



OPEN Alcohol use and optimal chronic diseases' treatment outcomes among adults aged 40 years and above in rural South Africa

Rumbidzai Mupfuti^{1✉}, Chodziwadziwa. W. Kabudula² & Joel Msafiri Francis³

Chronic diseases are significant problems in South Africa. Chronic diseases' treatment outcomes are critical to the reduction of morbidity and mortality. There is limited data in South Africa on alcohol use and treatment outcomes of chronic diseases in older people. Understanding the association between alcohol use and chronic diseases treatment outcomes would inform potential interventions to address the duo. We analysed data from wave 1 of the Health and Ageing in Africa—a longitudinal Study in an INDEPTH community (HAALSI) study. We performed descriptive analysis to determine the prevalence of optimal chronic diseases' treatment outcomes (suppressed HIV viral load, normal blood pressure and normal blood sugar—euglycemia) and applied modified Poisson regression to determine the association between alcohol use and chronic diseases' treatment outcomes. The prevalence of optimal treatment outcomes was 87.4% suppressed viral load for those living with HIV, 42.7% normal blood pressure for hypertensives, 53.6% with euglycemia among diabetics and 52.4% with normal outcome parameters among those with multimorbidity. Alcohol use did not negatively impact the optimal treatment outcomes for HIV (aRR = 1.00, 95%CI 0.93–1.09), hypertension (aRR = 0.88, 95%CI 0.68–1.14), diabetes mellitus (aRR = 0.73, 95%CI 0.44–1.22), and multimorbidity (aRR = 1.00, 95%CI 0.93–1.09). Alcohol use was not significantly associated with treatment outcomes possibly due to underreporting of alcohol use. There is need to incorporate objective alcohol measurements and alcohol interventions in chronic diseases care settings. Furthermore, there is urgent need to strengthen the management of hypertension and diabetes, by adopting the strategies deployed for HIV management.

Keywords Alcohol use, HIV, Hypertension, Diabetes mellitus, Multimorbidity, Treatment outcomes

Abbreviations

AHDSS	Agincourt Health and Socio-demographic Surveillance Site
AIDS	Acquired Immuno-Deficiency Syndrome
ART	Anti Retro-viral Therapy
BMI	Body Mass Index
C.W.K	Chodziwadziwa W. Kabudula
CVDs	Cardiovascular diseases
HAALSI	The Health and Ageing in Africa – a Longitudinal Study in an INDEPTH community
HbA1C	Hemoglobin A1C
HIV	Human Immunodeficiency Virus
J.M.F	Joel Msafiri Francis
NCDs	Non-communicable diseases
PLHIV	People Living with HIV
R.M	Rumbidzai Mupfuti
SA NSP-NCD	South African National Strategic Plan for the Prevention and Control of Non-communicable diseases

¹Division of Epidemiology and Biostatistics, School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. ²MRC/Wits Rural Public Health and Health Transitions Research Unit (Agincourt), School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. ³Department of Family Medicine and Primary Care, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa. ✉email: rmupfuti@gmail.com

SADHS	South African Demographic and Health Survey
WHO-SAGE	World Health Organisation Study on Global AGEing and Adult Health
WHO	World Health Organisation

South Africa faces a quadrupled burden of disease resulting from communicable, non-communicable diseases, maternal-child mortality, and injuries¹. This is due to the rapid epidemiological and nutritional transitions occurring because of improved healthcare and disease prevention strategies². HIV, hypertension, and diabetes mellitus are among the top prevalent chronic conditions causing mortality in South Africa, with the elderly population succumbing to multiple conditions resulting in multimorbidity. Multimorbidity which is the existence of two or more chronic conditions in the same individual³, leads to clinical complexity.

Older adults tend to experience a disproportionate share of NCDs (non-communicable diseases) burden and related complications such as CVDs (cardiovascular diseases)⁴. A demographic shift in PLHIV (people living with HIV) to older age has led to an increased risk of acquiring NCDs⁵. Uncontrolled hypertension and diabetes mellitus are among the leading risk factors for CVDs⁴. In addition, HIV-infected individuals are also at an increased risk for CVDs. There is a great need to prioritize treatment control strategies for chronic diseases as part of an initiative to prevent the growing incidence of CVD and premature mortality.

The rates of control of chronic diseases (HIV, hypertension, and diabetes mellitus) are still low in Africa, despite advances in treatment. According to the WHO SAGE wave 2, only 18% of people on antihypertensives were controlled⁶. An estimated 19% of people on treatment for diabetes mellitus achieved glycemic control according to the SADHS 2016⁷. Conversely, according to the 2017 National Population-Based Survey about 87% of those on HIV antiretroviral treatment achieved viral suppression⁸. Achieving treatment control is multifaceted, requiring the synergy of different prevention interventions.

Alcohol consumption has been recognized as a unique modifiable risk factor for population health, affecting both infectious and non-communicable diseases⁹. Alcohol is a toxic and addictive drug that has been shown to play a role in some mechanisms suggesting a multiplicative effect in acquiring the chronic condition¹⁰. The aging population is more susceptible to the toxic effects of alcohol, with the already increased chronic disease burden amongst this group. As of 2016, the percentage of alcohol-attributable deaths was 12.9% for infectious diseases and 19% for cardiovascular disease and diabetes worldwide with the highest age-standardized alcohol-attributable burden of disease and injury of 70.6 deaths per 100 000 people occurring within the African region⁹. The 2016 SADHS reported problem drinking in 15% of men and 2.5% of women aged between 45 and 64 years old¹¹. Harmful alcohol use is an important public health concern that needs to be addressed among the older population to control chronic diseases.

Both alcohol consumption and chronic diseases (HIV, Hypertension and Diabetes) are expected to increase in low to middle-income countries over the next years¹². This results in significant problems resulting in a major social impact thereby increasing the costs for national health systems¹². Given the increase in the aged population, these predictions will affect the older population even more. The treatment outcomes of chronic diseases can also be affected by drug-to-drug interactions which might occur between alcohol and the medications making them ineffective. A few studies have reported on the alcohol use and treatment outcomes for chronic diseases in an aging population in sub-Saharan Africa. The studies done have reported inconsistent findings. Some researchers reported an association between alcohol use and treatment outcomes for HIV, hypertension, and diabetes mellitus^{13,14,15} while other researchers reported no association.^{16,17,18}

In South Africa, with alcohol use being generally accepted in some social norms among older populations, it is often under-recognized¹⁹ and has been poorly understood in relation to poor treatment outcomes of chronic illnesses. It is unknown if harmful alcohol use contributes to treatment outcomes of chronic diseases in an aging population. Findings from this study will help to inform interventions targeted at improving treatment outcomes of chronic diseases (HIV, hypertension, and diabetes mellitus). The main aim of this study was to determine the association between alcohol use and treatment outcomes of HIV, hypertension, and diabetes mellitus among adults aged 40 years and above in rural South Africa²⁰.

Methods

Study setting

The primary study was conducted in South Africa, Mpumalanga Province in a rural sub-district where the Agincourt Health and Demographic Surveillance Site (HDSS) has been in operation since 1992. The Agincourt HDSS study area of approximately 450 km² is spread across thirty-one villages and covers a population of 116,000 individuals²¹.

We used data from wave 1 of the “Health and Aging in Africa: A Longitudinal Study of an INDEPTH Community in South Africa (HAALSI)” study. The baseline survey comprised men and women aged 40 years or older sampled from the ongoing Agincourt HDSS²⁰. The study was conducted between November 2014 and November 2015. Information on cognitive and physical functioning, social networks, economic well-being, cardiometabolic disease and HIV risk factors was collected through interviewer-administered questionnaires. Also included in the survey were anthropometric measurements and point-of-care blood tests for haemoglobin, glucose, and lipids. Dried blood spots were collected and later tested for HIV, HIV viral load, and C-Reactive Protein²⁰.

Study design and population

This was a cross-sectional study addressing the research question through secondary data analysis of the HAALSI dataset. There were 12,875 men and women from the Agincourt HDSS who met the eligibility criteria of being aged 40 years and above and permanently residing in the Agincourt HDSS study site for 12 months preceding the 2013 census²⁰. From the sampling frame, 6281 were randomly chosen to participate with gender-

specific sampling fractions being developed. However, 5059 people (2345 men and 2714 women) completed their interviews and were enrolled in the study²⁰. The eligibility criteria for our study was all participants aged 40 years and above in the 2014 HAALSI study who self-reported being on treatment for the following chronic diseases: HIV, hypertension, and diabetes mellitus.

Outcomes

The main outcomes were optimal treatment outcomes for HIV, hypertension, diabetes mellitus and multimorbidity. Ascertainment of being on treatment was self-reported for hypertension, diabetes mellitus and HIV based on the questions: “*ever received treatment for high blood pressure?*”, “*ever received treatment for diabetes?*” and “*ever received ART?*” respectively²⁰. The optimal treatment outcomes were based on local South African guidelines. The optimal HIV treatment outcome (controlled) was defined as a viral load of less than 1000 copies/ml²². The optimal treatment outcome (controlled) for hypertension was defined as systolic blood pressure < 140mmHg and diastolic blood pressure < 90mmHg²³. The optimal treatment outcome (controlled) for diabetes mellitus was defined as a random blood glucose of less than 11.1mmol/l or fasting blood glucose of less than 7mmol/l²⁴. Multimorbidity was defined as the existence of 2 or more chronic conditions from the following diseases (HIV, hypertension, and diabetes mellitus). The optimal treatment outcome for multimorbidity was defined as having optimal treatment outcomes for all 3 chronic diseases. Outcome variables were categorized as 0 = controlled and 1 = uncontrolled. According to the World Health Organization, for HIV (2025)- 95% of people on antiretroviral treatment should be virally suppressed²⁵, for Diabetes Mellitus- 80% of diabetes mellitus patients on treatment should achieve glycemic control²⁶ and for Hypertension- 80% of hypertensive patients on treatment should achieve blood pressure control²⁶.

Primary exposure

The main exposure was alcohol use which was defined according to the frequency of drinking alcohol in the past 30 days by the following question: “*How often do you have at least 1 alcoholic drink?*” The following responses were given: daily drinking, 5–6 days per week, 1–4 days per week, 1–3 days per month, less than once per month and does not currently drink²⁰. Alcohol use was recategorized into 3 groups for HIV, hypertension, and multimorbidity treatment outcomes: at least once a week (daily drinking, 5–6 drinks per week and 1–4 days a week), at least once a month (1–3 drinks per month and less than 1 per month) and none (does not currently drink). For diabetes mellitus treatment outcome, alcohol use was categorized into 2 groups, 0 = none and 1 = Yes due to the smaller sample size.

Covariates

The covariates included age group, sex, education category, nationality, BMI, employment status, wealth asset index, marital status, size of the household and tobacco use which were self-reported. Age group was recategorized into 2 groups: “40–60 years” and “60 years and older”²⁷. Wealth index was created from household characteristics and asset ownership using the Principal Component Analysis.

Data management and analysis

STATA version 17 was used for data management and analysis²⁸. Data missing completely at random, a complete case analysis was used and where data missing not at random, a sensitivity analyses was used to measure bias. Descriptive statistics of the total study population were computed for alcohol use and covariates. This was reported as frequencies and proportions. Pearson’s Chi-square test was used to determine the prevalence of optimal treatment outcomes for each chronic condition (HIV, hypertension, diabetes mellitus and multimorbidity) across alcohol use and other covariates. Each selected exposure variable was cross tabulated with the optimal treatment outcome of each chronic disease (HIV, hypertension, diabetes mellitus and multimorbidity). The output of this cross-tabulation was reported as proportions (n, %). (Supplementary Tables 1–5). Univariate modified Poisson regression was used to assess the relationship between the optimal treatment outcome of each chronic disease (HIV – viral load suppression, hypertension – controlled blood pressure, diabetes mellitus – controlled glycemia, and multimorbidity – optimal for all the three conditions) with alcohol use and the covariates. Then, all exposures with p-value (<0.20) were added in the multivariate modified Poisson regression²⁹ to determine the association of alcohol use and each chronic disease treatment outcome adjusting for other factors. The final model also included exposure variables considered as apriori confounders including sex, age, tobacco use and wealth index. Interaction terms among alcohol use and exposure variables (age and sex) were checked for all the four models and all are not statistically significant. The final model fit for the association between alcohol use and the chronic diseases’ treatment outcomes (HIV, hypertension, diabetes mellitus and multimorbidity) were assessed using a post-estimation goodness-of-fit test. Finally, adjusted relative risk (aRR) and their corresponding 95% confidence intervals (95% CI) and p values from the final models were reported. A p value of <0.05 was considered statistically significant.

Ethical considerations

The HAALSI study received ethics approval from the following institutions: The University of the Witwatersrand ref M141159, the Harvard School of Public Health ref C13-1608-02 and the Mpumalanga Provincial Office. The participants’ data were coded and de-identified. For this study, ethics approval was obtained from the University of the Witwatersrand Human Research Ethics Committee ref M230446.

Results

Population characteristics

Out of the 5055 participants, almost three quarters (76.9%) reported no alcohol use with only 12.2% reporting alcohol use at least once a week and 10.9% reporting alcohol use at least once a month. More than half of the participants (53.7%) were female and 51% of participants were aged 60 years and above. 1526 (30%) of the participants within the study population were migrants. 2306 participants (45.7%) received no formal education and a third of the participants (34%) received some primary level of education. Just over half of the participants (50.9%) were married and participants were approximately equally distributed with an average of 20% of participants per wealth index quintile. Most of the participants (73.7%) were not working and 48.2% ($n=2438$) of participants lived in a 3 to 6 people household. Lastly, the majority of the participants ($n=4608$) reported no tobacco use and only 36.7% of participants had a normal BMI. (Table 1)

Prevalence of HIV viral load suppression controlled (glycemia and blood pressure) and optimal outcomes for all conditions among those with multimorbidity

Figure 1 shows the prevalence of optimal chronic diseases' treatment outcomes for HIV, hypertension, diabetes mellitus and multimorbidity. The prevalence of optimal treatment outcomes was 87.4% (450/515) HIV viral load suppression, 42.7% (713/1668) for controlled hypertension, 53.6% (140/261) for diabetes mellitus and 52.4% (475/907) for multimorbidity.

Characteristic	Categories	<i>n</i>	%
Age Group (years)	40–60	2479	49.0
	61 and above	2580	51.0
Sex	Female	2714	53.7
	Male	2345	46.3
Country of origin	South Africa	3528	69.8
	Mozambique/other	1526	30.2
Level of education	No formal education	2306	45.7
	Some primary (1–7 years)	1716	34.0
	Some secondary (8–11 years)	574	11.4
	Secondary or more (12+ years)	446	8.9
Marital status	Never married	290	5.7
	Separated / divorced	650	12.9
	Widowed	1540	30.5
	Currently married	2575	50.9
Wealth asset index	1	1046	20.7
	2	1001	19.8
	3	991	19.6
	4	1007	19.9
	5	1014	20.0
Household size	Living alone	534	10.6
	Living with one other person	538	10.6
	Living in 3–6-person household	2438	48.2
	Living in 7+ person household	1549	30.6
BMI category	Underweight	258	5.5
	Normal	1719	36.7
	Overweight	1328	28.3
	Obese	1384	29.5
Employment status	Employed (part or full time)	805	16.0
	Not working	3719	73.7
	Homemaker	521	10.3
Tobacco use	Yes	447	8.4
	No	4608	91.6
	None	3887	76.9
Alcohol use	At least once a week	617	12.2
	At least once a month	551	10.9

Table 1. Baseline characteristics of HAALSI population ($N=5059$) enrolled between November 2014 and November 2015. The total number of observations for each variable does not add up to ($N=5059$) in each column due to missing values. Missing data for marital status: 4, alcohol use: 4, tobacco use: 4, country of origin: 5, employment status: 14, level of education: 17 and BMI: 370.

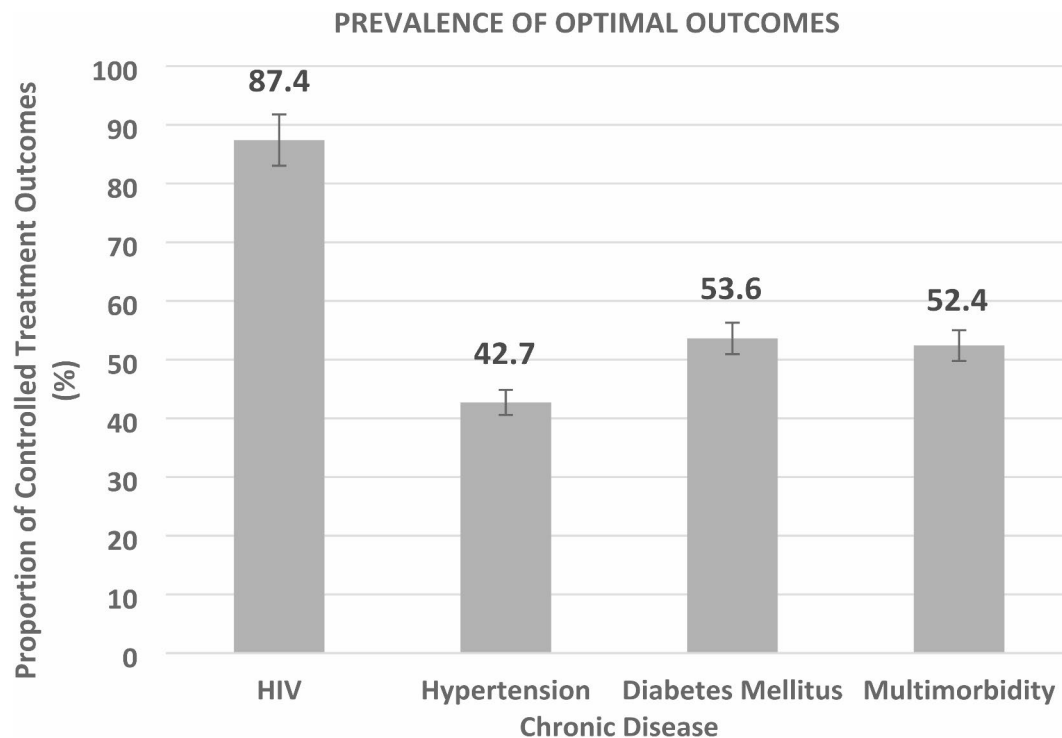


Fig. 1. Prevalence of HIV viral load suppression, controlled (glycemia and blood pressure) and optimal outcomes for those with multimorbidity.

Alcohol use and HIV viral load suppression

There was no statistical difference on HIV viral load suppression between participants reporting alcohol use at least once a week (aRR = 1.00, 95% C.I 0.93–1.09) and those reporting alcohol use at least once a month (aRR = 0.92, 95% C.I 0.8–1.05) compared to those that reported no alcohol use (Table 2).

Other factors associated with HIV viral load suppression: Females were 13% more likely to have HIV viral load suppression (aRR = 1.13, 95% C.I 1.04–1.24) compared to males. Similarly, participants who reported to have attained secondary education or more were 14% more likely to have HIV viral load suppression (aRR = 1.14, 95% C.I 1.01–1.21) compared to participants that reported no formal education. Overall, there was no association found between HIV treatment outcomes and the following covariates: age, wealth index, BMI, tobacco use and marital status. (Table 2)

Alcohol use and controlled hypertension

Participants reporting alcohol use at least once a week and at least once a month were 12% less likely to have controlled hypertension (aRR = 0.88, 95% C.I 0.68–1.14) compared to those that reported no alcohol use. However, the associations were not statistically significant. (Table 3)

Other factors associated with controlled hypertension: Female participants were 22% more likely to have controlled hypertension (aRR = 1.22, 95% C.I 1.07–1.39) compared to male participants. Participants aged above 60 years were 18% more likely to have controlled hypertension (aRR = 1.18, 95% C.I 1.05–1.34) compared to participants aged between 40 and 60 years old. Conversely, obese (aRR = 0.75, 95% C.I 0.64–0.84) and overweight (aRR = 0.84, 95% C.I 0.73–0.97) participants were 25% and 16% less likely to have controlled hypertension respectively compared to participants with a normal BMI. There was no association between hypertension treatment outcomes and the following covariates: country of origin, wealth index and tobacco use. (Table 3)

Alcohol use and controlled glycemia

Among those with diabetes, participants reporting alcohol use were 27% less likely to have controlled glycemia (aRR = 0.73, 95% C.I 0.44–1.22) compared to those that reported no alcohol use. However, this association was not statistically significant. (Table 4)

Other factors associated with controlled glycemia: Female participants were 25% less likely to have controlled glycemia (aRR = 0.75, 95% C.I 0.58–0.97) compared to male participants. Homemakers were 51% less likely to have controlled glycemia (aRR = 0.49, 95% C.I 0.23–1.01) compared to those that were employed. However, this association was not statistically significant. The following covariates were not associated with controlled glycemia: age, BMI, wealth index and tobacco use. (Table 4)

Characteristic	Categories	Total N(%) ^a	RR ^b (95% C.I)	<i>p</i> value ^d	aRR ^c (95% C.I)	<i>p</i> value ^d
Alcohol Use	None	358 (89.5)	1	0.080	1	0.438
	At least once a week	46 (80.7)	0.90 (0.79–1.02)		1.00 (0.93–1.09)	
	At least once a month	46 (79.3)	0.87 (0.77–1.02)		0.92 (0.80–1.05)	
Sex	Male	198 (82.2)	1	0.001	1	0.296
	Female	252 (92.0)	1.12 (1.04–1.20)		1.13 (1.04–1.24)	
Age group (in years)	40–60	312 (86.0)	1	0.102	1	0.106
	61 and above	138 (90.8)	1.06 (0.99–1.12)		1.06 (0.98–1.13)	
	No formal education	171 (86.4)	1	0.097	1	0.045
Education category	Some primary (1–7 years)	182 (89.7)	1.03 (0.97–1.12)		1.07 (0.98–1.16)	
	Some secondary (8–11 years)	60 (81.1)	0.94 (0.83–1.06)		0.98 (0.85–1.12)	
	Secondary or more (12+ years)	35 (94.6)	1.10 (0.99–1.20)		1.14 (1.01–1.25)	
Marital status	Never married	27 (77.1)	1	0.099	1	0.058
	Separated / divorced	93 (82.3)	1.07 (0.87–1.30)		1.02 (0.85–1.23)	0.798
	Widowed	156 (89.7)	1.16 (0.96–1.40)		1.08 (0.90–1.28)	0.399
	Currently married	174 (90.6)	1.17 (0.98–1.41)		1.16 (0.98–1.40)	0.092
Wealth asset index	1	102 (83.6)	1	0.230	1	0.510
	2	102 (89.5)	1.07 (0.97–1.18)		1.07 (0.96–1.20)	
	3	95 (91.3)	1.09 (0.99–1.2)		1.06 (0.95–1.18)	
	4	83 (83.0)	0.99 (0.88–1.12)		0.99 (0.87–1.13)	
	5	68 (90.7)	1.08 (0.90–1.20)		1.04 (0.92–1.18)	
BMI category	Underweight	38 (82.6)	0.98 (0.85–1.13)	0.014	0.98 (0.85–1.13)	0.208
	Normal	204 (84.3)	1		1	
	Overweight	110 (94)	1.12 (1.03–1.20)		1.06 (0.99–1.14)	
	Obese	87 (90.6)	1.08 (0.98–1.16)		1.02 (0.93–1.11)	
Tobacco Use	Yes	32 (94.1)	1	0.086	1	0.119
	No	418 (86.9)	0.92 (0.84–1.01)		0.92 (0.81–1.02)	

Table 2. Association between reported alcohol use and HIV viral load suppression amongst participants of the HAALSI study ($N = 5059$), enrolled between November 2014 and November 2015. C.I = confidence interval. ^a sample of each exposure category. ^b crude relative risk from modified Poisson regression. ^c adjusted relative risk from modified Poisson regression. ^d the overall P -value for trend across all categories of individual variable. Significant values are in bold. 1 => Reference category. Deviance goodness of fit model = (108.498), $p = 0.999$.

Alcohol use and optimal treatment outcomes among those with multimorbidity

Among those with multimorbidity there was no difference in treatment outcomes for participants reporting alcohol use at least once a week and at least once a month (aRR = 1.00, C.I: 0.93–1.09) compared to those that reported no alcohol use. The associations were not statistically significant. (Table 5)

Other factors associated with optimal treatment outcomes among those with multimorbidity: Among participants with multimorbidity those aged above 60 years were 6% less likely to have optimal treatment outcomes (aRR = 0.94, 95% C.I 0.90–0.99) compared to those aged between 40 and 60 years. In addition, Immigrants (Mozambique or other) were 6% likely to have optimal treatment outcomes (aRR = 1.06, 95% C.I 1.00–1.12) compared to those from South Africa. Obese (aRR = 0.89, 95% C.I 0.84–0.94) and overweight (aRR = 0.92, 95% C.I 0.89–0.97) were less likely to have optimal treatment outcomes compared to participants with a normal BMI. (Table 5)

Sensitivity analyses: We carried out a sensitivity analysis to determine the association between alcohol use and optimal treatment outcomes among those with multimorbidity. The results obtained across alcohol use categories were similar for both multimorbidity (HIV, hypertension and diabetes mellitus) (Table 5) and multimorbidity without HIV (Supplementary Table 6).

Discussion

The study sought to establish the association between alcohol use and chronic diseases' treatment outcomes (HIV viral load suppression, controlled hypertension, and glycemic control) among adults aged 40 years and above in rural South Africa. This study shows that the prevalence of optimal treatment outcome was highest for HIV (87.2%) and suboptimal for hypertension (43.7%), diabetes (53.6%), and multimorbidity (52.4%). Furthermore, alcohol use was not significantly associated with any of the chronic diseases' treatment outcomes (HIV, hypertension, diabetes mellitus and multimorbidity).

The prevalence of optimal hypertension treatment outcome was 42.7%, which is within the range of similar studies done in South Africa that reported a prevalence ranging from 19 to 56% of controlled hypertension outcomes³⁰. However, the WHO SAGE wave 2 reported that only 18% had controlled hypertension treatment

Characteristic	Categories	Total N(%) ^a	RR ^b (95% C.I)	p value ^d	aRR ^c (95% C.I)	p value ^d
Alcohol Use	None	613 (43.7)	1	0.230	1	0.350
	At least once a week	43 (36.8)	0.84 (0.65–1.07)		0.88 (0.68–1.14)	
	At least once a month	57 (38.8)	0.89 (0.71–1.09)		0.88 (0.70–1.09)	
Sex	Male	238 (39.6)	1	0.055	1	0.003
	Female	475 (44.5)	1.12 (0.99–1.26)		1.22 (1.07–1.39)	
Age group (in years)	40–60	222 (38.1)	1	0.006	1	0.007
	61 and above	491 (45.3)	1.18 (1.05–1.34)		1.18 (1.05–1.34)	
Country of origin	South Africa	533 (43.7)	1	0.201	1	0.343
	Mozambique/other	179 (40.1)	0.92 (0.80–1.05)		0.93 (0.81–1.08)	
Wealth asset index	1	114 (40.6)	1		1	0.583
	2	128 (41.6)	1.02 (0.84–1.23)	0.557	1.01 (0.83–1.23)	
	3	129 (42.3)	1.04 (0.85–1.26)		1.00 (0.82–1.23)	
	4	175 (46.4)	1.14 (0.95–1.36)		1.13 (0.94–1.37)	
	5	167 (42.1)	1.03 (0.86–1.24)		1.08 (0.89–1.31)	
BMI category	Underweight	28 (53.8)	1.08 (0.82–1.42)	0.005	1.13 (0.85–1.49)	<0.001
	Normal	188 (49.7)	1		1	
	Overweight	202 (43.1)	0.87 (0.74–1.00)		0.84 (0.73–0.97)	
	Obese	251 (39.5)	0.79 (0.69–0.91)		0.75 (0.64–0.86)	
Tobacco Use	Yes	80 (45.2)	1	0.477	1	0.646
	No	633 (42.5)	0.93 (0.79–1.11)		1.05 (0.86–1.27)	

Table 3. Crude and adjusted association between alcohol use and controlled hypertension amongst participants of the HAALSI study ($N=5059$), enrolled between November 2014 and November 2015. C.I= confidence interval. ^a sample of each exposure category. ^b crude relative risk from modified Poisson regression. ^c adjusted relative risk from modified Poisson regression. ^d the overall P -value for trend across all categories of individual variable. Significant values are in bold. 1 => Reference category. Deviance goodness of fit model = (1087.7), $p=0.990$.

outcome⁶. We also reported a prevalence of 53.6% for optimal diabetes mellitus treatment outcome, which is much higher than a prevalence of 19% and 23% reported in previous studies done in South Africa²⁴⁷. The prevalence optimal HIV treatment outcome was 87.3%, which was similar to a population-based survey that reported 87% were virally suppressed⁸. The prevalence of optimal hypertension and diabetes mellitus treatment outcomes are better than those reported in previous studies but still inadequate. The improved hypertension treatment outcome could be attributed to the improved health care amongst this population which has been followed up in the Agincourt HDSS since 1992.

Alcohol use was not associated with any of the chronic diseases (HIV, hypertension, and diabetes mellitus) treatment outcomes in this study population. These findings might have been influenced by several factors that include this study did not assess adherence to treatment for the participants that self-reported being on treatment. Baum et al., found that adherence to medication mediates the association between alcohol use and HIV treatment outcomes³¹. In addition, this study population was an older population and Korhonen et al. concluded that initiation of chronic disease medication was associated with a greater decline in alcohol consumption³². Furthermore, a study done showed that alcohol consumption patterns differ with age and older age groups were associated with lower alcohol consumption³³. However, this study assessed the frequency of alcohol use and did not quantify the alcohol consumption of those that self-reported alcohol use. Lastly, alcohol use was self-reported in this study which could have resulted in social desirability bias thereby affecting our results. Stockwell et al. found that infrequent drinkers under-estimate their consumption more than frequent drinkers³⁴. Recent studies have suggested using biomarkers such as Phosphatidylethanol, carbohydrate-deficient transferrin and gamma-glutamyl transferase to validate self-report alcohol use³⁵. Nonetheless, these biomarkers should be interpreted with caution in people with liver disease.

For viral load suppression the study findings are consistent with a study done in Kenya which showed that alcohol use was not associated with a suppressed viral load¹⁷. Another study found that women aged 50 years and above were less likely to have a non-suppressed viral load than women under 50 years³⁶. Conversely, some studies that found a significant association between alcohol use and a high viral load were among a younger population and those that consumed more than 20 units of alcohol per week¹³. Cook et al., suggested that differences in the way alcohol consumption is defined and measured can result in different conclusions on the relationship between alcohol consumption and HIV (34).

For hypertension treatment outcomes, findings are supported by a study done which found that older age groups had a better awareness of lifestyle changes and good treatment outcomes¹⁸. A reduction in alcohol consumption was shown to reduce blood pressure among hypertensive men who were drinkers³⁷. Other studies showed light drinking to be protective and moderate to heavy drinking was associated with increased blood pressure, however, the effects of alcohol are heterogenous and vary according to dose and pattern³⁷.

Characteristic	Categories	Total N(%) ^a	RR ^b (95% C.I)	p value ^d	aRR ^c (95% C.I)	p value ^d
Alcohol Use	None	128 (54.5)	1	0.453	1	0.23
	Yes	12 (46.2)	0.85 (0.55–1.3)		0.73 (0.44–1.22)	
Sex	Male	66 (58.9)	1	0.135	1	0.027
	Female	74 (49.7)	0.84 (0.67–1.05)		0.75 (0.58–0.97)	
Age group (in years)	40–60	43 (45.7)	1	0.067	1	0.182
	61 and above	97 (68.1)	1.27 (0.98–1.63)		1.22 (0.91–1.64)	
Employment status	Employed	12 (46.2)	1	0.033	1	0.026
	Not working	120 (58.3)	1.26 (0.82–1.94)		1.10 (0.67–1.82)	
	Homemaker	8 (27.6)	0.6 (0.29–1.23)		0.49 (0.23–1.01)	
Wealth asset index	1	16 (51.6)	1	0.754	1	0.43
	2	19 (45.2)	0.88 (0.54–1.41)		0.93 (0.55–1.60)	
	3	29 (56.9)	1.10 (0.73–1.67)		1.16 (0.71–1.89)	
	4	34 (58.6)	1.14 (0.76–1.70)		1.36 (0.86–2.20)	
	5	42 (53.2)	1.03 (0.69–1.50)		1.11 (0.70–1.76)	
BMI category	Underweight	2 (100)	1.85 (1.42–2.40)		2.45 (1.20–4.97)	0.8
	Normal	26 (54.2)	1		1	
	Overweight	36 (49.3)	0.91 (0.87–0.97)		0.92 (0.65–1.31)	
	Obese	57 (51.8)	0.89 (0.84–0.93)		1.01 (0.73–1.42)	
Tobacco Use	Yes	13 (61.9)	1	0.389	1	0.547
	No	127 (52.9)	0.85 (0.60–1.22)		0.86 (0.54–1.39)	

Table 4. Crude and adjusted association between alcohol use and controlled glycemia amongst participants of the HAALSI study ($N = 5059$), enrolled between November 2014 and November 2015. C.I = confidence interval. ^a sample of each exposure category. ^b crude relative risk from modified Poisson regression. ^c adjusted relative risk from modified Poisson regression. ^d the overall P -value for trend across all categories of individual variable. Significant values are in bold. 1 => Reference category. Deviance goodness of fit model = (147.51), $p = 1.00$.

For diabetes mellitus treatment outcomes, the findings are similar to the other studies in sub-Saharan Africa that showed alcohol was not associated with poor glycemic control^{16,15}. However, other studies reported that moderate alcohol consumption of 5 to 20 g of alcohol use was associated with better glycemic control as it decreases HbA1C and increases insulin sensitivity³⁵.

For multimorbidity treatment outcomes, there are a few studies that have looked at multimorbidity interventions and the evidence to support the different approaches is still limited³⁸. But a study done on hypertension control among people living with HIV- showed that alcohol use was not associated with the treatment outcomes³⁹.

In this study, some covariates such as age, sex and BMI were associated with treatment outcomes. Specifically, females were more likely than men to have optimal treatment outcomes for HIV and hypertension that is consistent with previous studies that reported females had better outcomes because they tend to adhere to treatment schedules more than men in South Africa^{40,41}.

Another important covariate in this study was age as such those older than 60 years were more likely to have optimal treatment outcomes for HIV, hypertension and diabetes mellitus, we attribute this to the impact of lifestyle modifications among older age groups following chronic disease diagnosis. On the other hand, those with multimorbidity had poorer treatment outcomes possibility due to challenges associated with multimorbidity, for example, polypharmacy leading to unfavorable drug side effects.

Strengths and limitations

An important strength of this study- is the use of biomarkers and objective measurements to measure treatment outcomes of chronic diseases. This minimizes bias related to self-reported data. It is important to consider the following limitations when interpreting this study's findings. First, because this study was cross-sectional, it was not possible to determine the temporal relationship between alcohol use and treatment outcomes. Therefore, not possible to establish causality. Second, alcohol use was self-reported and that could be subjected to recall and social desirability bias. This could have led to underreporting and therefore biased the association of alcohol use and chronic diseases' treatment outcomes towards the null. Lastly, the hypertension and blood glucose were assessed at one time point and therefore unable to determine/ establish long term control of hypertension and diabetes. For glycemic assessment, HbA1C assessment would have been a better indicator of glycemic control as it measures the average blood sugar levels over the past three months.

Conclusion

This study has shown that reported alcohol use is not associated with chronic diseases' treatment outcomes (HIV, hypertension, diabetes mellitus and multimorbidity). This is possibly due to underreporting of alcohol use in the aging population, highlighting the greater need for more objective alcohol use measurements. In addition, the

Characteristic	Categories	Total N(%) ^a	RR ^b (95% C.I)	p value ^d	aRR ^c (95% C.I)	p value ^d
Alcohol Use	None	382 (51.6)	1	0.357	1	0.981
	At least once a week	50 (59.5)	1.05 (0.98–1.15)		1.00 (0.93–1.09)	
	At least once a month	43 (52.4)	1.00 (0.93–1.08)		1.00 (0.93–1.08)	
Sex	Male	190 (50.5)	1	0.352	1	0.296
	Female	285 (53.7)	1.02 (0.98–1.07)		1.03 (0.97–1.08)	
Age group (in years)	40–60	265 (58.4)	1	<0.001	1	0.013
	61 and above	210 (46.4)	0.92 (0.89–0.96)		0.94 (0.90–0.99)	
Country of origin	South Africa	329 (49.9)	1	0.014	1	0.040
	Mozambique/other	145 (58.9)	1.06 (1.01–1.11)		1.06 (1.0–1.12)	
Education category	No formal education	209 (52.1)	1	0.174	1	0.173
	Some primary (1–7 years)	171 (52.8)	1.00 (0.96–1.05)		1.02 (0.97–1.08)	
	Some secondary (8–11 years)	64 (59.8)	1.05 (0.98–1.12)		1.08 (0.99–1.16)	
	Secondary or more (12+ years)	31 (43.1)	0.94 (0.86–1.03)		0.99 (0.89–1.08)	
Marital status	Never married	19 (52.8)	1	0.001	1	0.026
	Separated / divorced	96 (65.8)	1.08 (0.97–1.22)		1.01 (0.96–1.20)	
	Widowed	168 (52.3)	0.99 (0.89–1.12)		1.03 (0.92–1.15)	
	Currently married	192 (47.6)	0.97 (0.86–1.08)		0.98 (0.87–1.09)	
Wealth asset index	1	97 (61.4)	1	0.030	1	0.884
	2	93 (54.1)	0.95 (0.89–1.04)		0.97 (0.90–1.04)	
	3	90 (52.6)	0.95 (0.88–1.01)		0.98 (0.92–1.06)	
	4	106 (51.5)	0.94 (0.88–1.00)		0.98 (0.90–1.05)	
	5	89 (44.5)	0.89 (0.84–0.96)		0.96 (0.89–1.04)	
BMI category	Underweight	23 (74.2)	1.06 (0.96–1.17)	<0.001	1.04 (0.94–1.16)	0.001
	Normal	164 (64.3)	1		1	
	Overweight	126 (50.2)	0.91 (0.87–0.97)		0.92 (0.87–0.97)	
	Obese	142 (45.5)	0.89 (0.84–0.93)		0.89 (0.84–0.94)	
Tobacco Use	Yes	45 (56.3)	1	0.459	1	0.742
	No	430 (52.0)	0.97 (0.90–1.05)		0.99 (0.91–1.07)	

Table 5. Crude and adjusted association between alcohol use and optimal treatment outcomes among those with Multimorbidity amongst participants of the HAALSI study ($N = 5059$), enrolled between November 2014 and November 2015. C.I = confidence interval. ^a sample of each exposure category. ^b crude relative risk from modified Poisson regression. ^c adjusted relative risk from modified Poisson regression. ^d the overall P -value for trend across all categories of individual variable. Significant values are in bold. 1 => Reference category. Deviance goodness of fit model = (131.66), $p = 1.00$.

prevalence of optimal hypertension, diabetes mellitus and multimorbidity treatment outcomes were low. There is an urgent need to optimize treatment outcomes to reduce morbidity and mortality in sub-Saharan Africa. We also need to incorporate objective alcohol measurements in chronic diseases care settings. Furthermore, there is an urgent need to strengthen the management of hypertension and diabetes, by adopting the strategies deployed for HIV management. Also, critical to strengthen the management of multimorbidity in older populations.

Data availability

Data are available in a public, open access repository. Any additional data requests could be directed to chodzivadziwa.kabudula@wits.ac.za. The HAALSI baseline data are publicly available at the Harvard Centre for Population and Development Studies (HCPDS) programme website <https://haalsi.org/data>.

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Author contributions

R.M. conceived the current study with support from J.M.F. C.W.K. conceived, designed, and implemented the HAALSI study. R.M. carried out the data analysis. J.M.F. and C.W.K. critically appraised the data analysis plan. All authors (R.M., C.W.K., J.M.F.) participated in the interpretation of the data. R.M. drafted the manuscript. All authors provided critical revisions to the draft manuscript. All authors approved the final version of the paper.

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Declarations

Competing interests

The authors declare no competing interests.

Ethical approval

The study was approved by the University of Witwatersrand Human Research Ethics Committee (Approval No.230446).

Consent for publication

All authors declare that they consent to publication.

Additional information

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Correspondence and requests for materials should be addressed to R.M.

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