The association between tobacco and alcohol use and health outcomes in individuals living with diabetes and prediabetes in South Africa: A cross-sectional study

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Background. Smoking and alcohol misuse are lifestyle factors that can be controlled and have significant health effects. Both these factors increase the risk of developing conditions such as diabetes mellitus because they affect glucose metabolism and can interfere with blood glucose control in individuals with diabetes. Research on tobacco and alcohol use and specific health outcomes among adults with prediabetes or type 2 diabetes mellitus (T2DM) could provide valuable information leading to more efficient treatment and management of this disease.

Objectives. To assess the association between tobacco and alcohol use and specific health outcomes among South African adults with prediabetes or T2DM.

Methods. Data from the 2016 South African Demographic and Health Survey were analysed using Stata v17. Participants were classified into prediabetes or T2DM groups, based on a glycated haemoglobin cut-off of 5.7% or self-report of a previous diagnosis of T2DM. Exposures of interest were self-reported current tobacco smoking and problem/risky alcohol use. The associations between these exposures and health outcomes in the different groups were assessed using multivariable logistic regression analysis. We adjusted for specific confounders in the regression models.

Results. Of a total of 6 108 participants (mean (standard deviation) age 41 (19) years), 72.2% (n=4 409) had prediabetes and 27.8% (n=1 699) T2DM; 17.7% (n=1 084) were current smokers and 9.3% (n=565) reported problem/risky alcohol use. Current smoking was significantly associated with 40% increased odds of shortness of breath (adjusted odds ratio (aOR) 1.40; 95% confidence interval (CI) 1.1 - 1.7; p<0.001) and 67% increased odds of chronic obstructive pulmonary disease (COPD)/asthma (aOR 1.67; 95% CI 1.2 - 2.2; p<0.001). Problem/risky alcohol use was significantly associated with 40% increased odds of COPD/asthma (aOR 1.40; 95% CI 1.1 - 1.7; p=0.001) and 92% increased odds of having cancer (aOR 1.92; 95% CI 1.5 - 2.5; p<0.001).

Conclusion. There is a need for targeted smoking cessation programmes and alcohol misuse counselling among individuals living with diabetes and prediabetes.

Keywords: Type 2 diabetes mellitus, T2DM, prediabetes, glucose intolerance, tobacco smoking, alcohol use, problem/risky drinking, health outcomes, South Africa.

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The global prevalence of diabetes mellitus for 2021 was estimated to be 10.5%, which amounts to 463 million adults suffering from the disease.[1] According to the World Health Organization (WHO), diabetes was the direct cause of 1.5 million deaths worldwide in 2019.[2] In the International Diabetes Federation (IDF) Africa region, 24 million adults (20 - 79 years) were living with diabetes in 2021.[3] As in the rest of the world, diabetes is also a major health concern in South Africa (SA). According to the IDF, in 2021 the age-adjusted prevalence of diabetes in SA was 10.8%.[1] Since 2015, diabetes has been the second leading cause of death in SA overall, and the leading cause of death in women.[4] With SA's suboptimal health system and the already heavy burden imposed by a high incidence of communicable, non-communicable, perinatal and maternal, and injury-related disorders, diabetes places additional strain on the country's fragile health status.[5] Diabetes is a metabolic disease characterised by chronic hyperglycaemia.[6] There are three forms of diabetes: type 1 diabetes mellitus, type 2 diabetes mellitus (T2DM), and gestational diabetes mellitus.[3] T2DM accounts for 90% of total cases of diabetes.[3] Prediabetes is a condition classified by intermediate hyperglycaemia. Impaired glucose tolerance (IGT) is present in both prediabetes and diabetes, and is also an intermediate condition in the transition from normality to diabetes. People with IGT are at high risk of progressing to type 2 diabetes, although this is not inevitable.[2]

The diagnosis of T2DM in resource-constrained settings is a challenge, with the highest proportions of undiagnosed diabetes being in low- and middle-income countries, especially in Africa, with 54% in the IDF African region.[3] Similarly, in SA, limited resources in remote and rural areas pose a challenge for the diagnosis and management of T2DM. There are various methods of diagnosing

and screening for T2DM, including fasting plasma glucose tests, glycated haemoglobin (HbA1c) tests and 2-hour post-load glucose tests. Venous whole-blood samples are taken for HbA1c testing, but as an initiative to improve diabetes management in rural areas, dried blood spot (DBS) sampling has been used as an alternative.[7] A few studies have reported that DBS samples are comparable to samples obtained from venous blood. Mastronardi *et al.*[8] found that when DBS samples were processed within 7 days and applied to correction equations, the results showed a high correlation with results from venous blood samples, while Maleska *et al.*[9] reported that HbA1c testing using DBS was accurate and comparable with whole-blood values. Other studies have shown similar results, but Hall *et al.*[7] assert that there is a need for standardisation of sample collection, transportation, storage and analysis methods for DBS samples.

Smoking and alcohol misuse are lifestyle factors that can be controlled and have significant health effects. Both tobacco and alcohol are addictive substances that require cessation interventions. A review by Adams[10] found that concurrent use of tobacco and alcohol results in a synergistic effect on behaviour and may potentiate the negative effects of both substances. Use of these two substances has the effect of cross-reinforcement, which is the enhanced motivational effect to consume the other substance by stimulating shared neurobiological mechanisms that reinforce the effects of the substances.[10] Tobacco smoking and alcohol misuse increase the risk of developing conditions such as diabetes, as a result of cell damage caused by these substances.[11] These substances also have an effect on glucose metabolism and can interfere with blood glucose control in individuals with diabetes.[11] Smoking is also associated with development of health problems such as various types of cancer, dental disease, cataracts and macular degeneration, cardiovascular disease, which includes peripheral vascular disease and an increased risk of stroke, and liver disease.[12]

Like smoking, alcohol misuse also contributes to various negative health outcomes. In one study,[13] conducted from 2014 to 2015 in SA, alcohol use was reported by 33.1% of the population, and of these, 43% reported binge drinking. Although there is evidence that moderate alcohol consumption may have a beneficial effect on glucose control in patients with diabetes,[14] heavy chronic consumption of alcohol has the opposite effect and affects glucose metabolism as well as insulin resistance.[14] Heavy drinking contributes to high calorie intake, which leads to excess weight and a high glycaemic load. Alcohol misuse can also lead to the development of pancreatitis, alter carbohydrate and glucose metabolism and impair liver function, which also affects blood glucose levels.[14] Another effect of alcohol on T2DM is the alteration of appetite-regulating hormones, specifically ghrelin and leptin.[15] Excessive alcohol use contributes to the development of nerve and vision damage similar to T2DM, and could therefore increase the risk of developing and the degree of nerve and eye conditions.[15] Although tobacco smoking and alcohol misuse have a synergistic effect on certain mechanisms and systems in the human body, they also have some different mechanisms and health outcomes, so there was a need for separate investigation of these two substances in the present study.

This study compared specific health outcomes of people with T2DM and prediabetes in a nationally representative sample of individuals who used tobacco and alcohol with those who did not use these substances. Data on health outcomes were collected using the South African Demographic and Health Survey (SADHS) questionnaires regarding specific outcomes. Although there have been similar studies on this topic, limited research is available regarding people living with diabetes who smoke tobacco or misuse alcohol in an SA setting.

Methods

Study design

This was a cross-sectional quantitative study using secondary data collected from the 2016 SADHS.[16] The focus of the SADHS survey was to collect national data on demographic and primary healthcare indicators. The survey was conducted in collaboration with Statistics South Africa (Stats SA) and the South African Medical Research Council (SAMRC), with technical support from the ICF (originally Inner-City Fund) through the Demographic and Health Surveys (DHS) Program of the United States Agency for International Development (USAID). This current sub-study assessed tobacco smoking and alcohol use among participants aged ≥15 years with diabetes or prediabetes (HbA1c level ≥5.7% as measured in the SADHS) in SA.

Sampling procedure used by the SADHS

The Stats SA Master Sample Frame, which was compiled from the 2011 census enumeration areas,[16] was used to derive the sampled households for the 2016 SADHS. The sampling convention used by Stats SA in the SADHS is residential dwelling units. One dwelling unit contains on average 1.03 households. To ensure comparability across all nine provinces, a power allocation was used instead of a proportional allocation across primary sampling units.[16] The provinces were stratified according to urban, farm or traditional areas, resulting in 26 sampling strata.[16] The subsampling scheme followed by the SADHS has been published elsewhere.[16]

Measurements

Biochemical and anthropometric measurements

Height and weight measurements were taken by fieldworkers using Seca 878 digital scales and Seca 213 portable stadiometers (Seca, Germany). Waist circumference was measured for both women and men using a Seca 201 measuring tape. The height and weight measurements were used to calculate the participants' body mass index (BMI).[16]

Finger-prick blood specimens were collected for laboratory HbA1c testing of consenting women and men aged ≥15 years. HbA1c was measured as a percentage of total haemoglobin. DBS specimens were used instead of blood samples.[16] The calibration equation: venous = (DBS – 0.228)/0.9866 was used to account for the difference in specimen type.[17] For the purpose of this study, the HbA1c DBS specimens were used to assess indicators of diabetes or prediabetes, but care should be taken in interpreting these results, as the calibration factor is not validated and was not specifically developed for the SA population.[16]

Three blood pressure measurements were taken from consenting men and women aged ≥15 years. Hypertension classifications were made based on the average of the second and third readings according to internationally recommended WHO categories (Fig. 1).[16]

Exposures

Tobacco smoking

In the SADHS, people who smoke were defined as people who smoke one or more tobacco products daily or occasionally.[16] Smoking status was assessed using responses to one question:[16] 'Do you currently smoke tobacco every day, some days or not at all?' Smoking status was categorised as people who currently smoke (occasionally or every day) and people who do not smoke.

Alcohol use

People who misuse alcohol were defined according to risky drinking/problem drinking. Risky drinking was defined as a participant who drank ≥5 standard measures of alcohol on a single occasion during

the 30 days prior to the survey.[16] Problem drinking behaviour was defined using the CAGE (Concern/Cut-down, Anger, Guilt, and Eye-opener) test. The four questions were: (*i*) 'Have you ever felt you should cut down your drinking?' (*ii*) 'Have people annoyed you by criticising your drinking?' (*iii*) 'Have you ever felt bad or guilty about your drinking?' and (*iv*) 'Have you ever had a drink first thing in the morning to steady your nerves or to get rid of a hangover (eye-opener)?' Two 'yes' responses to the four questions indicated problem drinking. Both people who reported risky or problem drinking behaviour were merged to make up the sample who use alcohol.

Health outcomes

Health outcomes investigated in this study included cardiovascular disease (heart attack and stroke) and cancer, and these were ascertained through a report of previous diagnosis by a doctor or a nurse. Pulmonary conditions included chronic bronchitis, based on previous diagnosis and other pulmonary symptoms. Hypertension was assessed using systolic and diastolic blood pressure readings. Symptoms were collected based on a series of questions and summarised into three categories: shortness of breath, asthma symptoms, and chronic obstructive pulmonary disease (COPD) symptoms.[16]

Study procedures

The data sets for SADHS 2016 male and female participants were obtained from the DHS website after approval had been granted.[16] Data were generated by four questionnaires, i.e. the women's, men's, household and biomarker questionnaires. Information regarding tobacco and alcohol use and the self-reported prevalence of a variety of non-communicable diseases were extracted from data generated from responses to the women's and men's questionnaires. Responses to the biomarker questionnaire generated data on blood pressure measurement and HbA1c testing. Demographic information, including age, ethnicity, residential area, education and wealth index, was collected using the household questionnaire.

In the SADHS sample, 12 717 eligible adults comprising women aged 15 - 49 years and men aged 15 - 59 years were identified and 10 336 were successfully interviewed for the adult health module, yielding a response rate of 81%.[16] Among these respondents, 66% of women and 59% of men had their HbA1c successfully measured.[16] The final number for the subsample used in the present study amounted to 6 108 participants with either an HbA1c measurement of ≥5.7% or previously diagnosed diabetes (Fig. 2).

Hypertension

Three blood pressure measurements were taken, and the average* of the second and third measurements was used to classify respondents according to internationally recommended categories (WHO 1999). Respondents were classified as having hypertension if they had a systolic blood pressure level of 140 mmHg or above or a diastolic blood pressure level of 90 mmHg or above at the time of the survey or were currently taking antihypertensive medication to control their blood pressure.

Blood pressure category	Systolic (mmHg)		Diastolic (mmHg)
Optimal	<120	AND	<80
Normal	120-129	OR	80-84
High normal	130-139	OR	85-89
Level of hypertension			
Grade 1, mildly elevated	140-159	OR	90-99
Grade 2, moderately elevated	160-179	OR	100-109
Grade 3, severely elevated	180+	OR	110+

Note: Respondents whose blood pressure would fall in two different rows based on their systolic and diastolic levels are classified according to the highest blood pressure row they fall in on either of the two measures.
*If only two measurements were available, the second measurement was used to classify the respondent as having hypertension; if only one measurement was available, it was used to classify the respondent.

Fig. 1. Hypertension classification used in the South African Demographic and Health Survey.[16] (WHO = World Health Organization.)

Data management

Data entry, storage and validation

After the SADHS data were downloaded, data were stored on a password-protected laptop as well as on the cloud. All data were deidentified at the time of download from the DHS website and were kept confidential by the researchers.

Sampling weights in the SADHS

The SADHS is designed to provide a sample that is representative of the SA population and aims to include enough participants from each province for sufficient analyses. Some provinces are sparsely populated, and the SADHS sample design oversampled from these provinces, leading to over-representation of certain provinces and therefore certain households and individuals. To correct the oversampling, sampling weights were applied in the analyses. The SADHS data provided the weighting variable. In the SADHS, weighting was calculated based on the two-stage sampling design. Each household was deemed to have a selection probability that was a product of the household's selection probability from the first-stage sampling and the selection probability from the second-stage sampling. The inverse of that selection probability was then used as the design weight for the household.

Statistical analysis

The data from the 2016 South African Demographic and Health Survey were analysed using Stata v17 (StataCorp, USA). Demographic factors, smoking and alcohol use status were summarised using descriptive statistics. Missing data were excluded from the analysis. Categorical data were summarised using proportions and frequencies. Numerical data were tested for normality, and then summarised using means and standard deviations (SDs) if normally distributed and medians and interquartile ranges if not normally distributed.

Health outcomes were compared independently among participants who smoked or misused alcohol and those who did not do so. A χ^2 test was used to compare categorical data of health outcomes between the exposure groups. For measured or numerical data, including BMI and blood pressure, data were tested for normality by visual inspection of histograms. A two-tailed *t*-test was used for normally distributed data and a Wilcoxon rank-sum test for data that were not normally distributed. Exact *p*-values are reported, and 95%

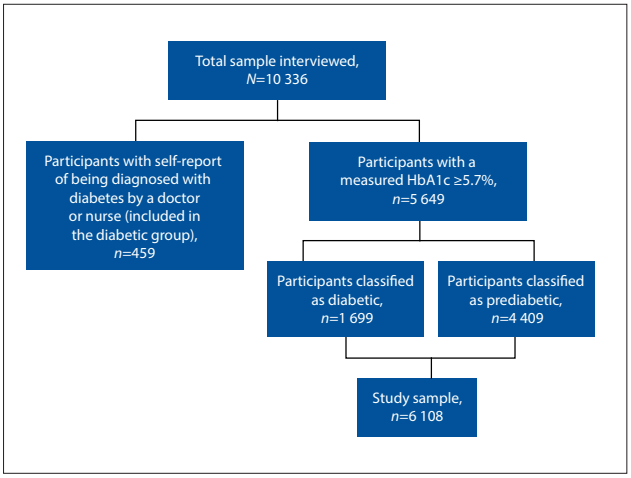

Fig. 2. Flow chart showing the selection of participants from the South African Demographic and Health Survey.[16] (HbA1c = glycated haemoglobin.)

confidence intervals (CIs) are reported for point estimates. An alpha level of ≤0.05 was used to confirm statistical significance.

The odds of health outcomes in the different groups were assessed using multivariable logistic regression analysis, with the outcome defined as the presence or absence of comorbidities including hypertension, cardiovascular disease, chronic bronchitis, shortness of breath, COPD/asthma and cancer, and the exposures as smoking and risky or problem alcohol consumption. Basic demographic outcomes and common health variables were identified as possible confounders based on the possibility (through the review of relevant literature) that they may have an effect on smoking and drinking behaviour. We adjusted for specific confounders in multivariable logistic models for smoking status as exposure and health outcomes as well as alcohol use status and health outcomes. Confounders for smoking were age, sex, marital status, ethnicity, BMI, place of residence and employment status. Confounders for alcohol use status were age, sex, marital status, ethnicity and education. Weights were applied in the analyses to enable the sample to better represent the SA population.

Ethical considerations

The SADHS protocol was reviewed and approved by the SAMRC Ethics Committee and the ICF Institutional Review Board.[16] For the present study, ethics approval was granted by the Stellenbosch University Health Research Ethics Committee before the commencement of the study (ref. no. S21/11/226).

All participants in the SADHS study provided consent before data were collected.[16] For this study, a waiver of informed consent was granted by the Stellenbosch University Health Research Ethics Committee because the study used de-identified secondary data that had been collected with informed consent.

Results

Characteristics of participants by smoking and alcohol use status

The characteristics of participants and comparisons by smoking and alcohol use are set out in Table 1. The total sample consisted of 6 108 participants who had either diabetes (n=1 699) or prediabetes (n=4 409). The mean (SD) age of the total sample group was 41 (19) years, with most participants being in the age groups 15 - 24 years (24.2%) and 25 - 34 years (20.1%). Almost two-thirds of the participants were female (62.5%), and participants of black African ethnicity formed the majority (86.8%) of the sample (Table 1).

There was no difference in mean age of people who did not smoke and people who smoked (Table 1). The age group with the highest proportion of people who smoked was 45 - 54 years (21.8%), and the groups with the lowest proportions were 15 - 24 years (14.9%) and ≥65 years (12.8%). A higher proportion of men smoked compared with women (35.4% v. 7.2%, respectively; p<0.001) (Table 1).

The mean (SD) age of people who reported problem or risky drinking behaviour was lower than that of people who did not report such behaviour (38 (15) years v. 41 (19) years, respectively; p=0.003). A higher proportion of men reported problem or risky drinking behaviour compared with women (17.9% v. 4.0%, respectively; p<0.001).

Association between health outcomes and current smoking

Table 2 compares health outcomes in people with IGT who did not smoke with those in people who currently smoked. Those who currently smoked had a higher prevalence of hypertension compared with those who did not smoke (41.2% v. 36.3%, respectively; p=0.019), and more reports of shortness of breath than people who did not smoke (44.1% v. 35.2%, respectively; p<0.001). People who smoked also had a higher prevalence of cancer compared with those who did not smoke (2.2% v. 1.1%, respectively; p=0.034).

After adjusting for demographic factors, smoking, compared with non-smoking, was significantly associated with 40% increased odds of shortness of breath (adjusted odds ratio (aOR) 1.40; 95% CI 1.1 - 1.7; p<0.001) and 67% higher odds of COPD/asthma (aOR 1.67; 95% CI 1.2 - 2.2; p<0.001).

Smoking, compared with non-smoking, was also associated with 2-fold higher odds of cancer (aOR 1.98; 95% CI 0.9 - 4.4; p=0.093), although with weak evidence against the null hypothesis.

Association between health outcomes and problem/risky drinking

The proportion of shortness of breath was higher among people who reported problem or risky drinking behaviour compared with those who did not (50.7% v. 35.4%, respectively; p<0.001). The proportions of individuals with other health outcomes were fairly similar between people who reported problem/risky drinking behaviour and those who did not (Table 3).

After adjusting for demographic factors, problem and risky drinking, compared with no problem/risky drinking, was significantly associated with 40% higher odds of reported or diagnosed COPD or asthma (aOR 1.40; 95% CI 1.1 - 1.7; p<0.001), and a significantly increased odds, by 92%, of having cancer (aOR 1.92; 95% CI 1.5 - 2.5; p<0.001) (Table 3).

Discussion

In this study using data from the SADHS, we found that smoking was associated with shortness of breath, COPD, asthma and cancer among people with diabetes or prediabetes. For problem or risky drinking, we found an association with cancer in this population. Smoking was significantly associated with 40% higher odds of shortness of breath and 67% higher odds of COPD/asthma. Our results are consistent with findings from other studies. An *et al.*[18] found that smoking was associated with an increased rate of respiratory symptoms, including cough and shortness of breath. Shortness of breath is a broad symptom of poor overall health; it can be caused by various mechanisms in the body, and can be related to infections, asthma, COPD, cancer and pulmonary embolism, as well as heart problems and systemic illnesses.[19] Smoking affects the structure of the lungs via various mechanisms based on specific components of tobacco smoke. These mechanisms include cilia toxicity, impairment of lung defences, acting as irritants, and causing oxidative stress. These mechanisms in turn contribute to the development of most pulmonary diseases.[20] Smoking has been linked to various pulmonary diseases such as lung cancer, COPD and chronic bronchitis, and to an increased risk of death from pneumonia.[21]

There are abundant data on the effect of T2DM on various organs in the human body. Khateeb *et al.*[21] suggested that proinflammatory and proliferative properties as well as micro- and macrovascular effects of diabetes may be the mechanism by which lung and pulmonary diseases are affected in people living with diabetes. Respiratory symptoms are common in patients with diabetes, and they have an increased risk of developing pulmonary disease.[21] T2DM is associated with airway hyper-responsiveness, and the risk of asthma in people with diabetes is twice that of people without diabetes.[22] People with diabetes and COPD who smoke have been shown to have worse outcomes with regard to mortality and hospitalisation.[21]

We found that smoking was also associated with 2-fold higher odds of cancer, although the p-value of 0.09 suggested weak evidence

Table 1. Characteristics of participants by smoking and alcohol use status (*N*=6 108)

Characteristic	Overall (*N*=6 108), *n* (%)*	Non-smoking (*n*=5 024), *n* (%)*	Current smoking (*n*=1 084), *n* (%)*	*p*-value	Non-drinking (*n*=5 543), *n* (%)*	Problem/ risky drinking (*n*=565), *n* (%)*	*p*-value
Age (years)							
Mean (SD)	41 (19.0)	40.88 (19.0)	40.76 (16.6)	0.377	41.14 (18.9)	38.14 (15.3)	0.003
Age categories				<0.001			<0.001
15 - 24	1 515 (24.2)	1 291 (85.1)	224 (14.9)		1 384 (91.3)	131 (8.7)	
25 - 34	1 204 (20.1)	958 (79.9)	246 (20.1)		1 041 (87.9)	163 (12.1)	
35 - 44	910 (16.1)	735 (80.9)	175 (19.1)		823 (89.1)	87 (10.9)	
45 - 54	860 (13.8)	676 (78.3)	184 (21.8)		777 (90.3)	83 (9.7)	
55 - 64	779 (12.7)	626 (81.1)	153 (18.9)		720 (92.1)	59 (7.9)	
≥65	840 (13.2)	738 (87.2)	102 (12.8)		798 (95.7)	42 (4.3)	
Gender				<0.001			<0.001
Female	3 808 (62.5)	3 539 (92.8)	269 (7.2)		3 650 (96.0)	158 (4.0)	
Male	2 300 (37.5)	1 485 (64.6)	815 (35.4)		1 893 (82.1)	407 (17.9)	
Marital status				<0.001			0.002
Never married	3 085 (50.1)	2 493 (81.0)	592 (19.0)		2 749 (90.0)	336 (10.1)	
Married	2 116 (35.9)	1 753 (82.7)	363 (17.3)		1 940 (90.9)	176 (9.1)	
Widowed	643 (9.9)	570 (89.0)	73 (11.1)		613 (96.4)	30 (3.7)	
Divorced	264 (4.1)	208 (76.6)	56 (23.4)		241 (87.9)	23 (12.1)	
Ethnicity				<0.001			0.128
Black African	5 392 (86.8)	4 540 (84.2)	852 (15.8)		4 881 (90.8)	511 (9.3)	
White	210 (4.6)	161 (76.0)	49 (24.1)		198 (92.1)	12 (7.9)	
Coloured	439 (7.0)	267 (60.8)	172 (39.3)		398 (88.7)	41 (11.3)	
Indian/Asian/other	67 (1.6)	56 (85.2)	11 (14.8)		66 (98.6)	1 (1.4)	
BMI							
Mean (SD)	27.5 (7.5)	28.23 (7.5)	24.15 (6.1)	<0.001	28.00 (8.0)	25.49 (6.6)	<0.001
BMI categories (*n*=4 234)				<0.001			0.006
Underweight	339 (6.8)	227 (64.9)	112 (35.1)		302 (89.5)	37 (10.5)	
Normal	2 307 (54.0)	1 672 (73.3)	635 (26.7)		2 008 (87.6)	299 (12.4)	
Overweight/obese	1 588 (39.2)	1 397 (87.2)	191 (12.8)		1 465 (91.7)	123 (8.3)	
Education				0.174			0.141
Primary or less	4 558 (72.8)	3 703 (81.4)	855 (18.6)		4 138 (90.9)	420 (9.2)	
Complete secondary	1 064 (18.2)	894 (84.1)	170 (16.0)		967 (92.0)	97 (8.0)	
Higher	486 (9.1)	427 (84.8)	59 (15.2)		438 (88.1)	48 (12.0)	
Wealth index				0.361			0.204
Poorest	1 386 (21.6)	1 135 (82.1)	251 (17.9)		1 283 (92.7)	103 (7.3)	
Second	1 299 (19.8)	1 083 (82.9)	216 (17.1)		1 163 (90.0)	136 (10.0)	
Middle	1 433 (21.4)	1 175 (83.7)	258 (16.3)		1 287 (90.9)	146 (9.1)	
Fourth	1 196 (19.5)	981 (82.3)	215 (17.7)		1 078 (89.3)	118 (10.8)	
Richest	794 (17.7)	650 (79.6)	144 (20.4)		732 (90.9)	62 (9.1)	
Residence				<0.001			0.012
Urban	3 082 (60.4)	2 402 (78.5)	680 (21.5)		2 767 (89.9)	315 (10.1)	
Rural	3 026 (39.6)	2 622 (87.9)	404 (12.1)		2 776 (92.2)	250 (7.8)	
Currently employed	1 905 (32.3)	1 490 (78.8)	415 (21.2)	0.003	1 687 (88.7)	218 (11.3)	0.608
Glucose tolerance				<0.001			<0.001
Diabetes	1 699 (27.3)	1 473 (28.6)	226 (21.4)		1 604 (28.1)	95 (19.3)	
Prediabetes	4 409 (72.7)	3 551 (71.4)	858 (78.6)		3 939 (71.9)	479 (89.7)	

SD = standard deviation; BMI = body mass index.
*Except where otherwise indicated.

against the null hypothesis in the study sample size. The weak evidence against the null hypothesis may have been due to the very low proportion of cancer in the sample, which would have reduced the power of the study to detect a significant odds ratio. Tobacco smoke contains known carcinogens as well as many other toxic chemicals. Cancer, specifically lung cancer, is a well-known smoking-related disease and one of the most common causes of smoking-related death.[23] A study by Jacob *et al.*[24] showed that smoking was positively associated with 13 different types of cancers, including liver cancer, bladder and kidney cancers, pancreatic cancer and lymphoma. Some of the factors associated with cancer development are diabetes, alcohol misuse, smoking, chemical exposure, obesity

Table 2. Association between smoking status and health outcomes (*N*=6 108)

Factor	Non-smoking (*n*=5 024), *n* (%)	Current smoking (*n*=1 084), *n* (%)	*p*-value	Unadjusted OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Hypertension	1 841 (36.3)	447 (41.2)	0.019	1.23 (1.0 - 1.5)	0.019	1.04 (0.8 - 1.3)	0.671
Cardiovascular disease	292 (5.7)	56 (5.2)	0.628	0.91 (0.6 - 1.3)	0.236	1.20 (0.76 - 1.91)	0.440
Chronic bronchitis	83 (1.8)	13 (1.4)	0.375	0.73 (0.4 - 1.5)	0.376	0.68 (0.3 - 1.5)	0.319
Shortness of breath	1 698 (35.2)	461 (44.1)	<0.001	1.45 (1.2 - 1.7)	<0.001	1.40 (1.1 - 1.7)	<0.001
COPD/asthma	458 (96.4)	153 (93.7)	0.292	1.60 (1.3 - 2.1)	<0.001	1.67 (1.2 - 2.2)	<0.001
Cancer	51 (1.1)	18 (2.2)	0.034	2.08 (1.0 - 4.1)	0.038	1.98 (0.9 - 4.4)	0.093

OR = odds ratio; CI = confidence interval; COPD = chronic obstructive pulmonary disease.

Table 3. Association between drinking status and health outcomes (*N*=6 108)

Factor	No problem/ risky drinking (*n*=5 543), *n* (%)	Problem/ risky drinking (*n*=565), *n* (%)	*p*-value	Unadjusted OR (95% CI)	*p*-value	Adjusted OR (95% CI)	*p*-value
Hypertension	2 056 (36.9)	232 (39.8)	0.282	1.13 (0.9 - 1.4)	0.282	1.15 (0.9 - 1.5)	0.254
Cardiovascular disease	319 (5.8)	29 (4.4)	0.263	0.76 (0.5 - 1.2)	0.269	1.18 (0.7 - 2.0)	0.528
Chronic bronchitis	88 (1.8)	8 (1.4)	0.500	0.75 (0.4 - 1.6)	0.480	1.05 (0.4 - 2.6)	0.916
Shortness of breath	1 888 (35.4)	271 (50.7)	<0.001	0.73 (0.4 - 1.5)	<0.001	0.68 (0.3 - 1.5)	0.319
COPD/asthma	519 (96.1)	92 (93.4)	0.337	1.45 (1.2 - 1.7)	0.319	1.40 (1.1 - 1.7)	<0.001
Cancer	64 (1.2)	5 (1.7)	0.575	1.87 (1.5 - 2.4)	0.570	1.92 (1.5 - 2.5)	<0.001

OR = odds ratio; CI = confidence interval; COPD = chronic obstructive pulmonary disease.

and dietary habits.[6] In particular, diabetes has been linked to hepatocellular, hepatobiliary, pancreatic, breast, ovarian, endometrial and gastrointestinal cancers, and it is also associated with an increased risk of mortality in cancer patients.[6] Our findings suggest that the effect of smoking on cancer is consistent in individuals with prediabetes and T2DM.

We found that problem and risky alcohol use was significantly associated with 40% increased odds of COPD or asthma. Frantz *et al.*[25] reported similar results, showing that heavy drinking was associated with COPD and respiratory symptoms compared with moderate drinking. MacMurdo *et al.*[26] found that people with asthma or COPD who misused alcohol were more likely to have increased disease-related morbidity than non-misusers. Sisson[27] found similar results: comparing men who reported a moderate total alcohol intake (7.0 - 14.0 drinks/week), never drinkers (0 drinks/week) and those with high alcohol intake (>20.0 drinks/week), heavy drinkers had higher risks of COPD. It is thought that the mechanism by which alcohol affects the lungs is related to the volatility of alcohol, which promotes alcohol movement from the lung circulation to the airway epithelium and into the lung's conducting airways.[27]

Our study showed significantly increased odds, by 92%, of risky/problem drinkers having cancer. These findings are in agreement with research from other cohorts. It is estimated that in Europe, 10% of all cancer cases in men and 3% of all cancer cases in women are attributable to alcohol consumption.[28] In a meta-analysis by Choi *et al.*,[29] moderate drinking (1 - 2 drinks/day) significantly increased the incidence of two types of cancer, male colorectal cancer and female breast cancer, whereas it decreased the incidence of both female and male haematological cancers.

Hypertension, cardiovascular disease and chronic bronchitis showed no significant associations with smoking in the present study. Similarly, there were no significant associations between problem or risky alcohol use and hypertension, cardiovascular disease, chronic bronchitis or shortness of breath. These findings contrast with established results from cohort studies.[30,31] One reason for this anomaly in our study could be that the SADHS did not specifically report on the amount of alcohol and tobacco consumed. People who are chronic heavy drinkers could have different symptoms from people who binge drink. Another reason could be that a large part of the sample population was aged <40 years; as cardiovascular disease and hypertension are more common among older people, this could affect the results. The DHS is well designed to minimise bias, but as this is a survey of self-report, bias cannot be excluded completely. The cross-sectional design makes it possible that there could be participants with undiagnosed cardiovascular disease. Chronic bronchitis could be under-reported as a result of misdiagnosis or misclassification, as chronic bronchitis has pulmonary symptoms similar to those of asthma and COPD. Shortness of breath was self-reported by participants, and reporting bias could affect the results. The effect of alcohol on the lungs is dependent on the concentration, duration and route of exposure. Low exposure may improve mucociliary clearance, stimulate bronchodilation, and reduce inflammation and injury.[27]

The present study confirms the association between tobacco smoking and risky or problem drinking and certain health outcomes. The study therefore clearly shows the need for more focus on cessation programmes and counselling in patients with substance abuse, and particularly in people with already compromised health such as those living with diabetes and prediabetes. In an SA study by Ayo-Yusuf and Omole,[32] it was found that increased exposure to smoking cessation advice was associated with increased numbers of attempts to quit. There is a need for more accessible substance abuse cessation and counselling programmes in SA, especially in underprivileged poor communities.[33] A focus on accessibility could improve the success of substance abuse cessation and in turn improve the overall health of people who smoke or misuse alcohol and who are living with diabetes or prediabetes.

Study strengths and limitations

A strength of this study was that we used data from the SADHS, which had a relatively large sample size, was nationally representative

and was rigorously conducted in terms of sampling design. Some limitations of the study include the self-reported measures of smoking and alcohol exposures, and health outcomes. The use of DBS samples for HbA1c testing also posed a challenge, as this has not been validated in an SA setting and research is still needed to confirm its usefulness. As this was a cross-sectional study design, results should be viewed in light of the fact that causal inference cannot be determined.

Conclusion

In people with prediabetes and diabetes, smoking increased the odds of shortness of breath, COPD and asthma, and cancer, while risky alcohol use increased the odds of cancer. This study highlights the possible effect of smoking and drinking behaviour on the health status of people with prediabetes and diabetes and suggests a need for smoking cessation programmes and alcohol use counselling in individuals with IGT.

Data availability. The datasets generated and analysed during the present study are available from the first author (SJM) on reasonable request. Additionally, the data can be accessed via the Demographic and Health Survey (DHS) website (https://dhsprogram.com/methodology/survey/survey-display-390.cfm). Any restrictions or additional information regarding data access can be discussed with the corresponding author (COE).

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Author contributions. SJM, TC and COE were responsible for the conception of the study. SJM was responsible for sourcing the data, data analysis, interpretation, and drafting the work. TC and COE were involved in data analysis, interpretation, and critical review of the manuscript. All authors approved the final manuscript.

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