*			
Female	461	68	37	75.5	498	68.5		484	68	13	86.7	497	68.4		481	68	18	85.7	499	68.5		465	67.2	27	93.1	492	68.2				
Male	217	32	12	24.5	229	31.5		228	32	2	13.3	230	31.6		226	32	3	14.3	229	31.5		227	32.8	2	6.9	229	31.8				
Total	678	100	49	100	727	100		712	100	15	100	727	100		707	100	21	100	728	100		692	100	29	100	721	100				
Age range																															
							P<0.001*							P<0.001*							P<0.001*							P<0.001*			
18-24	494	71.8	6	12	500	67.8		497	68.7	5	33.3	502	68		500	69.6	3	14.3	503	68.1		489	69.6	10	33.3	499	68.1				
25-34	89	12.9	6	12	95	12.9		93	12.9	2	13.3	95	12.9		91	12.7	3	14.3	94	12.7		89	12.7	6	20	95	13				
35-44	51	7.4	12	24	63	8.5		64	8.9	1	6.7	65	8.8		62	8.6	3	14.3	65	8.8		58	8.3	5	16.7	63	8.6				
45-54	39	5.7	12	24	51	6.9		48	6.6	1	6.7	49	6.6		45	6.3	4	19	49	6.6		45	6.4	4	13.3	49	6.7				
55-64	12	1.7	14	28	26	3.5		19	2.6	5	33.3	24	3.3		17	2.4	8	38.1	25	3.4		19	2.7	5	16.7	24	3.3				
65 and above	3	0.4	0	0	3	0.4		2	0.3	1	6.7	3	0.4		3	0.4	0	0	3	0.4		3	0.4	0	0	3	0.4				
Total	688	100	50	100	738	100		723	100	15	100	738	100		718	100	21	100	739	100		703	100	30	100	733	100				
Ethnicity																															
							P=0.116							P=0.01*							P<0.001*							P=0.002*			
African	580	84.1	35	71.4	615	83.2		607	83.8	10	62.5	617	83.4		606	84.3	11	52.4	617	83.4		592	84.1	22	73.3	614	83.7				
Asian	24	3.5	5	10.2	29	3.9		29	4	0	0	29	3.9		29	4	0	0	29	3.9		29	4.1	0	0	29	4				
Indian	48	7	5	10.2	53	7.2		51	7	2	12.5	53	7.2		51	7.1	1	4.8	52	7		50	7.1	3	10	53	7.2				
Mixed	18	2.6	2	4.1	20	2.7		18	2.5	2	12.5	20	2.7		16	2.2	3	14.3	19	2.6		14	2	4	13.3	18	2.5				
White	20	3.9	2	4.1	22	3		19	2.6	2	12.5	21	2.8		17	2.4	6	28.6	23	3.1		19	2.7	1	3.3	20	2.7				
Total	690	100	49	100	739	100		724	100	16	100	740	100		719	100	21	100	740	100		704	100	30	100	734	100				
Designation																															
							P<0.001*							P=0.014*							P<0.001*							P<0.001*			
Other	9	1.3	1	2.1	10	1.4		10	1.4	0	0	10	1.4		10	1.4	0	0	10	1.4		10	1.5	1	3.6	11	1.5				
Staff	137	20.4	39	83	176	24.5		165	23.4	8	57.1	173	24.1		160	22.8	14	82.4	174	24.2		155	22.6	17	60.7	172	24.1				
Student	526	78.3	7	14.9	533	74.1		529	75.1	6	42.9	535	74.5		531	75.7	3	17.6	534	74.4		522	76	10	35.7	532	74.4				
Total	672	100	47	100	719	100		704	100	14	100	718	100		701	100	17	100	718	100		687	100	28	100	715	100				
*P < 0.05, significant association between the variables																															

There was a significant association observed between the genders in the anthropometric measurements, systolic blood pressure, and blood cholesterol (Table 6). About 34.5% of the participants had abdominal (central) obesity, based on the WC classification. There were more females with abdominal obesity (27.9%) compared to the males (6.7%). Similarly, obesity was more prevalent in females (23.87%) than in males (12.03%). There were 68/77 (88.3%, 72.7% females and 15.6% males) participants with combined obesity and increased WC classification (Table 7), and there were 58/107 (54.2%, 40.2% females, 14.0% males) with combined overweight and increased WC classification. There were statistically significant differences among the cholesterol levels between the different ethnicities ($p = 0.004$). Across the various age ranges and the designations, a statistically significant association was observed in all the biochemical markers, waist circumference, and BMI ($p < 0.05$).

Table 6: Association between biochemical marker and measurements with demographic characteristics

Biochemical Marker and measurements	Outcome		Mean/Median	P-Value
Weight (kg)	Gender	Male	71 (63-81)	P<0.001*
		Female	64 (54-75)	
		Total	67 (56-78)	
	Age range	18-24	62 (54-72)	P=0.0001*
		25-34	74 (62.5-83)	
		35-44	78 (71-90)	
		45-54	80.5 (71-95)	
		55-64	79 (73-90.25)	
		65 and above	54 (46-92)	
		Total	67 (56-78)	
	Ethnicity	African	67 (56-79)	P=0.5010*
		Asian	68 (53-77)	
		Indian	59 (50-79)	
		Mixed	61.5 (55.5-72)	
		White	63 (53-74)	
	Designations	Total	67 (56-78)	P=0.0001*
		Staff	77.5 (70.5-89)	
		Student	63 (54.25-73)	
		Other	82 (71.5-94)	
Height (m)	Gender	Male	1.7 (1.57-1.69)	P<0.001*
		Female	1.6 (1.56-1.64)	
		Total	1.6 (1.57-1.69)	
	Age range	18-24	1.62 (1.58-1.69)	P=0.6270
		25-34	1.64 (1.56-1.7)	
		35-44	1.64 (1.59-1.71)	
		45-54	1.64 (1.57-1.7)	
		55-64	1.59 (1.56-1.69)	
		65 and above	1.54 (1.47-1.61)	
		Total	1.62 (1.57-1.69)	
	Ethnicity	African	1.62 (1.58-1.69)	P=0.4350
		Asian	1.68 (1.55-1.72)	
		Indian	1.61 (1.56-1.67)	
		Mixed	1.57 (1.56-1.66)	
		White	1.62 (1.57-1.66)	
	Total	Total	1.62 (1.57-1.69)	

Biochemical Marker and measurements	Outcome		Mean/Median	P-Value
Waist circumference (cm)	Designations	Staff	1.62 (1.57-1.68)	P=0.5822
		Student	1.62 (1.58-1.69)	
		Other	1.69 (1.6-1.75)	
		Total	1.62 (1.57-1.69)	
	Gender	Male	80 (73-93))	P=0.0002*
		Female	75 (68-87)	
		Total	77 (69-89)	
	Age range	18-24	73.5 (67-80)	P<0.001*
		25-34	87 (75-93)	
		35-44	95.5 (81-102)	
		45-54	94 (89-105)	
		55-64	95 (72-110)	
		65 and above		
		Total	77 (69-89)	
	Ethnicity	African	77 (69-89)	0.2390
		Asian	85.5 (75.5-95.5)	
		Indian	77.5 (65-89)	
		Mixed	72.75 (71-87)	
		White	73 (70-77)	
		Total	77(69-89)	
	Designations	Staff	93 (83-102)	P=0.0001*
		Student	74 (67-80)	
		Other	91 (82-102)	
		Total	77 (69-88.5)	
Body Mass Index (BMI) (Kg/m ²)	Gender	Male	24.03 (21.23-27.17)	P=0.0690
		Female	24.8 (21.21-29.71)	
		Total	24.37 (21.22-28.78)	
	Age range	18-24	22.77 (20.42-25.97)	P=0.0001*
		25-34	27.71 (25.06-31.18)	
		35-44	29.55 (26.17-35.59)	
		45-54	30.62 (26.22-36.37)	
		55-64	29.82 (25.5-34.71)	
		65 and above	-	
		Total	24.25 (21.22-28.7)	
	Ethnicity	African	24.57 (21.23-28.95)	P=0.6530
		Asian	23.88 (22.06-26.41)	
		Indian	22.19 (19.83-28.52)	
		Mixed	23.73 (22.14-27.86)	
		White	23.05 (22.6-27.55)	
		Total	24.31 (21.23-28.7)	
	Designations	Staff	29.55 (25.91-34.96)	P=0.0001*
		Student	22.86 (20.45-26.43)	
		Other	33.72 (26.29-37.24)	
		Total	24.24 (21.22-28.52)	
Average Systolic Blood pressure (mmHg)	Gender	Male	125.44	P<0.001*
		Female	115.13	
		Total	118.34	
	Age range	18-24	114.96	P=0.0040*
		25-34	119.24	
		35-44	129.09	
		45-54	127.22	
		55-64	134.65	
		65 and above	131.5	
		Total	118.37	
	Ethnicity	African	118.26	P=0.5190
		Asian	119.86	
		Indian	116.63	
		Mixed	123.38	
		White	118.15	
		Total	118.34	
	Designations	Staff	126.57	P=0.0010*

Biochemical Marker and measurements	Outcome		Mean/Median	P-Value
Average Diastolic Blood pressure (mmHg)		Student	115.18	
		Other	126.6	
		Total	118.16	
	Gender	Male	81.7	P=0.0849
		Female	80.33	
		Total	80.76	
	Age range	18-24	78.11	P<0.001*
		25-34	83.44	
		35-44	88.41	
		45-54	87.66	
		55-64	86.72	
		65 and above	85.5	
		Total	80.68	
	Ethnicity	African	80.52	P=0.5700
		Asian	80.19	
		Indian	81.44	
		Mixed	83.77	
		White	81.07	
		Total	80.68	
	Designations	Staff	86.52	P<0.001*
		Student	78.46	
		Other	86.91	
		Total	80.57	
Blood Glucose (mmol/l)	Gender	Male	4.8 (4.1-5.5)	P=0.4390
		Female	4.9 (4.2-5.7)	
		Total	4.8 (4.2-5.7)	
	Age range	18-24	4.8 (4.0-5.5)	P=0.0022*
		25-34	4.85 (4.4-5.65)	
		35-44	5.35 (4.4-6.15)	
		45-54	5.4 (4.6-5.9)	
		55-64	5.0 (4.4-5.9)	
		65 and above	6.45 (5.1-7.8)	
		Total	4.8 (4.2-5.7)	
	Ethnicity	African	4.8 (2.94-4.44)	P=0.3650
		Asian	5.5 (4.3-5.7)	
		Indian	5.1 (4.6-5.8)	
		Mixed	5.0 (4.2-5.7)	
		White	4.9 (4.3-5.7)	
		Total	4.8 (4.2-5.7)	
	Designations	Staff	5.2 (4.5-6)	P=0.0010*
		Student	4.8 (4-5.5)	
		Other	4.6 (4.3-6)	
		Total	4.8 (4.2-5.7)	
Blood Cholesterol (mmol/l)	Gender	Male	3.2 (2.63-4.16)	P<0.001*
		Female	3.92 (3.2-4.6)	
		Total	3.79 (2.3-4.52)	
	Age range	18-24	3.48 (2.89-4.3)	P=0.0001*
		25-34	4.1 (3.49-4.8)	
		35-44	4.41 (3.12-5.3)	
		45-54	4.44 (3.68-5.04)	
		55-64	3.87 (3.48-5.02)	
		65 and above	3.96 (2.92-5)	
		Total	3.77 (2.97-4.47)	
	Ethnicity	African	3.65 (2.94-4.44)	P=0.0040*
		Asian	4.68 (4.13-5.24)	
		Indian	4.09 (3.37-4.73)	
		Mixed	3.95 (3.05-4.44)	
		White	3.8 (3.35-5.1)	
		Total	3.78 (2.97-4.5)	
	Designations	Staff	4.44 (3.65-5.03)	P=0.0001*
		Student	3.52 (2.93-4.34)	
		Other	4.2 (3.89-4.38)	

Biochemical Marker and measurements	Outcome		Mean/Median	P-Value
		Total	3.79 (2.99-4.52)	
*P < 0.05, significant association between the variables				

Table 7: Waist category compared to the Body Mass Index (BMI)

Waist category	Body Mass Index				Total
	Underweight	Normal weight	Overweight	Obese	
Increased risk Females	1	5	43	56	105
Increased risk Males	0	1	15	12	28
Normal WC Females	21	101	29	7	158
Normal WC Males	4	66	20	2	92
Total	26	173	107	77	383

3.3. Follow-up surveys

There was a 60.61% (20/33) response rate for the follow-up surveys. Of the 33 participants that were contacted, a total of 15 (75%) participants went for further care post-STEPPS screening event. Seven of the participants reported that they had significant findings (Figure 2). Two participants found that the severity of their condition had worsened, whilst three participants were newly diagnosed with either hypertension or diabetes. Many of the participants cited reasons such as lack of perceived need to screen, cost, and time constraints due to work/study as factors contributing to the inability to establish routine screening. The interventions the participants chose to take are depicted in Figure 3, with 16 of the participants reporting that STEPPs encouraged them to take these steps.

Table 8: STEPPS follow-up participants and their responses

	Frequency (n)	Percent (%)
Age range		
18-24	6	30
25-34	1	5
35-44	4	20
45-54	4	20
55-64	5	25
Total	20	100
Gender	Frequency (n)	
Female	13	65
Male	7	35
Total	20	100
Further care was sought after STEPPS referral	Frequency (N)	
No	5	25
Yes	15	75
Total	20	100
Significant findings after further care	Frequency (n)	Percent (%)
Yes	7	35
No	8	40
Not applicable	5	25
Total	20	100

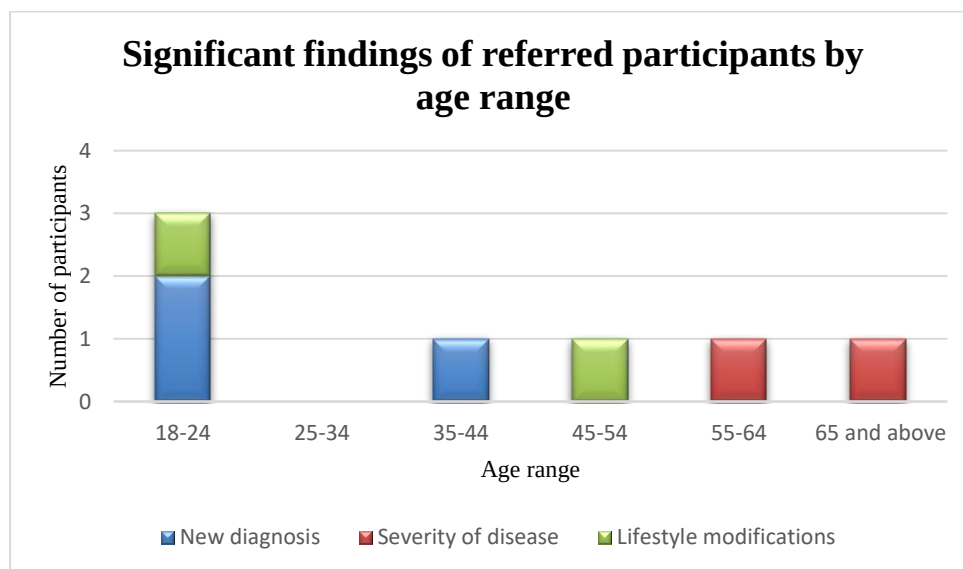


Figure 2: Details of the findings of the referred participants

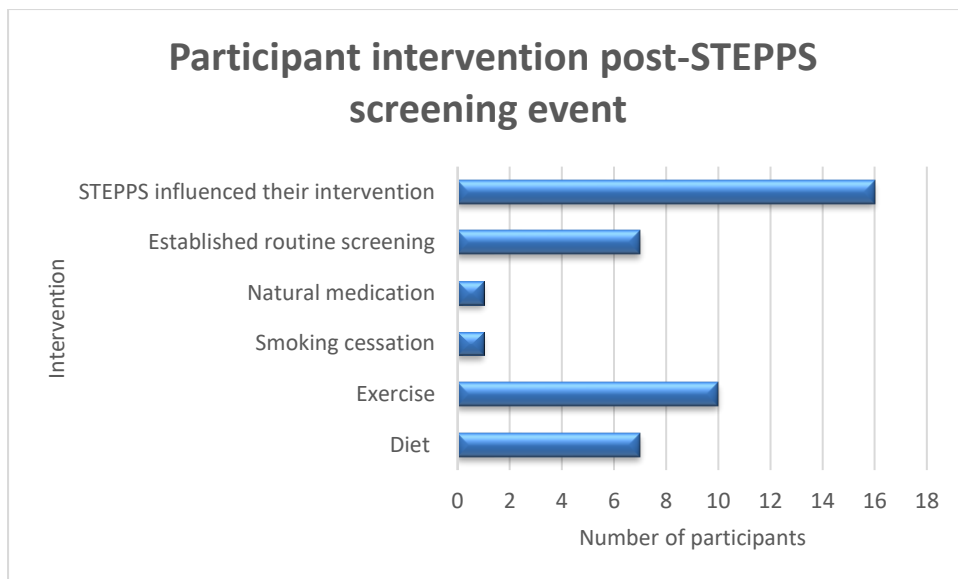


Figure 3: Intervention post-STEPPS screening event

4. Discussion

The STEPPS screening initiative has demonstrated the practicality of empowering students to conduct a CVD risk factor screening event at a university. This study highlights a notable occurrence of cardiovascular risk factors among the University staff and students. The results emphasize the importance of routine screening, as a notable proportion of participants who were previously unaware of any conditions exhibited biochemical readings indicative of hypertension, diabetes, dyslipidaemia, and obesity. The elevated biochemical readings and measurements may be due to an underlying condition or a pre-diagnosis stage of the condition. As NCDs develop over decades, these participants are unlikely to seek further care until symptomatic.

It is widely acknowledged an individual's demographic profile influences the determination of the CVD risk factor profile⁴⁴⁻⁴⁶. There are four demographic characteristics, namely the age range, gender, ethnicity, and designation/occupation which were analysed for associations with the occurrence of hypertension, diabetes, cholesterol, obesity, and their biochemical markers. Apart from SBP and DBP, definitive inferences could not be drawn due to the non-normal distribution of the data.

The findings of the current study have identified the occurrence of self-reported hypertension as 6.5%. Among the staff, there were 39/180 (21.67%) staff members that indicated they have hypertension, this is comparable to the occurrence of hypertension of the staff population at

Makerere University, Uganda (20.6%) and at the University of the Western Cape (UWC), South Africa (26.9%)^{47, 48}. In contrast, there were 7/533 (1.31%) students that indicated they have hypertension which is comparable the findings at the Walter Sisulu University, where no students were diagnosed with hypertension⁴⁹. However, much lower than the occurrence of hypertension (22.1%) among the student population at the King Abdulaziz University (KAU) Jeddah, Kingdom of Saudi Arabia (KSA)⁵⁰.

Although all these universities were in the urban region, this discrepancy may be due to the geographical locations, socio-cultural factors, and lifestyles, as Uganda and South Africa may have more similarities as they are both in Africa in comparison to KSA. It may also be due to the availability of healthcare services and as such detection, as KSA is identified as a more developed nation compared to the African countries, which are identified as Low-and-Middle Income Countries (LMIC). Furthermore, it was found that there were 133/727 (18.3%) participants (14.4% undiagnosed, 3.8% previously diagnosed) with high blood pressure readings, indicating the presence of potentially undiagnosed and poorly controlled hypertension in this study.

The hypertension occurrence, SBP, and DBP in this study were strongly associated ($P < 0.05$) with the individual's age and designation, indicating that age and the occupation of an individual may influence the BP readings. This was found to be the case in Eng *et al*, (51)'s study, where participants with higher occupational status and more stressful occupations were found to have higher SBP. Consistent with Shisana *et al*, (52)'s findings, there was a significant association between the SBP between the genders ($P = 0.0000$), with the males showing higher SBP means compared to the females. There was no significant association found between the genders for DBP. Although the occurrence of increased blood pressure readings among the males (20.4%) and females (17.4%) were similar, the results agree with other studies where the males are more likely to have hypertension compared to females^{47, 53}. Hypertension was also the most common condition reported.

It was found that the occurrence of self-reported diabetes in the current study was 2.09%. The self-reported occurrence of the staff in this study (4.44%) and at UWC (5.1%) were very similar, while the student population at KAU had 15.6% reported high blood sugar^{48, 50}. The screening results revealed 13 (2.83%) participants (76.9% undiagnosed, 23.08% previously diagnosed) with high blood sugar which was much higher than the undiagnosed population with high blood sugar (45.5%) found at the upstate New York college⁵⁴ (53). The authors

attribute the high levels of impaired fasting glucose to the high levels of diabetes type 2 risk factors such as physical inactivity (61.4%) and increased BMI ($\geq 25\text{kg/m}^2$) (36.4%) among the population⁵⁴. Although the current study revealed that the occurrence of increased BMI was also high (46.7%), the physical activity level was not assessed. Notably, approximately 36% of the participants in this study indicated that this was their first screening event which may explain the increased undiagnosed participants. There is limited data on the HbA1c result of the participants, however, among the 13 participants that exhibited high blood sugar, three participants consented to the HbA1c test provided, which revealed two (one was previously diagnosed) of them had high HbA1c levels ($\geq 6.5\%$). This indicates that one of them was undiagnosed and the other was an uncontrolled diabetic. The presence of undiagnosed diabetes underscores a significant deficiency in regular health check-ups and screenings, potentially leading to severe complications if not promptly addressed. Conversely, the case of uncontrolled diabetes highlights the imperative need for improved management and monitoring of individuals with a diagnosis. Inadequate diabetes control may result from insufficient follow-up, limited access to medications, or a lack of comprehensive patient education on lifestyle modifications and adherence to treatment regimens.

Notably, the age, designation, and ethnicity of participants were significantly associated with the occurrence of diabetes. Both age and designation are also correlated to an individual's blood glucose levels. Tagorda Jr *et al*, (55) found that age had a significant association with diabetes, with the older population more likely to develop diabetes compared to the younger population. In general, aging was closely linked to cardiovascular and metabolic disorders^{55, 56}, which is consistent with the findings of this study.

Concerning the occurrence of dyslipidaemia in this study, the self-reported diagnosis of cholesterol was 2.87%. The staff (7.8%) had a much lower self-reported cholesterol occurrence compared to the staff at UWC (23.1%)⁴⁸. This could be due to the staff population at UWC being restricted to administrative staff while this study does not restrict it to admin staff only and may include staff (such as cleaners, academics, researchers and security) that may be more active instead of sedentary compared to staff with administrative roles. The cholesterol screening results indicated that 8.5% of individuals were potentially undiagnosed or unaware of their cholesterol status. There were 55 participants with one abnormal lipid parameter and at least six participants with two abnormal lipid parameters. It was found that 12.78% of staff had high cholesterol, although the observed TC was higher than the self-reported cholesterol,

indicating high levels of unawareness, however, it was much lower than the measured cholesterol (40%) of the staff population at a university in KwaZulu Natal⁵⁷.

All demographic characteristics were significantly associated with cholesterol occurrence ($P < 0.05$) while only the blood cholesterol biomarker exhibited a significant association with ethnicity. This is consistent with findings indicating that the ethnicity of an individual may influence the risk of dyslipidaemia as it was found that lower TC and higher HDL levels were more common among individuals of African origin compared to other ethnicities^{6, 42, 58, 59}.

In this study, it was found that the observed obesity (12.39%) was three times the self-reported obesity (3.91%). The screening outcomes among the staff population in this study revealed high rates of classification as overweight (38.8%) and obesity (44.8%) which is inconsistent with other studies that had overall lower rates of overweight and obesity^{47, 55, 60, 61}. In contrast, the observation of increased BMI ($\geq 25\text{kg/m}^2$) (34.16%) among the student population was similar to other student populations at the University of Botswana (36.8%) and New York College (36.4%)^{54, 62}. This could be explained by the demographic difference between the staff and student populations, as most students fall within the 18-24 age range, whereas staff members are generally older. It's commonly observed that as individuals age, they are more likely to experience overweight and obesity⁶².

The occurrence of obesity had a significant association with each of the demographic characteristics ($P < 0.05$), while only certain anthropometric measurements demonstrated a significant association (Table 6). The occurrence of obesity was more prevalent in women (23.87%) compared to the males (12.03%) in this study, consistent with the findings of Nakhooda and Wiles (63), about the student population of the University of Kwa-Zulu Natal, South Africa. However, international studies have shown a different trend. For instance, McCarthy and Warne (60) examined gender differences in the physical activity status and knowledge of Irish university students and staff, while Abu Shanab and Al-Sabbah (64) assessed the prevalence of overweight and obesity among university students at a Palestinian university. Both studies found that the occurrence of obesity was higher among males compared to females^{60, 64}.

An individual's BMI is unable to differentiate between lean mass and fat mass and the fat distribution of the individual⁶⁵. In terms of determining CVD risk, BMI is not the only indicator of risk, central obesity and visceral obesity may also predict CVD risk^{28, 66}. The staff population in this study that was at increased risk (79.4%) due to abdominal (central) obesity, was

comparable to the staff population at the Western Cape University (73.1%)⁴⁸. In contrast, the student population (21.3%) with abdominal (central) obesity was found to be lower to a study based at Stellenbosch University that assessed the metabolic risk status among third-year physiology students, where 25% of female students and 14% of males exhibited waist circumferences above the accepted range⁶⁷. This study also found higher occurrences of abdominal obesity among females compared to males.

A better indication of CVD risk is the combined occurrence of increased BMI and WC, indicating the presence of android obesity. In the study conducted by Doi and Shah (65), obese participants and their anthropometric measurements were compared to their CVD risk factors to compare the risk between gynoid obesity and android obesity. It was found that CVD risk factors were significantly associated with android obesity Doi and Shah (65). Among those with abdominal obesity, 88.3% were obese and 54.2% were overweight.

A total of 130 participants (16.95%) smoke regularly and socially, which is comparable to the 16.2% national average in South Africa⁶⁸. Interestingly, a university in Uganda, had zero active smokers among the staff population, due to a zero-smoking policy at the university and smoking cessation information readily available in urban settings⁴⁷. Remarkably, a university workplace health promotion programme aimed at preventing NCDs examined the health of its employees over six years and discovered that although smokers' baseline blood pressure was higher than non-smokers', the SBP decreased more than non-smokers' during this period⁵¹.

Notably, a considerable number (46.9%) of participants indicated that they engage in screening exclusively when it is offered as a dedicated screening event. One of the reasons cited for the non-establishment of routine screening was the expense involved, however, 37.9% of the participants indicated that they have medical aid. Interestingly, even among those with medical aid, 45.6% stated that they only underwent screening during screening events, and ~36% mentioned that this was their first screening event. This suggests that financial constraints may hinder some participants from organising regular screening, however, others may still choose not to establish routine screening even if it is covered by their medical aid. This highlights the idea that participants are unlikely to actively pursue screening and preventative measures unless they are provided within the framework of their education or work environment. Participants unanimously agreed that the campus was an ideal place to conduct screening and hoped there were more stations and more regular screenings taking place. They further

suggested other places where they would like to have similar screening stations, such as malls, community places, and workplaces.

In the context of the May Measurement Month global initiative, BP measurements were recorded from an opportunistic sample in South Africa. The findings reveal a significant prevalence (29.7%) of hypertension, coupled with a lack of awareness (45.7%) about the condition⁵³. This is consistent with the findings of Kamerman (56) who cites concerns over the increased underdiagnosis of hypertension and diabetes that was found in his assessment using the 2016 South African Demographic and Health Survey (SADHS), which draws a nationally representative sample of the population. It was found that the prevalence for hypertension, based on recall was 18.9% while the measured prevalence using blood pressure measurements was 37.1%, indicating that 49% of the cases are potentially undiagnosed. Similarly, the prevalence for diabetes mellitus, based on recall was 4.5% while the measured prevalence based on the HbA1c values was 11.4%, indicating that about 61% of the cases are potentially undiagnosed. Of particular concern is the lack of awareness among the young population, where Woodiwiss *et al*, (53) found that 76% of the young population in their study (< 40 years of age) were unaware of their blood pressure readings, while Kamerman (56) mentions that the biggest percentage difference in recall and measured blood pressure measurement was in the youngest group (15 – 24, 2.3% v. 15.2%). This highlights the importance of health promotion and screening initiatives directed at younger populations and individuals who are less likely to seek healthcare services, especially since many participants only conducted screening as it was offered at the screening event. This is reinforced by the striking revelation that among the seven referred participants with significant findings during the follow-up surveys, three (42.9%) participants in this study were within the 18-24 age range, encompassing two (28.6%) newly diagnosed cases and one (14.3%) participant was provided recommendations for lifestyle modification to halt disease progression (Table 8).

This observation highlights a concerning occurrence of early onset CVD risk factors among young adults. The identification of new cases within this age group underscores the importance of early screening and intervention. Moreover, the provision of lifestyle modification recommendations to a young participant signifies the potential of university-based screening programs to influence health behaviours and potentially mitigate long-term disease progression. These findings suggest that such screening initiatives can play a crucial role in early detection and intervention, thereby potentially reducing the burden of CVD over time.

The results align with the research question, which aims to assess the occurrence of cardiovascular diseases identified at the STEPPS screening events during 2022 and to evaluate the impact of a university-based screening program on the health interventions for referred patients. The data from this study indicate that the screening program not only identifies individuals at risk but also facilitates timely recommendations and interventions, particularly among younger populations who may benefit the most from early lifestyle changes.

Regarding the perception of the participants toward screening services offered, all participants reported that they were comfortable during the screening sessions and the results were explained to them. Furthermore, all participants state that they will “Definitely recommend” (15/20) and are “likely to recommend” (5/20) the screening event to family and friends (Figure 4). Participants had an overall positive perception regarding student-led screening aligning with the conclusions drawn by Bastianelli *et al*, (33) regarding public perception of POCT screening conducted by pharmacy students.

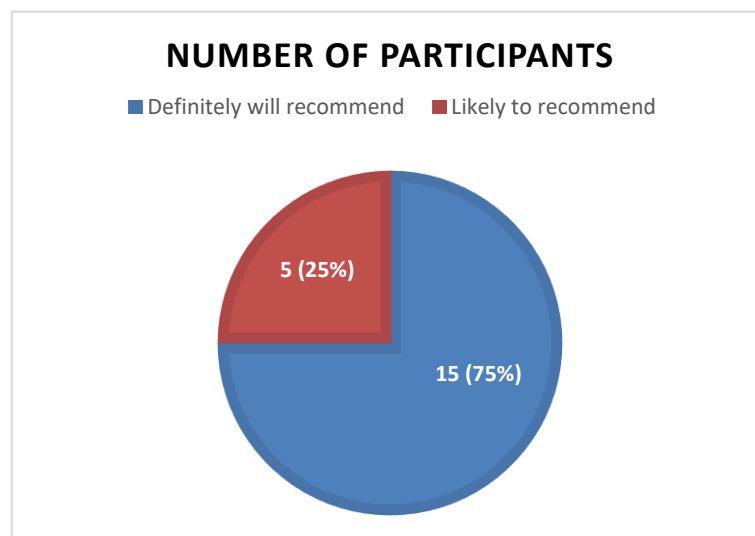


Figure 4: Likelihood of participants recommendation

Remarkably, among the reported post-intervention findings, it is noteworthy that the proportion of participants without significant findings (40%) exceeded the significant ones. This disparity may be attributed to transient factors such as caffeine intake, recent physical activity, or stress that may have influenced the elevated readings during the STEPPS screening. One participant’s experience exemplifies this observation, despite being referred for elevated blood pressure

readings, subsequent screening revealed normalized blood pressure. The participant attributed the initial elevated reading to heightened academic and personal stress levels at the time of the STEPPS screening event. One participant expressed a preference for student-led screening as there was less fear of health practitioners and the students were receptive to questions. This suggests that the participant favoured student-led screening over health practitioners' screenings, possibly because they felt less intimidated by the students. It also demonstrates that students were more willing to answer questions and the participant viewed them as a dependable source of information. This is consistent with the findings observed by Bastianelli *et al*, (33), which indicate that the patients perceived graduate pharmacy students as a reliable source of general health information.

Limitations

Incomplete records and insufficient participant information posed challenges in accurately representing the sample, introducing potential biases. Participants in this study are self-selected; therefore, they may not be representative of the university population at large. Given the participants demonstrated interest in this initiative, they may skew towards a healthier or health-conscious mindset, comprising self-motivated individuals.

Additionally, reliance on self-reported data for the occurrence of conditions and follow-up behaviours introduces a significant limitation. The absence of means to verify and validate this information extends to the assessment of long-term health behaviour changes. Concerns also arise regarding the timing and regularity of participant follow-up, with potential recall bias affecting responses to subsequent surveys. Factors such as the complexity of consent procedures and changing contact details, particularly as participants leave the university, contribute to loss in follow-up. While participant satisfaction was predominantly positive, it is essential to consider potential biases, including patient bias stemming from the provision of free healthcare services and social desirability bias where the participants overreport positive behaviour.

Despite the low incidence of hypertension, diabetes, cholesterol, and obesity within the study cohort, it's crucial not to overlook the prevalence of undiagnosed or unaware CVD risk factors. This is particularly significant given the considerable disparity between self-reported and measured CVD cases. The presence of non-modifiable risk factors such as family history needs to be considered. Among the participants, a notable percentage had a family history of

hypertension (~36%), diabetes (35.9%), cholesterol (~15%), and obesity (~9%) which may amplify their CVD risk, further emphasizing the need for attention. Additionally, unexplored modifiable factors like physical activity and nutrient intake warrant consideration. Moreover, the voluntary nature of test selection and further screening tests (HbA1c and lipid panel), coupled with the potential for participants to decline or refuse follow-up, introduces the possibility of underestimating CVD risk. Hence, any assumptions regarding occurrence should be approached with caution.

Recommendations:

A few recommendations may improve this study for future research. To promote the expansion of similar initiatives, other South African universities may consider initiating student-led screening and testing programmes.

To ensure the completeness of screenings, students should adhere to a more structured approach or employ a therapeutic outline. In addition to the clinical training, students should receive training in data collection techniques. Expanding the data collection tool/questionnaire to include a section on behavioural risk factors could provide valuable insights into the participants' physical activity levels and nutrient intake. Encouraging participants to be more receptive to follow-up surveys is crucial for assessing linkage to care and ensuring participant retention.

5. Conclusion

Student-led screening initiatives are appreciated by the recipients of the service at the university, with requests to expand the initiative. The screening results revealed a significant number of participants presenting with abnormal readings for blood pressure, blood glucose and blood cholesterol, with few of the participants being uncontrolled and undiagnosed as was seen with the follow-up survey participants. This indicates a presence of CVD risk factors among the university population. While there may have been few significant findings, it succeeded in raising participants' awareness of their health conditions and allowed the participants to engage with pharmacy students regarding their health. Awareness of an individual about one's NCD status may be a contributor to timely interventions. These health promotion initiatives are essential to facilitate early detection and for redirecting focus towards preventative measures, thereby fostering overall well-being. Furthermore, work-based learning initiatives like these empower students to actively practice and refine clinical skills.

Conflicting interests:

The authors declare no conflict of interest.

Author contributions:

UBQ conducted the study for a masters degree under the supervision of AO, RK and MV. All data were collected (STEPPS follow-up) and analysed by UBQ. The manuscript was written by UBQ and revisions were made by AO, RK and MV. All authors approved the final version.

Data availability:

Permission to use STEPPS 2022 data was granted by the Pharmacy department. Data is available on request.

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Supplementary materials

S1: STEPPS wellness questionnaire

Name and Surname:	
ID number/ DOB (yyyy/mm/dd):	
Signature:	
Date	

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MANUAL ENTRY QUESTIONNAIRE FOR STEPPS WELLNESS DAY	
PERSONAL & DEMOGRAPHIC DATA	
Date:	Designation: ☐ Staff ☐ Student ☐ Other
Please confirm that you understand and give permission for the Wellness Screenings to be performed on you and for your data to be recorded	☐ Yes ☐ No
Site	☐ Main Campus ☐ Education Campus ☐ Wits Res ☐ health Sciences Campus ☐ Outside wits
Please indicate your age range	☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65 and above
What is your sex?	☐ Male ☐ Female ☐ Other ☐ I do not wish to disclose
Ethnicity (Self-declared)	☐ African ☐ White ☐ Indian ☐ Mixed ☐ Asian ☐ Other
Level of education	☐ None ☐ Primary School ☐ Secondary School ☐ Matric Certificate ☐ Certificate ☐ Diploma ☐ Bachelors/Honours ☐ Masters degree ☐ PHD
What is your Occupation	
Are you on medical aid	☐ Yes ☐ No
If on medical aid, are you on any medical aid specific diabetes/hypertension/dyslipidaemia program?	☐ Yes ☐ No ☐ N/A
MEDICAL HISTORY	
Have you ever been diagnosed with Hypertension? (except in pregnancy)	☐ Yes ☐ No
Do you have a family history of Hypertension?	☐ Yes ☐ No ☐ N/A
When was your blood pressure (BP) last measured?	☐ Never ☐ Over 12 Months ago ☐ Within the last 12 months
Are you currently on prescribed blood pressure lowering treatment? If yes, please specify the medication?	☐ Yes ☐ No
For how long have you been taking the medication?	☐ Less than 1 year ☐ 1-5years ☐ >5years

Have you ever been diagnosed with diabetes? (except in pregnancy) If yes specify	☐ Yes ☐ No ☐ Type 1 ☐ Type 2 ☐ Other
Do you have a family history of diabetes?	☐ Yes ☐ No
When was your blood glucose level last measured	☐ Never ☐ Over 12 Months ago ☐ Within the last 12 months
Are you currently on prescribed diabetes medication? If yes specify the medication	☐ Yes ☐ No
For how long have you been taking the medication?	☐ Less than 1 year ☐ 1-5years ☐ >5years
Have you ever been diagnosed with High Cholesterol?	☐ Yes ☐ No
Do you have a family history of high cholesterol	☐ Yes ☐ No
When was your Cholesterol level last measured?	☐ Never ☐ Over 12 Months ago ☐ Within the last 12 months
Are you on any cholesterol lowering medication? If yes specify the medication	☐ Yes ☐ No
For how long have you been taking the medication?	☐ Less than 1 year ☐ 1-5years ☐ >5years
Have you ever been classified as overweight or obese by a health professional?	☐ Yes ☐ No
Are you on any prescribed weight loss medication? If yes specify the medication	☐ Yes ☐ No
For how long have you been taking the medication?	☐ Less than 1 year ☐ 1-5years ☐ >5years
To your best knowledge, are you pregnant?	☐ Yes ☐ No
How often do you consume alcohol?	☐ Never or rarely ☐ Less than once a week ☐ Regularly (More than one a week)
Do you smoke?	☐ Yes ☐ No
Are you currently fasting?	☐ Yes ☐ No
Do you have any other chronic condition besides the ones indicated above? If yes specify	☐ Yes ☐ No
Are you currently taking any other chronic or natural medication? If yes specify	☐ Yes ☐ No
Are you currently on other medication that is not chronic? If yes specify	☐ Yes ☐ No
WELLNESS TEST SELECTED (SELECT MOST APT BASED ON HISTORY)	
☐ BMI ☐ BP ☐ Blood Glucose ☐ Total Cholesterol ☐ Waist Circumference ☐ HBA1c ☐ Lipid Panel ☐ Hemoglobin ☐ Uric acid ☐ ECG	
RESULTS	
Weight: _____ kg	Height: _____ m
Waist Circumference: _____ cm	
BP (mm/Hg) (INSERT FIGURES) 1. _____ / _____ p = _____	Device used: 2. _____ / _____ p = _____
3. _____ / _____ p = _____	

Last meal, time:		Blood Glucose: _____ mmol/l Device: _____ Test: Random/Fasting	HbA1c: _____ %
Total Cholesterol: _____ mmol/l Device:		Haemoglobin: _____ mg/dl Known anemia: ☐ Yes ☐ No	Uric acid: _____ mg/dl Known gout: ☐ Yes ☐ No
HIV: ☐ +ve ☐ -ve	Lipid Panel: TC: _____ mmol/l HDL-C: _____ mmol/l Trig _____ mmol/l LDL-C _____ mmol/l TC/HDL Ratio:		BMI: _____ kg/m ² ECG: _____ FRS: _____
ACTIONS TAKEN			
Given appropriate lifestyle advice Specify type of advice given		☐ Yes ☐ No ☐ Smoking ☐ Salt restriction ☐ Exercise ☐ Diet ☐ Weight reduction ☐ Alcohol consumption	
Referred for follow-up testing		☐ Yes ☐ No	
Referred for better management of Chronic Condition		☐ Yes ☐ No	
If referred, may we follow up on your health?		☐ Yes ☐ No	
STEPS VOLUNTEER INFORMATION			
Name		Date:	
Signature:			

S 2: Follow-up survey of STEPPS CVD referred participants

Follow-up survey of CVD referred participants	
Demographical data	
What is your age?	☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65 and above
What is your sex?	☐ Male ☐ Female ☐ Other ☐ I do not wish to disclose
Interventions post-STEPPS screening event	
Did you seek further care after being referred from the STEPPS programme?	☐ Yes ☐ No
Did further care reveal anything of significance?	☐ Yes ☐ No
	If yes, severity or was it a diagnosis? ☐ Severity of the disease ☐ New diagnosis: _____ ☐ Other (Please specify): _____
Did you make any lifestyle changes since the STEPPS screening event?	☐ Yes ☐ No ☐ Diet ☐ Exercise ☐ Other (Please specify): _____ If not, why _____
Did you develop an established routine for screening and testing of your health condition after the STEPPS screening event?	☐ Yes ☐ No ☐ Monthly ☐ Every 6 months ☐ Yearly If not, why _____

Have you experienced any further symptoms since your last screening?	☐ Yes ☐ No
What treatments are you on to manage your disease?	☐ No treatment ☐ Aspirin ☐ Other medicines or pills ☐ Diet ☐ Exercise ☐ Other (Please specify): _____
STEPPS screening event feedback	
Did STEPPS influence the intervention you chose to take?	☐ Yes ☐ No
Are there any other screening tests you would like this initiative to offer?	☐ Yes ☐ No
Would you like screening stations (like STEPPS) to be more accessible?	☐ Yes ☐ No If Yes, where? _____ If not, why not? _____
Were you comfortable during the session?	_____ _____ _____
Were your results explained to you?	_____ _____ _____
How likely are you to recommend these sessions to your colleagues/friends?	1 – Unlikely to recommend 5- Very likely to recommend ☐ ☐ ☐ ☐ ☐

	1 2 3 4 5
Is there any other information you would like to share?	

S3: Data analysis parameters

Blood pressure

Self-reported prevalence for hypertension. The blood pressure was measured three times and an average was calculated. Anyone with an abnormal value of >140 systolic and/or >90 diastolic was referred. The referral parameters were based on the ESC guidelines as depicted in Table 1.

Table 1: Referral parameters for blood pressure

	Classification	Systolic (mmHG)		Diastolic (mmHG)
Normal	Optimal	<120	and	<80
	Normal	120-129	and/or	80-84
	High normal	130-139	and/or	85-89
Abnormal – Cause for referral	Elevated BP reading/Hypertension	≥140	and/or	≥90
	Isolated systolic	≥140	and	<90
	Isolated diastolic	<140	and	≥90

(1)

Blood glucose

Self-reported prevalence of diabetes. Any participant with abnormal values for Fasting Plasma Glucose (FPG) and Random Plasma Glucose (RPG), underwent the HbA1c testing. The clinical threshold for abnormal levels is explained in Table 2.

Table 2: Referral parameters for glucose

Blood Glucose	Normal		Abnormal – Cause for referral	
Fasting Plasma glucose (mmol/L)	<5.6 Diabetes excluded		>5.6-6.9 Impaired fasting glucose	≥ 7.0 Diabetes
Random Plasma glucose (mmol/L)	<5.6 Diabetes excluded	5.6-11.0 Inconclusive		≥11.1 Diabetes

Glycated Haemoglobin (HbA1c) (%)	<6.5 Inconclusive		≥6.5 Diabetes
*Table adapted from the ADA and SEMDSA guidelines (2, 3)			

Blood Cholesterol

Self-reported prevalence of cholesterol. The clinical threshold for abnormal levels is explained in Table 3.

Table 3: Referral parameters for cholesterol

Blood Cholesterol	Normal	Abnormal – Cause for referral	
Total cholesterol (TC) (mmol/L)	<4.9	≥ 5.0	
Low-Density-Lipoprotein (LDL) Cholesterol(mmol/L)	<2.9	≥ 3.0	
High-Density-Lipoprotein (HDL) Cholesterol(mmol/L)		Men	<1.0
		Women	<1.2
Triglycerides (mmol/L)	<1.6	≥ 1.7	
Table adapted from (4)			

Anthropometric measurements

Self-reported prevalence of obesity. The occurrence of obesity was determined by calculating the BMI using the weight (kg) and height (m) and categorizing them according to the BMI classifications guided by the WHO as shown in the Table 4. The waist circumference (WC) was used to determine the increased risk in an individual.

Table 4: Referral parameters for BMI and Waist circumference

Anthropometric measurements		
Body Mass Index (BMI)		
Classification	International BMI category (kg/m ²)	BMI category for Asians
Underweight	<18.5	<18.5
Normal weight	18.5-24.9	18.5-22.9
Overweight	25.0-29.9	23.0-24.9
Obese	≥30.0	≥25.0
Waist circumference (cm)		
Men	≥ 94	
Women	≥ 80	

(3)

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CHAPTER 4: CONCLUSION

4.1 Study highlights

All the objectives (one to six) were investigated and successfully discussed in the publication (Chapter 3). Objectives one to four were based on the analysis of the STEPPS 2022 screening results while objectives five and six were based on the follow-up surveys conducted with the CVD-related referrals.

The analysis of the STEPPS 2022 screening results has revealed the following observations/outcomes:

This study observed that males were more likely to have higher blood pressure compared to females, while abnormal readings for blood glucose, blood cholesterol, increased waist circumference (WC), and body mass index (BMI) were more common in females. Additionally, the staff population exhibited higher occurrences of abnormal readings for all measured risk factors, including increased WC and BMI. The age group 45-54 displayed the highest frequency of abnormal readings across all parameters, with the age groups 35-44 and 55-64 following closely. Regarding ethnicity, the occurrences of abnormal readings were relatively similar, although Africans had the lowest occurrences of abnormal blood pressure and blood cholesterol, while Whites had the lowest occurrences of increased BMI and WC.

Although the occurrence of CVD-related NCDs was low, there were a notable number of cases among the screened individuals that depicted values suggestive of hypertension (15.5%), diabetes (2.05%), dyslipidaemia (10.7%) and obesity (16.9%) without a previous diagnosis. These potentially undiagnosed participants highlight the need for increased screening efforts, especially since it was found in this study, that participants were more likely to participate in screening for CVD-related NCDs if it was presented as a screening event at their place of working or studying.

The follow-up survey has revealed the following observations:

- Participants had positive feedback and were satisfied with student-led screenings.
- None of the participants indicated that they felt the screening event was inferior due to it being conducted by students.
- Participants mention that work and study make it difficult to prioritize health.

4.2 Limitations

Significant instances of incomplete records and missing information were observed in the dataset, hindering its accurate representation. To address this limitation, adjustments to the data collection tool on REDCap could be made to enforce mandatory completion of essential information, such as demographic details. Additionally, while eligible participants underwent a complete lipid profile assessment, not all the details were recorded, resulting in missing values for HDL, LDL, and TG. Incorporation of a complete lipid profile would have enhanced the analysis of the results.

Another issue encountered was the voluntary nature of the screening process. An individual may have consented to a screening test and then express unwillingness to continue once the screening has started or they may decide against additional tests upon the occurrence of abnormal findings. This may be due to various reasons including time constraints, only having time for a limited number of procedures, or discomfort upon being informed about the finger prick test. The voluntary nature of this screening allows participants to leave if they wish.

Additionally, while data on alcohol and tobacco consumption was gathered, information on physical activity levels and nutrient intake was notably absent, which is essential for obtaining a comprehensive overview of an individual's modifiable risk factors. The inclusion of a behavioural section to assess the levels of physical activity and nutrient intake among the participants would enhance comprehension of the prevalent modifiable risk factors within the academic environment.

The follow-up of the participant had become tedious and complex. There was a substantial dropout rate of 39.4% among participants who initially consented to further follow-up surveys. This was partially due to changes in contact details but primarily stemmed from the complexity of obtaining consent. To mitigate this challenge, it is advisable to develop a protocol for follow-up and referrals for participants with abnormal findings. Ensuring the correctness of the contact details during the screening event is crucial. Although participants were able to recall the screening event, conducting the follow-up survey sooner and more consistently would be advantageous. As the study consisted of a retrospective review it became difficult to obtain consent. Ideally, it would be beneficial to acquire consent for future research arising from the screening results during the screening event, considering the difficulty in contacting participants, especially for written consent, and the potential technological limitations of some

participants. Establishing a formal logbook for referred participants, including their referral details, could streamline the process further.

4.3 Recommendations

During the follow-up survey, one participant mentioned the minimal advertising conducted for the initiative, making it easily overlooked. Implementing a promotional plan to raise awareness about the screening event would likely attract more participants. In conjunction with Wits News, future organisers could utilize various other channels such as posters, emails, and social media to effectively reach the target audience. Emphasize the importance of screening and preventative health measures in the promotional materials. Furthermore, establish screening dates in advance to provide individuals ample opportunity to attend the event.

Numerous participants expressed interest in extending the screening initiative to additional sites, such as various campus locations, shopping centers, and student residences. They further suggested more frequent screening days to accommodate those who missed previous events or wished to assess their health status over time. However, given this is a free service and is dependent on voluntary participation from students and funding, implementing these expansions may pose challenges. Collaboration with other organisations to help secure resources, expertise, and support for the screening events. The screening event must remain accessible to all members of the academic environment, including those with disabilities, by offering multiple screening locations, flexible scheduling, and other services as needed.

Moreover, students may be trained to provide motivational interviewing to promote health behaviour change. This approach, characterised by a client-centered counselling style, aims to elicit behaviour change by resolving any uncertainties (Banack *et al.*, 2012). Participants could be advised to adopt healthy behaviour through simple tasks like walking, especially considering the presence of scenic walkways and the overall safety on campus. Participation in clubs and community activities could promote healthy lifestyles. Additionally, the university administration may provide support for behaviour change by offering detailed information at the campus cafeteria, facilitating healthier choices for those aiming to make positive changes.

Finally, obtaining feedback from the recipients of the screening service and the students to assess the effectiveness of the screening event and to optimize the initiative for future events.

Future research

- Determine the behavioural choices of the participants, exercise habits, the nutrient intake, and the knowledge about healthy and unhealthy foods.
- Determine the knowledge of the participants about NCDs, and their risk factors and conduct their CVD risk assessment.
- Determine the long-term interventions of screening events by retaining records and having routine follow-ups
- Prevalence studies may be conducted on the co-occurrence of NCDs and HIV.
- Impact student screening event such as STEPPS may have on the knowledge and behaviours of the public

4.4 Conclusion

There is a considerable occurrence of CVD risk factors within the academic population, as evidenced by the significant number of undiagnosed and uncontrolled cases identified in this study. Elevated readings were observed among the participants for blood pressure (18.25%), blood glucose (2.83%) and blood cholesterol (11.36%). This underscores the urgent need for promotion and screening initiatives within this environment. Many participants were unaware of their health status and participated in screening only when it was made available through a screening event. Among those referred for follow-up, 43% had new diagnoses, and others showed disease escalation (29%) and required lifestyle modifications (29%), highlighting the critical role of screening in early detection and intervention.

Furthermore, this study found that early screening, particularly starting at a younger age, is crucial in preventing the progression of NCDs. Early identification allows for timely lifestyle modifications and medical interventions, reducing the long-term burden on the healthcare system and improving patient outcomes. Therefore, it is essential to commence health promotion efforts at the beginning of students' academic journeys, equipping them with knowledge and empowering them to take proactive measures regarding their health. The university setting provides a unique and beneficial environment for these initiatives, offering accessibility to a diverse population. By integrating health promotion and screening into the academic context, we can foster a health-conscious community, and students may assume the potential role as future advocates for health.

In conclusion, our findings emphasize the critical importance of early screening and continuous health promotion within academic institutions. These efforts not only address the immediate health needs of students and staff but also contribute to long-term public health benefits by reducing the incidence and severity of chronic diseases.

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APPENDICES

Appendix A: Participant Information Document



PARTICIPANT INFORMATION DOCUMENT

Study title: The analysis of a student-led university screening and testing programme for cardiovascular disease and diabetes

Good day

I am Umara Qureshi, a Masters student in the Department of Pharmacy and Pharmacology at the University of the Witwatersrand.

I am conducting research on the occurrence of cardiovascular diseases and diabetes identified at the STEPPs screening events and the impact of a university-based screening programme on the health interventions of participants.

Cardiovascular disease and diabetes are on the rise. It is important to determine the contributing factors and seek ways to manage these conditions by means of screening and testing programmes.

The study comprises of two parts. The first part is the analysis of the data collected during the STEPPs sessions to determine the occurrence of cardiovascular disease and diabetes. The second part involves the telephonic interviews of referred participants to determine the effectiveness of the screening programme. The interviews will follow the format of an approved questionnaire.

I am inviting the STEPPs referred participants to participate in my study for the follow up interviews. The interviews will be conducted telephonically at a time convenient for the participant.

The information from this interview will be used to establish if the participants derived benefit from the STEPPs programme and to determine the effectiveness of the referral process. This will be used to improve the process for the future participants.

The interviews will be recorded for the purpose of accurate data collection. All information shared in the study will be anonymous and confidential. Participation is voluntary.

Contact details: Name: Umara Bibi Qureshi

Email: 733160@students.wits.ac.za

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this

Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concern over the way the study is being conducted, please contact the Chairperson of this Committee who is Professor Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za and Rhulani.Mukansi@wits.ac.za

Thank you for reading this Participant Information Sheet.

Date: November 2022

Appendix B: Participant Consent Sheet



PARTICIPANT CONSENT SHEET

Study title: The analysis of a student-led university screening and testing programme for cardiovascular disease and diabetes

This Informed Consent gives the principal investigator permission to conduct a telephonic follow-up interview. *Please read this consent carefully before signing.*

I consent to have the principal investigator to contact me for a follow-up telephonic interview.

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that the information will be kept securely and confidential.
6. I understand that the information gathered from the interview will be used for the purpose of this study.
7. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
8. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
9. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:

Principal Investigator:

Name: Umara Bibi Qureshi

Email: 733160@students.wits.ac.za

Supervisor 1:

Name: Ane Orchard

Email: ane.orchard@wits.ac.za

Supervisor 2:

Name: Razeeya Khan

Email: razeeya.khan@wits.ac.za

Supervisor 3:

Name: Muhammed Vally

Email: muhammed.vally@wits.ac.za

Professor CB Penny, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Clement.Penny@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e-mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

Name of Participant: _____
Date: _____
Place: _____
Signature or mark _____

Witnessed by:

Name of Witness: _____
Signature: _____
Date: _____

Appendix C: Ethics (Medical) Letter



R14/49 Miss Umara Bibi Qureshi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M220918

NAME: Miss Umara Bibi Qureshi
(Principal Investigator)

DEPARTMENT: Pharmacy and Pharmacology

PROJECT TITLE: The analysis of a student-led university screening and testing programme for cardiovascular disease and diabetes

DATE CONSIDERED: 30/09/2022

DECISION: Approved unconditionally

CONDITIONS: N/A

NOTE: If contact information regarding student study participants is required, please contact the Registrar's office:
Nicoleen.Potgieter@wits.ac.za

SUPERVISOR: Dr A. Orchard, Mrs R. Khan and Mr M. Vally

APPROVED BY: 
Dr CB Penny, Chairperson, HREC (Medical)

DATE OF APPROVAL: 28/02/2023

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 Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. 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.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **September** and will therefore be due in the month of **September** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature

Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix D: Approval for the use of STEPPS 2022 data



**WITS
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Chair and Head: Department of Pharmacy and Pharmacology

Faculty of Health Sciences | 7 York Road Parktown, 2193 | Johannesburg | South Africa | Tel: +27 11 717 2052

9 June, 2022

To whom it may concern,

RE: APPROVAL FOR THE USE OF STEPPS DATA

This letter serves to grant Ms Umara Bibi Qureshi permission to use the 2022 STEPPS data for her Masters dissertation titled "The analysis of a student-led university screening and testing programme for cardiovascular disease and diabetes".

Yours Sincerely,

Professor Yahya E. Choonara | BPharm; MPharm; PhD; MASSAf; MPS; TWAS (Pharm. Sci.)
Personal Professor of Pharmaceutics
Chair and Head | Pharmacy and Pharmacology
Director and Principal Researcher | WADDP | <http://www.wits.ac.za/waddp>
University of the Witwatersrand | Faculty of Health Sciences
7 York Road, Parktown, 2193, Johannesburg, South Africa
W: <http://www.wits.ac.za/therapeuticssciences/pharmacy--pharmacology>

Appendix D: Approval of title



Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

30 January 2024
Person No: 733160
PAG

Miss UB Qureshi
30 Sable Street
Mackenzie Park
1501
South Africa

Dear Miss Umara Bibi Qureshi

Master of Pharmacy: Approval of Title

We have pleasure in advising that your proposal entitled *The analysis of a student-led university screening and testing programme for cardiovascular disease and diabetes* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Sandra Benn'.

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences



Appendix E: Turnitin Report

ORIGINALITY REPORT			
15%	12%	10%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS
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