

**Understanding the severity of alcohol as risk factor for
high blood pressure in the presence of social and
epidemiological variables: A South African cross
sectional study**

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Dedication

For my family
&
Little H.,

You Are My Eternal Sunshine

Abstract

Background: the incidence of high blood pressure in South Africa has increased over the past few decades (Chopra *et al.*, 2009; Seedat, 2012). Public health scientists have warned that this trend might be correlated to a multitude of unhealthy behaviors at the individual level, including heavy alcohol consumption (Chopra *et al.*, 2009; Hillbom *et al.*, 2011; Seedat, 2012; Strogatz *et al.*, 1991). Previous studies have established a synergistic effect between alcohol consumption and high blood pressure leading to an increased risk of cardiovascular and renal disease within countries of the global north (Abe *et al.*, 1994; Keil *et al.*, 1993; Steyn *et al.*, 1997). Not only is this trend under studied in South Africa, the severity of alcohol's impact on blood pressure remains to be discerned in the country. Objectives: shedding light on the epidemiological and social factors impacting the association between alcohol consumption and blood pressure. Based on previous observations, it is hypothesized that certain epidemiological factors will be strongly associated with high blood pressure in the presence of alcohol consumption. Findings from this research would inform healthcare professionals on the diagnosis of high blood pressure cases in the South African population as this research aims to identify the factors associated with high blood pressure, thus, alleviating the problem of underdiagnosed cases that have been found to incur heavy costs on the healthcare system (Chopra *et al.*, 2009; Seedat, 2012). Methods: in the present study, we have investigated social and epidemiological factors, as informed by previous research, which are associated with blood pressure in the presence of alcohol consumption within a South African context by using data collected from the South African Demographic and Health Survey (SADHS). Conclusion: Our findings indicate a correlation between ethnicity and blood pressure, as well as having a heart attack and high blood pressure measurements.

Key questions

What is already known about this topic?

The correlation between alcohol and blood pressure has been well documented in previous studies (Abe *et al.*, 1994; Guo *et al.*, 2010; Russell *et al.*, 1991; Zhang *et al.*, 2013). Acutely, alcohol causes a modest fall in blood pressure, but, continued consumption has been found to result in a dose-dependent rise in blood pressure (Husain *et al.*, 2014; Khan *et al.*, 2007). Alcohol abuse in particular is highly prevalent in South Africa (Olaoluwa *et al.*, 2013) and is an important risk factor for hypertension, stroke, and mortality. Alcohol consumption is also linked to high blood pressure (BP) and addiction among adolescents – important risk factors for hypertension (Bloxham, 1979; Hillbom *et al.*, 2011; Olaoluwa *et al.*, 2013).

What are the new findings?

Since there has been a shift in prevalence from communicable to non-communicable diseases, health conditions such as high blood pressure have attracted the attention of health researchers in recent years (Chopra *et al.*, 2009). Health researchers have become interested in lifestyle habits that could be associated with developing chronic health conditions (Seedat *et al.*, 2013). Studies similar to this one achieve that goal by a) observing epidemiological factors associated with chronic health conditions (b) statistical measuring the hypothesized correlations.

Recommendations for policy

Based on this research, health policy makers are recommended to adopt holistic approaches to preventing cardiovascular disease. As observed from our findings, factors such as salt content, history of heart attack and diabetes are variables which collectively interact to influence one's blood pressure readings.

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List of abbreviations

ADH: Alcohol Dehydrogenase

AIDS: Acquired Immune Deficiency Syndrome

BMI: Body Mass Index

BP: Blood Pressure

GDP: Gross Domestic Product

HIV; Human Immunodeficiency Virus

HR: Heart Rate

PAR: Population Attributable Risk

SADHS: South African Demographic and Health Survey

CHAPTER 1: Introduction

1.1 Background

In 1915, physician Lian was the first to describe the association between elevated blood pressure and alcohol consumption, through his observations of French soldiers. Causality was confirmed by subsequent studies (Abe *et al.*, 1994; Connor *et al.*, 2005; Keil *et al.*, 1993; Seedat, 1999; Steyn *et al.*, 1997). Today, excessive alcohol consumption is an established risk factor for high blood pressure which is the largest contributor to global burden of disease, accounting for 7% of global disability adjusted life years (Seedat, 1999; Steyn *et al.*, 1997). The burden of hypertension has been increasing continuously in sub-Saharan Africa over the past few decades (Seedat, 1999; Steyn *et al.*, 1997). Although researchers have identified a genetic predisposition to high blood pressure in individuals of African heritage, the increasing prevalence of hypertension is still alarmingly high (Puddy *et al.*, 2005). This has severe potential consequences in the region as a large proportion of those with the condition probably remain undiagnosed, untreated, or inadequately treated, hence, are at high risk for morbidity and mortality from potentially preventable complications of hypertension such as stroke and heart disease (Abe *et al.*, 1994; Connor *et al.*, 2005; Keil *et al.*, 1993; Seedat, 1999; Steyn *et al.*, 1997). In South Africa, particularly, it is currently regarded as the country's greatest health challenge after HIV/AIDS (Chopra *et al.*, 2009; Peer *et al.*, 2013). In the year 2000 alone, high blood pressure was found as the second leading contributor to mortality in the country after sexually transmitted diseases (Norman *et al.*, 2007; Russell *et al.*, 1991).

High blood pressure, or hypertension, is defined by an elevated blood pressure in the arteries comprising the cardiovascular system, and can develop into a chronic health condition (Seedat,

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1999; Steyn *et al.*, 1997). Blood pressure mainly depends on the heart muscle's contractile ability which is divided into two actions—contractions, known as systole, and relaxations, known as diastole (Seedat, 1999; Steyn *et al.*, 1997). For the purposes of this study and accompanying analysis, normal blood pressure at rest is within the range of 100–140 mmHg systolic and 60–90 mmHg diastolic (Seedat, 1999; Steyn *et al.*, 1997). High blood pressure is said to be present if it is often at or above 140/90 mmHg (Seedat, 1999; Steyn *et al.*, 1997). Hypertension puts strain on the heart, possibly leading to hypertensive heart disease and coronary artery disease (Seedat, 1999; Steyn *et al.*, 1997). Dietary and lifestyle changes can improve blood pressure control and decrease the risk of health complications, although drug treatment is still often necessary in people for whom lifestyle changes are not enough or not effective (Seedat, 1999; Steyn *et al.*, 1997).

In addition to the increased prevalence of high blood pressure in the country, recent studies have also observed an increasing trend in the drinking habits of the adult population (Herrick, 2012; Parry *et al.* 2005). The importance of this observation is apparent when considering the aforementioned correlation between alcohol and high blood pressure. In other words, the increase in prevalence of alcohol consumption in South Africa might render an increased number of individuals at risk for high blood pressure. In fact, a systematic review on the population completed by Puddy and colleagues (2005) has reported that heavy weekend drinkers and regular drinkers both have high blood pressure, and elevated blood pressure is frequently seen during acute alcohol withdrawal. Cessation of drinking, however, eventually leads to the normalization of blood pressure. Moreover, the effect of alcohol in elevating blood pressure is more prominent in elderly people than in the young (Andersen *et al.*, 2009; Hillbom *et al.*, 2011; Puddy *et al.*, 2005).

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Although the molecular basis underlying the relationship between alcohol and high blood pressure remains unclear, extensive research has been underway. Studies of this kind have highlighted the altered state of alcohol metabolism within the cellular environment of heavy drinkers which is associated with toxicity (Abe *et al.*, 1994; Guo *et al.*, 2010; Russell *et al.*, 1991; Zhang *et al.*, 2013). Specifically, transgenic technology has been employed to investigate the metabolic pathway of alcohol breakdown by the enzyme Alcohol Dehydrogenase (ADH) within cardiac muscle tissue displaying contractile dysfunction (Guo *et al.*, 2010; Zhang *et al.*, 2013). Individuals who consume high levels of alcohol have been found to overexpress this enzyme as their body compensates for the increased presence of alcohol in the system (Guo *et al.*, 2010; Zhang *et al.*, 2013). The accumulation of ethanol within cardiac tissue is currently thought to play a key role in the pathway linking ADH and hypertension (Guo *et al.*, 2010; Zhang *et al.*, 2013). The possible mechanisms by which ethanol has been suggested to increase blood pressure include: (a) a direct effect on the central nervous system, by interfering with central inhibitory pathways, which control the vasomotor center or increasing sympathetic activity (Guo *et al.*, 2010; Zhang *et al.*, 2013), (b) activation of the rennin–angiotensin system by ethanol (Zhang *et al.*, 2013), and (c) aortic endothelial oxidative injury and down regulation of the nitric oxide generating system (Zhang *et al.*, 2013).

Alcohol-induced elevation in blood pressure has been reported to be reversible with cessation of alcohol consumption (Herrick *et al.*, 2012; Hillbom *et al.*, 2011; Parry *et al.* 2005). As such, there is potential for reversing the aforementioned trends through targeted community-based interventions in South Africa. In fact, targeted prevention programs specific to reducing high blood pressure are estimated to lead to a 2% reduction in the incidence of high blood pressure that is caused by population attributable risk factors (Peer *et al.*, 2013). Population attributable

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risk factors, PARs, are factors that lead to an increased incidence of a certain health condition when population is exposed (Hillbom *et al.*, 2005). Norman and colleagues predicted, in a recent article (2007), that population-based strategies such as dietary educational programs and strategies to promote physical activity would help reduce the influence of factors which are believed to lead to high blood pressure, such as high salt intake.

1.2 Research Objectives

In an effort to maintain up-to-date population health information that would assist policymakers and program managers in evaluating and designing programs and strategies for improving health services in the country, the South African Department of Health implemented the South African Demographic and Health Survey (SADHS) in 1998. The health survey collects nationally representative information on various demographic and health indicators. As such, the survey holds up-to-date and nationally representative data that is of relevance to this study.

This study is building on literature on alcohol consumption within South Africa as being a risk factor for blood pressure. In other words, we aim to investigate whether a significant correlation exists between high levels of alcohol consumption by South African adults and elevated blood pressure. Answering this question would improve our understanding of a major health concern in the country and if it might correlate with certain lifestyle choices. Furthermore, we aim to tease apart any demographic factors that might be influencing the aforementioned correlation. This objective has been recommended by previous studies alluding to gender based differences in susceptibility to high blood pressure, in addition to genetic and physiological factors.

1.3 Research Questions

The research question asked by this study will provide empirical knowledge and evidence within the South African context for the impact of certain lifestyle and behavioural choices that might be correlated to the observed trends. Findings should ultimately help policy makes and public health workers who might be interested in designing community-based prevention programs to reduce the current prevalence of high blood pressure in the country. Furthermore, healthcare professionals would be better equipped in the diagnostic and treatment profiles of patients engaging in the behaviours investigated by our study. For example, a physician treating a patient with high blood pressure will be better able to recommend lifestyle changes that are suited for the patient's demographic.

As such, our research question for this study is:

1. In the presence of alcohol consumption, what factors are associated with high blood pressure?

1.4 Rationale

The association between alcohol and blood pressure has been well documented in previous studies (Abe *et al.*, 1994; Guo *et al.*, 2010; Russell *et al.*, 1991; Zhang *et al.*, 2013). Our aim in this study is to take this finding a step further while focusing on South Africa's adult population by defining the relative influence on high blood pressure of alcohol consumption among other risk factors in South Africa. We will collect a multitude of demographic and health data from our participant pool including: blood pressure, ethnicity, alcohol consumption indicators, smoking, gender, history of high blood pressure. These variables will be cross examined to assess their level and significance of interaction. Lastly, we will focus the population of interest on the Western Cape region only as this is a densely populous area where plenty of research has been

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conducted on the demographic structure which will help guide the conclusions to be drawn from our results.

This research study is of value, firstly, as it will focus on a social behavior that might have direct implications on a serious health issue. Secondly, findings from this research will provide tangible evidence in terms of actual numerical values for the number of individuals who have concurrent alcohol and blood pressure issues.

CHAPTER 2: Literature Review

The University of Ottawa Library online databases such as PubMed were utilized to conduct this literature review. All relevant articles were imported and organized using the reference manager software “RefWorks” (University of Ottawa, 2014).

2.1 Historical Context

With a population of 49.3 million and GDP per capita of \$5786 in 2009, South Africa is Africa’s biggest economy. Since 2000, GDP per capita has risen by \$2736 or 90% in nominal terms (World Bank, 2015). However, with official unemployment in excess of 25%, average life expectancy of 51.5 (which represents a decline of 4.5 years since 2000) and average HIV prevalence of 18% (World Bank, 2015), the country faces clear barriers to achieving equity in health. Added to this, South Africa’s high rate of alcohol consumption is layered over a post-apartheid ‘protracted and polarised health transition’ characterised by the ‘persistence of infectious diseases, high maternal and child mortality and the rise of non-communicable diseases’ (Chopra *et al.*, 2009). South Africa may be an exception in the region for its reasonably and relatively well-developed alcohol regulations and a vocal public health lobby (Parry, 2010); but its fine line between ‘sociable and unsociable drinking’ (Chopra *et al.*, 2009) presents clear policy challenges. This most clearly plays out in the tension between the drinking undertaken in the many upscale urban restaurants and bars and a broad tendency among drinkers to binge. Moreover, the vulnerabilities to the multiple effects of alcohol consumption are not limited to the country’s drinkers, but rather endured by the majority of the population. Furthermore, the co-existence of regulatable (i.e. licensed and legal) and unregulatable (i.e. unlicensed and illegal) drinking spaces present clear governance challenges.

2.2 High Blood Pressure in South Africa

The South African Demographic and Health Survey (SADHS) provides the most comprehensive estimates of blood pressure. A random, nationally representative sample of 13,802 persons 15 years of age or older was selected in 1998, their blood pressure and associated risk factors were recorded, as were socio-demographic data (Steyn *et al.*, 1998).

Several determinants for elevated blood pressure have been recorded by scientists within the South African context, one of which being high salt content in the diet (Hillbom *et al.*, 2011). It is believed that a diet high in salt and low in fruit and vegetable intake is characteristic of the region and in combination with high alcohol consumption particularly in men contribute significantly to elevating blood pressure (Hillbom *et al.*, 2011).

High blood pressure has been strongly linked to cardiovascular disease, a significant health threat in sub-Saharan Africa, and is one of the main causes of morbidity and mortality (Bloxham, 1979; Norman, 2007) Smoking and alcohol consumption are associated with the development of hypertension and CVD (Bloxham, 1979; Hillbom *et al.*, 2011; Olaoluwa *et al.*, 2013). Alcohol abuse in particular is highly prevalent in South Africa (Olaoluwa *et al.*, 2013) and is an important risk factor for hypertension, stroke, and mortality. Alcohol consumption is also linked to high blood pressure (BP) and addiction among adolescents – important risk factors for hypertension (Bloxham, 1979; Hillbom *et al.*, 2011; Olaoluwa *et al.*, 2013). Furthermore, there is a J-shaped association between alcohol intake and mortality with heavy drinkers having higher mortality (Bloxham, 1979; Hillbom *et al.*, 2011; Olaoluwa *et al.*, 2013).

Some studies also reported a linear association between alcohol consumption and BP (Bloxham, 1979; Hillbom *et al.*, 2011; Olaoluwa *et al.*, 2013). An accurate estimation of alcohol intake is

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still a challenge and a biomarker of alcohol with sufficient sensitivity and specificity is yet to be identified (Bloxham, 1979; Hillbom *et al.*, 2011; Olaoluwa *et al.*, 2013).

It is interesting to note that there were no significant differences in the risk for high blood pressures when accounting for socio-economic factors. However, the risk for high blood pressure was significantly lower in women compared to men (Akinboboye *et al.*, 2003; Peer *et al.*, 2013).

2.3 Alcohol Consumption in South Africa

In recent years, levels of alcohol consumption have increased in South Africa (Parry *et al.*, 2005). In a study by Parry and colleagues (2005), the levels of alcohol consumption reported by men were 45% and 17% by women. Urban residents were more likely than nonurban dwellers to report current drinking (Parry *et al.*, 2005). Moreover, One third of current drinkers reported risky drinking over weekends (Parry *et al.*, 2005; Sleight *et al.*, 1996; Van Rooyen *et al.*, 2000). The authors recommend that although the proportion of the population consuming alcohol in South Africa is low, it is nonetheless alarming to note that many of those who drink alcohol appeared to engage in risky drinking regularly, particularly over weekends (Parry *et al.*, 2005). This subpopulation is thus at risk for developing alcohol related health problems including high blood pressure (Marmot *et al.*, 1994; Parry *et al.*, 2005; Puddy *et al.*, 2005).

2.4 Alcohol Consumption as a Risk Factor for High Blood Pressure

An association between alcohol consumption and high blood pressure was first reported by the physician Lian in 1915 who noted an increased prevalence of high blood pressure among French soldiers drinking more than 2Liters of wine a day (Lian, 1915). Subsequently, the association has been documented in many studies involving various populations types (Husain *et al.*, 2014). Acutely, alcohol causes a modest fall in blood pressure, but, continued consumption has been

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found to result in a dose-dependent rise in blood pressure (Husain *et al.*, 2014; Khan *et al.*, 2007). The reduction in blood pressure following acute levels of consumption is thought to be induced by peripheral vasodilation despite a slight increase in cardiac output; the chronic increase in blood pressure, however, is thought to reflect a shift of calcium into vascular smooth muscle cells that is coupled with an outward shift of magnesium (Husain *et al.*, 2014; Khan *et al.*, 2007).

The association between blood pressure and alcohol intake was studied in two recent studies. The first, conducted by Andersen and colleagues (2009), investigated all hospitalized stroke patients in Denmark after 2001 and gathered information by using standardized risk factor evaluation. High blood pressure, high alcohol intake and smoking were found to favour the occurrence of hemorrhagic stroke (Andersen *et al.*, 2009).

The second study calculated population attributable risks (PARs) for the association between risk factors and cardiovascular disease (O'Donnell *et al.*, 2010). PAR estimates the public health impact of a risk factor in a population (O'Donnell *et al.*, 2010). Calculated estimates of PAR for alcohol-induced high blood pressure varied between 7% and 33% worldwide (O'Donnell *et al.*, 2010), and high blood pressure was reported to be the most important risk factor for cardiovascular disease (O'Donnell *et al.*, 2010).

2.5 Blood Pressure in Other Countries within the African Continent

The reported prevalence of hypertension in Africa ranges from 25% to 35% in adults aged 25 to 64 years, and increases with advancing age (Rehm *et al.*, 2009). A recent study of urban and rural Tanzania reported rates of stroke mortality higher than those of England and Wales, and suggested that untreated hypertension is an important etiological risk factor (Cois & Elrich,

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2014; Rehm *et al.*, 2009). In Kenya there is a paucity of data on hypertension prevalence (Rehm *et al.*, 2009). In a survey conducted in 1986 at a regional centre, among both rural and urban residents, non-standardised hypertension was reported at a prevalence of 6.4% (Cois & Elrich, 2014). A 2008 regional cross-sectional study, restricted to subjects aged over 50 years of age and conducted in predominantly rural population, reported a prevalence of 50.1% (Joshi *et al.*, 2014).

2.6 Social Factors Mediating Proposed Correlation

Socioeconomic disparities in the prevalence of hypertension have hypothesized in high income countries, where strong epidemiological evidence associates higher socioeconomic status (SES) with a lower prevalence of high blood pressure and cardiovascular disease, an association that is consistent across a variety of indicators of social position (Colhoun, 1998; Kaplan, 1993).

By contrast, the pattern of association appears diverse in sub-Saharan Africa, where a mix of positive and negative gradients has been found across studies, in some distinct by gender (Poulter, 1985; Lang, 1988; Norman, 2001).

Inconsistencies in SES measurements, sample heterogeneity and different degrees of economic development have been argued as possible explanations of these conflicting results (Colhoun, 1998; Norman, 2001).

However, the overall picture is far from complete and a better understanding of the reasons for this heterogeneity is needed in order to inform population based preventive interventions.

A recent study by Cois and Elhrich (2014) has found that after adjustment for age, race and antihypertensive treatment, higher education and income were independently associated with higher diastolic blood pressure in men. In women higher education predicted lower values of both diastolic and systolic blood pressure while higher income predicted lower systolic blood pressure. In both genders, body mass index was a strong mediator of an adverse indirect effect of

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socioeconomic status on blood pressure (Cois & Elhrich, 2014). Together with physical exercise, alcohol use, smoking and resting heart rate, body mass index therefore contributed substantially to mediation of the observed relationships in men (Cois & Elhrich, 2014). By contrast, in women unmeasured factors played a greater role (Cois & Elhrich, 2014). As such, the authors concluded that in countries undergoing epidemiological transition, where factors associated with high blood pressure are changing, effects of socioeconomic status on blood pressure may vary by gender. In women, factors other than those listed above may have substantial role in mediating the association and merit investigation (Cois & Elhrich, 2014).

CHAPTER 3: Methods

3.1 Ethics

In October 2015, communications with the Research Ethics and Integrity office at the University of Ottawa were concluded with clearance of this study. Email communication stated that upon discussion with the Protocol Officer, it had been confirmed that this study does not require ethics approval. The project using data from the South African Demographic and Health Survey is in accordance with article 2.2 of the Tri-Council Policy Statement, which states the reason for clearance as being due to data that is publically available and accessible.

3.2 Research context

Using secondary data, provided by the South African Demographic and Health Surveys (SADHS), this study will mainly ascertain the severity of the impact of alcohol on high blood pressure. The population of interest will be that of individuals aged 18 to 65 years old residing in the Western Cape region in South Africa at the time of data collection in the year 1998. Sample size of the study population was 936. IBM SPSS 20 was used to run statistical analyses to measure the severity of alcohol's influence on blood pressure in the presence of social and epidemiological factors.

The SADHS protocol was reviewed and approved by the Institutional Review Board of ICF Macro. The Institutional Review Board of ICF Macro complied with the United States Department of Health and Human Services requirements for the "Protection of Human Subjects" (45 CFR 46). (ICF Macro is now known as ICF International). All subjects were fully informed about the objectives and procedures of the survey and gave written informed consent prior to voluntary participation. Field workers were available to translate information into the participant's native language. The participants were assured of the confidentiality and anonymity

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of the results. Participants found to have chronic illnesses such as hypertension and human immunodeficiency virus (HIV) were referred to their local clinics and hospitals. Sampling was random.

3.3 Populations characteristics

This study focused on the sub-population of the Western Cape region in South Africa. The fourth largest of the nine South African provinces, Western Cape (Figure 16 below) is situated in the south-western part of the country with a population size of 5.8 million inhabitants and area of 129449 square kilometers (SADHS, 2015). Two thirds of the province's residents live in the metropolitan area of Cape Town (SADHS, 2015). Based on data provided by the SADHS (2015), this study reported 62% of the province's residents to individuals who identify themselves to be of colour, 12% reported their ethnicity as White, 25% as Black or African, and 0.53% as South/ East Asian. With regards to ethnic group, our analytics were restricted by a small response rate. Ethnic groups were lumped to either white or non-white. Although a non-significant finding, results show that individuals who identify as white are more likely to have high blood pressure. Afrikaans is the plurality language, and is spoken by 53% of residents, followed by 22% English, and 25% IsiXhosa.

The age distribution in the province follows a bi-modal curve pattern with the first mode falling in the late teens and second late thirties. The mean age is 37years old. There are slightly more female than male residents, 53% female to 47% male.

Due to low response rates, education variables were lumped to either "no education/ elementary" or "above elementary". The average household income the region was reported to be R143,460.

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25% of the population was reported to be unemployed. Over 52% of the population was reported to be employed (SADHS, 2015).



Figure 1. Map of South Africa (Global securities, 2016).

3.4 Inclusion/ Exclusion criteria

The inclusion criteria for the study was any adult between age of 18 to 65 who had completed the SADHS in 1998 while residing in the Western Cape region. Participants outside the age bracket were excluded.

3.5 Research design and questionnaire

Structured demographic, socio-economic, lifestyle and physical activity questionnaires, developed and standardised for the DHS survey were completed by the participants with the assistance of fieldworkers. The questions on alcohol consumption included a ‘yes/ no’ answer depending on participant’s perception of their level of alcohol use. Anthropometric measurements such as height, body weight and waist circumference (WC) were measured for each participant (Precision Health Scale, A & D company, Tokyo, Japan; Invicta Stadiometer, IP 1465, Leicester, UK; Holtain unstretchable metal tape) using standardised methods informed by previous research (Marfell-Jones *et al.*, 2006). Blood pressure was taken after a 10-minute rest period. Systolic BP (SBP), diastolic BP (DBP) and heart rate (HR) were measured in duplicate, five minutes apart, with the validated Omron HEM-757 apparatus (Omron Healthcare, Kyoto, Japan), while the participants were seated upright with the right arm at heart level.

Appropriately sized cuffs were used for obese participants. Following the guidelines of International Society of Hypertension, participants with a BP measurement of 140 and/or 90mm Hg at follow-up, were regarded as hypertensive (Weber *et al.*, 2014).

We believe the aforementioned design was suitable for our study as the data collected and methodology followed combine self-reported measures and numerical data points. This will inform findings by providing a participant perspective as well as epidemiological evidence for hypothesized correlations. Also, response types and patterns might give a peak into cultural factors influencing our findings.

3.6 Statistical analyses

The main statistical test to answer the research question was a bivariate regression analysis of the variables of interest. First, a study relevant population was deduced based on inclusion and exclusion criteria in addition to the variables of interest. A sample size of 936 was arrived at upon completion of the data cleaning exercise. It should be noted though that certain variables, which will be discussed when relevant, had a sample size smaller than 936 due to lower response rate. We also, eliminated “Don’t know” and missing responses. Since the blood pressure variables were categorical we completed an internal validity exercise of manually checking whether the categorical labels match the numerical values collected. The first author of this manuscript read each response twice to ensure correct categories were entered.

The sample was then divided into two categories based on which blood pressure category the participant’s blood pressure reading fell under. The original data set provided by SADHS divided blood pressure readings into three response types; “High”, “Normal” or “Low”. Since we aimed to use bivariate regression models, we divided this response further to two main subgroups for this study “Low/ Normal” or “High/ Normal”. Thus, all subsequent analyses were conducted by comparing the variables of interest to either one of these blood pressure groups.

Descriptive statistics were then performed on demographic and categorical variables, as displayed in the graphs and figures following this section. This enabled us to get a sense of the population of interest and potentially help explain any patterns we might find when conducting later analyses.

Demographic and epidemiological variables of interest to this study include: age, gender, ethnic background, educational level, smoking history, work for payment in the past 12 months, salty

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food consumption, weight category, salty food consumption, diabetes, drinking on weekends, drinking during the week, alcohol consumption severity indicator questions, cholesterol, stroke, heart attack, family history of stroke and high blood pressure.

3.7 Data collection and recruitment

Data collection for the SADHS is completed by trained field workers (SADHS, 2015).

Households were chosen at random and asked to volunteer their time to participate in a national health survey (SADHS, 2015). The SADHS requires participants to provide blood pressure measurements as part of the survey, which was collected and categorized into low, normal or high. Three blood pressure readings are collected from a participant at five minute intervals. The study population was assessed for the levels of alcohol consumption based on responses to the CAGE questionnaire. The CAGE questionnaire, the name of which is an acronym of its four questions, is a widely used method of screening for alcoholism.

Two "yes" responses indicate that the possibility of alcoholism should be investigated further.

The questionnaire asks the following questions:

1. Have you ever felt you needed to **C**ut down on your drinking?
2. Have people **A**nnoyed you by criticizing your drinking?
3. Have you ever felt **G**uilty about drinking?
4. Have you ever felt you needed a drink first thing in the morning (**E**ye-opener) to steady your nerves or to get rid of a hangover?

3.8 Data quality and recruitment

Low reliability of self-report data, including those on alcohol and tobacco use is a well-known problem in population-based surveys, which usually results in observed associations biased towards the null (Whitlock, 2001).

In the case of data recorded for SADHS, recording inaccuracies by interviewers as well as inaccurate responses by participants include digit preference, rounding, heaping certain ages, dates, or omission of events in the past or deliberate distortion of information in an effort by interviewers to lighten their workload. Additionally, selective non-reposes could create non-sampling error in measurement (SADHS, 2003).

For the ethnic group variable we collapsed the response variable to “white” or “non-white” due to low response rates which might have influenced our findings.

CHAPTER 4: Results

The following is an analysis based on data provided by the Demographic and Health Survey (DHS). Implemented by the South African Department of Health, the data for this analysis was collected in 1998 by the South African Demographic and Health Survey (SADHS). The health survey collects nationally representative information on various demographic and health indicators. As such, the survey holds up-to-date and nationally representative data that is of relevance to this study.

The Study's main question is about the factors associated with blood pressure in the presence of alcohol consumption. The population of interest was that of individuals aged 18 to 65 years old residing in the Western Cape region in South Africa at the time of data collection in the year 1998. Sample size of the study population was about 936. IBM SPSS 20 was used to run statistical analyses for the severity of alcohol as a risk factor for blood pressure in the presence of other factors.

The main statistical test to answer our question was a bivariate regression analysis of the variables of interest. Demographic and epidemiological variables of interest to this study include: age, gender, ethnic background, educational level, smoking history, work for payment in the past 12 months, salty food consumption, weight category, salty food consumption, diabetes, drinking on weekends, drinking during the week, alcohol consumption severity indicator questions, cholesterol, stroke, heart attack, family history of stroke and high blood pressure.

The variables chosen for assessing the severity of participant's alcohol consumption levels are described in the CAGE questionnaire:

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Two "yes" responses indicate that the possibility of alcoholism should be investigated further.

The questionnaire asks the following questions:

1. Have you ever felt you needed to **C**ut down on your drinking?
2. Have people **A**nnoyed you by criticizing your drinking?
3. Have you ever felt **G**uilty about drinking?
4. Have you ever felt you needed a drink first thing in the morning (**E**ye-opener) to steady your nerves or to get rid of a hangover.

Although the proportion of the South African population to report harmful levels of alcohol consumption was expected to be low, we nonetheless anticipated to find a significant association between high blood pressure and high levels of alcohol consumption. This finding was expected to be magnified when dividing the population by gender as well as age. Men were expected to show a stronger association between levels of alcohol consumption and elevated blood pressure, furthermore, this trend is expected to be more prominent in older adults. These predictions were not validated by our statistical analyses.

The survey's population was largely consistent of female, middle aged, urban city dwellers who spoke Afrikaans. Interestingly, the majority of respondents have not had their blood pressure measured in the last 12 months, nor did they report to be aware of their blood pressure measurements. Results show that respondents' relatives did not have high blood pressure either. Moreover, the majority of respondents had normal blood pressure measurements.

Based on epidemiological and biological evidence, we expected that the variables considered in this study were causally linked. We also predicted to find a significant effect between education

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and income on blood pressure, partially mediated by cardiovascular health, nutrition and physical health, alcohol use and smoking, these predictions were not supported by the results.

In the case of having low/normal blood pressure, results revealed an association between dietary salt intake ($X^2=0.00$, $p=0.301$). Chi-square tests of significance revealed a significant correlation between non-white ethnic groups and having a low or normal blood pressure reading, however, this could not be confirmed by bivariate regression tests. Thus, other factors might be mediating this correlation.

Regression analyses for high/ normal blood pressure category revealed a significant correlation between having a heart attack in the presence of epidemiological and social variables.

With regards to nutrition and diet, participants were asked about the salt content of their diet.

Over half, 81%, reported following a lightly salted diet. The majority of respondents fell under a normal weight category, 64%. The mean respondent weight was reported to be 68.9kg with SD +/- 16.9kg, and mean height of 162.5cm SD +/- 10cm.

As such, these findings warrant further investigation into the topic as they will establish alcohol as a risk factor for high blood pressure in South Africa. Thus, this study has provided a platform for targeted prevention and investigative efforts for public health professionals and policy makers. Our results indicated the importance of dietary factors, lifestyle habits on an individual's blood pressure. Moreover, these findings add on to the present literature linking alcohol use to high blood pressure, which would be of great value to the cardiovascular literature as whole.

4.1 Alcohol related variables

Analyses for variables related to alcohol consumption indicated a significant correlation between gender and reporting week drinking practices, chi-squared value is 0.005. Moreover, men are more likely to report heavy drinking during the week. Interestingly, results show that the majority of individuals who drink during the weekend report drinking during the week, chi-squared = 0.003. This finding might allude to certain life style habits that might be practiced by individuals who drink regularly during the week and over drink during the weekend. Crossing this finding to blood pressure categories, we found a weak positive correlation between having high blood pressure and engaging in regular drinking patterns, i.e. drinking during the week ($X^2= 0.940$). This correlation was negatively correlated with low blood pressure ($X^2=0.409$).

4.2 Heart attack history and blood pressure

Regression analyses reported a significant correlation between having a heart attack and high blood pressure ($p= 0.021$). This finding was confirmed by chi-squared tests of analyses ($p=0.002$). Unfortunately, we could not explore this variable further in the “low/normal” blood pressure category due to insufficient data.

4.3 Salty food and blood pressure

Chi-squared tests of analyses indicated a significant correlation between having low blood pressure and salty food ($X^2= 0.00$). This finding was not confirmed by regression analyses which indicates that there are certain lifestyle factors that might be indirectly influencing this correlation.

Results tables below provide various representations of data and analytics.

Table 1. Data dictionary for variables of interest to study.

Variable	Definition	Number of respondents
Demographic		
Age	Participant's self-reported age in years. Response option open between 18 to 65.	936
Gender	Participant's self-reported gender. Response option categorical: Male, Female	936
Ethnic group	The Population Registration Act (1991) identified groups as White, Indian, Black and Colored. The Color group includes people of Khoisan, Malaysian, Griqua, Indian and Chinese heritage. This variable was collected based on self-reported categorization by participants. African denotes African/ Black. No definition was given for Indian group or White.	930
Educational level	Highest educational level attained. Responses are categorical: Elementary/ incomplete, Diploma/ incomplete.	862
Worked for payment in the past 12 months	Whether participant worked for payment in the past 12 months. Response categories: Yes, No	936
Smoke	Has participant ever smoked? Response categories: Yes, No	100
Epidemiological/ Social		
Blood pressure categories	Participant's measured average blood pressure. Response categorical: Low, medium, high. Low blood	936

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	pressure	
Salty food consumption	Participant's self-reported consumption of salty food. Response categories: Very salty, lightly salted, not salted	100
Weight category	Respondent's measured weight category: Underweight, normal weight, over weight	936
Diabetes	Whether participant ever received diagnosis of diabetes. Response categories: Yes, No	936
Cholesterol	Whether participant ever received diagnosis of high cholesterol. Response categories: Yes, N	936
Stroke	Whether participant ever had stroke. Response categories: Yes, No	936
Heart attack	Whether participant ever had stroke. Response categories: Yes, No	936
Alcohol consumption indicators		
Drinking during the week	Whether participant drinks during the week. Response categories: Yes, No	336
Drinking during weekends	Whether participant drinks during the week. Response categories: Yes, No	336
Have you ever felt you needed to Cut down on your drinking?	Has participant ever felt needed to Cut down drinking? Response categories: Yes, No	491
Have people Annoyed you by criticizing your drinking?	Has participant ever felt Annoyed by criticism of drinking? Response categories: Yes, No	492
Have you ever felt Guilty about drinking?	Has participant ever felt Guilty about drinking?	492

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	Response categories: Yes, No	
Have you ever felt you needed a drink first thing in the morning (Eye-opener) to steady your nerves or to get rid of a hangover?	Has participant ever felt needed a drink first thing in the morning (Eye-opener) to steady nerves or to get rid of a hangover? Response categories: Yes, No	173
Family history		
History of stroke	Family history of stroke. Response categories: Yes, No	923
History of blood pressure	Family history of blood pressure. Response categories: Yes, No	883

Table 2. Socio-demographic characteristics of population

	N	(%)
Age		
18-24	182	(19.44)
25-35	255	(27.24)
36-45	235	(25.10)
46-55	155	(16.56)
56-65	109	(11.64)
Men	434	(46.6)
Women	502	(53.4)
Large city	463	(49.5)
Small city	294	(31.4)
Towns	57	(6.1)
Countryside	122	(13.0)
Ethnic group		
Black/ African	241	(25.7)
Coloured	586	(62.6)
White	99	(10.6)
Asian/ Indian	4	(0.4)
Worked for payment in the last 12 months		
Yes	599	(64.0)
No	335	(35.8)
Ever had alcohol		
Yes	496	(53)
No	440	(47)
Blood pressure categorical		
Low	26	(7.3)
Normal	278	(78.08)
High	52	(14.6)
No education	45	(4.8)

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Elementary	762	(81.4)
Secondary	54	(5.8)
Further studies incomplete	46	(5.0)

Table 3. Multivariate Results of different socio-demographic factors and blood pressure categories, low/normal or high/normal, in South African adults aged 18-65.

	Low/Normal			High/Normal		
	OR	Unadjusted p-value	Adjusted p-value	OR	Unadjusted p-value	Adjusted p-value
Age	0.976	0.846	0.517	0.965	0.09	0.398
Ethnic group	0.405	0.003*	0.301	0.387	0.912	0.428
Gender	1.606	0.14	0.534	0.262	0.562	0.155
Close blood relative ever had high	Not enough data			3.032	0.000*	0.260
Smoke	0.648	0.221	0.556	2.516	0.250	0.378
Diabetes	Not enough data			7.488	0.006*	0.185
Weight	1.106	0.225	0.886	2.005	0.689	0.511
High cholesterol	0.444	0.342	0.446	4.029	0.083	0.429
Heart attack	Not enough data			7.348	0.002*	0.021*
Stroke	Not enough data			2.555	0.088	0.629
Close blood relative ever had stroke	Not enough data			1.431	0.955	0.741
Cut down on drinking	1.276	0.124	0.861	0.047	0.858	0.103
Annoyed by people	0.283	0.527	0.361	9.09	0.199	0.057
Felt guilty about	1.325	0.140	0.840	3.793	0.616	0.440

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Drink first thing	0.918	0.540	0.952	0.399	0.514	0.373
Work for payment	1.566	0.405	0.577	0.778	0.026	0.812
Education level	1.702	0.094	0.495	0.496	0.315	0.617
Drink during weekend	0.700	0.121	0.734	0.174	0.226	0.107
Drink during week	0.427	0.303	0.409	1.690	0.940	0.626
Salty food	2.145	0.00*	0.301	1.241	0.217	0.844

CHAPTER 5: Discussion

Blood pressure is a complex health factor that is often associated with many other health indicators. This observation is thus reflected in our suggested model, which takes into account many health variables in addition to alcohol related ones. Some of the variables we deemed necessary include smoking, age, ethnic group, family health history, weight, heart attack, stroke, and educational level. Below, we have provided a rationalization for our choice of variable as well as a description of findings.

Our findings indicate a significant correlation between blood pressure, smoking and gender that has been explored by many researchers (Etmin et al., 2011; Olaoluwa 2013). Two recent studies, however, one from Glasgow, Scotland, and the other from Birmingham, England, have shown that smoking is more common in a selected group of hypertensive subjects, namely those with malignant phase hypertension. By taking a diastolic pressure greater than 120 mm. Hg with bilateral retinal hemorrhages and exudates as the criteria for inclusion in their study, the Glasgow workers' identified 82 patients with malignant phase hypertension, and found that 82Y were smokers. By contrast, only 40 to 50% of patients in three age-matched control groups smoked. These differences were significant for the sexes separately and together, for cigarette smoking alone and for all forms of smoking combined. Chi-squared tests of significance between smoking and gender indicated a significant correlation between identifying as male and being a smoker ($X^2=0.000$). Our results show a negative correlation between reporting to be a smoker and having low pressure ($p=0.556$). Although this finding is not significant it could highlight negative lifestyle habits that might be associated with being a smoker. Thus, even though smoking itself might not lead to not having low blood pressure it could be associated with other negative life style habits.

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Our results show that most of the respondents are not concerned with their cardiovascular health. This is alluded to through answers to questions regarding blood pressure measurements, doctor visits, smoking and alcohol consumption. Interestingly, the majority of respondents did not report having a family history of high blood pressure. This finding is in contrast to our earlier predictions regarding the prevalence of high blood pressure in the region. Potential explanations for this finding include low reliability of self-reported data, the racial and gender structure of the region.

Due to the complexity of our data and the structure of the statistical software employed blood pressure was divided into two sub categories; low/ normal and high/ normal. We believe this subcategorization would not affect any significant findings as those categories would reflect on both analyses.

Analyzing low/ normal category versus all epidemiological factors resulted in a few significant findings. Contrary to our original hypothesis, respondents' self-reported answers to the CAGE questionnaire are not significantly correlated to their blood pressure status.

CHAPTER 6: Potential Limitations

There are a number of eminent limitations that are to be anticipated of case control studies such as this one. Firstly, causality cannot be analyzed due to the nature of the cross sectional data, thus, limiting the findings to observe associations only and not cause and effect. Secondly, since the data is reliant on self-reported measures of alcohol use there might be a potential recall bias or under-reporting by participants due to cultural or social reasons. Thirdly, since this study is relying on secondary data it is limited in the type of questions that can be asked of the sample population. Furthermore, previous research has identified a protective factor against high blood pressure experienced by younger women (Kim *et al.*, 2014). This observation is relevant to our study because it might explain weak correlations between high alcohol consumption and blood pressure. Blood pressure was collected at one point in time with three replicates; ideally blood pressure measurements are obtained at a 24 hour period, during which several readings are recorded and an average is obtained. This potential limitation might imply a reduced validity in collected blood pressure measurements.

Previous literature had highlighted the influence of dietary intake on blood pressure measures. This could not be tested due to lack of information available to the authors. Similarly, smoking behaviours could not be addressed in more detail due to limitations in questionnaire design.

Categorical variables such as smoking limited our ability to ask detailed analytical questions. For example, in the case of smoking, we could ask about associations between different smoking patterns and blood pressure values.

Similarly, the presentation of weight variables limited our ability to investigate further.

The small sample size for many of our variables, including cancer which we had to eliminate, disabled us from exploring areas of further interest, such as family history and blood pressure.

CHAPTER 7: Areas for Future Research

Additional research should be done to better understand the epidemiology of alcohol consumption in relation to high blood pressure in South Africa. Results from these studies would lead to a better understanding of the association between the two factors that implicate the individual at risk for cardiovascular disease. Furthermore, findings from future studies would help the development of successful and targeted community-based prevention programs that would not only disseminate knowledge to the population but also reduce the alarmingly high numbers of cardiovascular diseases in the country.

We also recommend comparative studies between gender and regions within South Africa. Previous literature indicated the potential of gender based differences in blood pressure in addition to protectant effect for younger women. Although we could not ascertain those findings in our study, we believe further research using biological measures from smaller sample size could yield more reliable results.

An additional future project of interest would be one testing the impact of educational campaigns on blood pressure readings. Community based educational programs would be established regarding the importance of healthy lifestyle habits on blood pressure. Biological measurements would be taken before, after and during the campaign. We recommend biological measures since the increase the validity of any potential conclusions that would be drawn out of the study.

Specific areas for future research include:

- Policy design surrounding appropriate diagnoses for individuals with high blood pressure.

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- Public health campaigns to increase awareness regarding the importance of reducing high levels of blood pressure in addition to emphasizing the importance of testing one's blood pressure levels.
- Empowering and educating individuals with alcohol misuse problems through community based efforts.

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