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Clustering of lifestyle risk behaviours and food insecurity in a population of South African adults: a cross-sectional study

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Abstract

Background Unhealthy lifestyle behaviours may be associated with food insecurity, yet limited research in low- and middle-income countries has examined the clustering of such behaviours and their association with food access challenges. This study explores the clustering of lifestyle risk behaviours, including polytobacco use, and their association with food insecurity among South African adults.

Methods Data were drawn from the 2021 Tobacco and Other Modifiable Risk Behaviours Online Survey, comprising 11,093 adults aged 18 years or older. Weighted logistic regression models were used to examine associations between lifestyle risk behaviours (any or poly tobacco/nicotine product use, heavy drinking, unhealthy diet, physical inactivity, inadequate sleep) and food insecurity. Statistical significance was set at $p < 0.05$.

Results Overall, 84.1% (95% CI: 72.90–96.65) were found to engage in two or more risk behaviours, while 7.0% (95% CI: 5.29–9.30) reported all five. The most common clustering involved physical inactivity and inadequate sleep (10.8%; 95% CI: 8.17–14.10). Concurrent daily polytobacco use and heavy drinking were significantly associated with food insecurity (OR = 2.20; 95% CI: 1.10–4.40). Severe financial difficulty (OR = 9.30; 95% CI: 4.78–18.11), Black African race (OR = 8.94; 95% CI: 6.44–12.43), unemployment and lower education were also associated with increased odds.

Conclusion Addressing financial hardship, racial disparities, and co-occurring lifestyle risk behaviours is critical to mitigating food insecurity and reducing non-communicable disease risk in South Africa.

Keywords Clustering, Risk behaviours, Food insecurity, Non-communicable diseases, Polytobacco

1 Background

The COVID-19 pandemic intensified public health challenges worldwide, and many of these impacts were especially evident in 2021. In South Africa, where poverty, unemployment, and racial inequality were already prevalent [1, 2], these disparities deepened, exacerbating food access challenges [3–5]. Food access challenges, commonly measured

as food insecurity [6] are closely linked to non-communicable disease (NCD) risk factors [7–9]. Food insecurity may contribute directly to NCDs by constraining households' ability to purchase and consume nutrient-rich foods, often forcing reliance on cheap, energy-dense staples that increase the risk of obesity, hypertension, and type 2 diabetes [10]. Conversely, the presence of NCDs can exacerbate food insecurity: chronic illness may increase medical expenditures and reduce earning capacity, leaving less household income available for food [11].

Behavioural risk factors such as smoking and heavy alcohol use have been shown to co-occur with food insecurity [12]. People experiencing food shortages may turn to tobacco or alcohol as coping mechanisms for stress or hunger [12, 13], while these behaviours may simultaneously intersect with broader patterns of socioeconomic vulnerability and poor health. Together, these interrelated clinical, behavioural, and economic factors underscore the complex and bidirectional relationships between food insecurity and health-related risks in disadvantaged populations.

During the pandemic, food insecurity rose from approximately 17% to 23.6% in South Africa [14]. Furthermore, several countries reported an increase in behavioural risk factors for NCDs, including unhealthy dietary patterns, increased alcohol intake and smoking, inadequate sleep, and physical inactivity due to lockdown policies [15–19]. While single-product smoking has been extensively studied in South Africa, less attention is paid to polytobacco use (the concurrent use of two or more tobacco products) [20], which may impose greater financial constraints on frequent users. Polytobacco use is associated with increased nicotine dependence and has been suggested to place competing demands on limited household resources, particularly in low-income settings already grappling with food insecurity [21].

Amidst this backdrop, the pandemic highlighted the urgent need to better understand how lifestyle risk behaviours cluster and co-occur, particularly those that may compete with essential household spending and coincide with both health risks and financial hardship. These behaviours frequently [22, 23] create a synergistic effect on NCD risk [24], and were commonly reported as coping mechanisms during the pandemic. However, evidence on their clustering, especially in relation to their intersection with material deprivation, such as food insecurity, remains limited. This gap is particularly pronounced in South Africa, where financial strain affects many households [25]. Although this analysis uses data from 2021, capturing the acute period of the COVID-19 pandemic, the findings remain relevant as economically disadvantaged households continue to face recurring and overlapping economic and health-related shocks beyond the pandemic period [4, 26, 27].

Given the interconnection between lifestyle factors and socioeconomic status [7], the overarching aim of this study was to:

(i) Examine how lifestyle risk behaviours cluster in the South African population during crises such as the COVID-19 pandemic; and
(ii) Assess the association between selected, cost-incurring NCD risk behaviours - specifically current polytobacco use and heavy alcohol consumption and, self-reported food insecurity, while controlling for socioeconomic status.

Drawing on existing literature, the study hypothesized that individuals engaging in intensive, cost-incurring risk behaviours would be more likely to experience food insecurity,

potentially reflecting allocation of disposable income towards sustaining these behaviours, leaving fewer resources for food and other material needs. Despite the relevance of these associations and potential trade-offs, few studies in low- and middle-income countries have explored this relationship. By addressing this knowledge gap, the study seeks to inform targeted public health interventions that aim to address both lifestyle risks and socio-economic vulnerabilities.

2 Methods

The data for this study comes from the larger Tobacco and Other Modifiable Risk Behaviours Online Survey (TORiS), a non-probability, web-based convenience survey conducted during 2021 in South Africa. The survey was administered through Health24 [28], a digital health platform within the 24.com media network, enabling large-scale online recruitment and collection of behavioural and health-related data in South Africa. TORiS was conducted between September 30 and November 30, 2021, targeting South African adults aged 18 years or older with internet access, and it was designed to generate national data on key modifiable determinants of health in South Africa, including tobacco use, alcohol consumption, physical activity, and food security, particularly in the context of the COVID-19 pandemic. The study protocol received approval from the Sefako Makgatho Health Sciences University Research Ethics Committee (SMUREC/D/157/2021:IR), following the Declaration of Helsinki and SMU REC ethical guidelines. All participants provided digital written informed consent prior to completing the study questionnaires. Due to the focus on behavioural clustering, the present secondary analysis uses data from respondents who completed the risk behaviour components required for this study.

A total of 12,733 surveys were completed. After excluding respondents who resided outside South Africa or did not specify their country of residence, and those who did not specify their gender as male or female, the final dataset comprised 11,093 responses.

Several data quality checks were implemented during data collection, including quarantining speeders based on response times and assigning an answer quality score using flags such as straight-lining, patterned responses, and gibberish answers.

The data was weighted to ensure that the demographic distribution of the sample by age, sex, and race was representative of the overall South African population.

3 Measures

3.1 Sociodemographic characteristics

Race: Participants self-identified with one of the race groups used in South Africa's national statistics: Black African, Coloured, Indian/Asian, or White. Respondents who self-identified as Indian in the survey were mapped to the Indian/Asian category.

Employment Status: Participants were asked, "Which of the following best describes your current employment situation?" Responses were categorized as follows:

- Employed: Participants who selected "Currently working (full or part-time)."
- Unemployed: Participants who selected "Not working, but worked in the past 12 months" or "Not working and never worked in the past 12 months."

Financial Difficulty: Participants were asked, "Which of the following best describes your financial condition over the past 12 months?" Responses were categorized into three levels of financial difficulty:

- No difficulty: Participants who selected "Very comfortable and secure" or "Able to make ends meet without much difficulty."
- Some difficulty: Participants who selected "Occasionally have some difficulty making ends meet" or "Tough to make ends meet but keeping my head above water."
- Severe difficulty: Participants who selected "In over my head."

3.2 Tobacco and nicotine use

Any tobacco or nicotine product use: This category includes both combustible tobacco products (manufactured cigarettes, roll-your-own cigarettes, cigars, pipe tobacco, hookah/water pipes) and non-combustible tobacco or nicotine products (e-cigarettes, heated tobacco products (HTPs), snuff, oral tobacco, and other smokeless tobacco products) [29, 30]. Current users/smokers were defined as participants who reported using any of these products "every day" or "some days."

Polytobacco: The concurrent use of two or more tobacco products, including manufactured cigarettes, roll-your-own cigarettes, cigars, pipe tobacco, hookah/water pipes, HTPs, snuff, oral tobacco, and other smokeless tobacco products [20]. For the purpose of this study, participants who reported using more than two of these products "every day" were classified as daily polytobacco users, while those who reported using more than two products on "some days" were classified as non-daily polytobacco users. This classification reflects the study's focus on costly risk behaviours, where the intensity of use is relevant. Daily use typically indicates a higher financial burden compared to non-daily use, which is particularly important when examining associations with outcomes such as food insecurity.

3.3 Alcohol consumption

Heavy drinking: Heavy drinking was measured by asking participants: "Considering all types of alcoholic beverages, how many times in the past 30 days did you have X or more drinks on an occasion?"

where $X = 5$ for men and $X = 4$ for women.

The prevalence of heavy drinking was defined according to the National Institute on Alcohol Abuse and Alcoholism (NIAAA) criteria—consuming 5 or more drinks (men) or 4 or more drinks (women) on any single day—within the past 30 days [31].

3.4 Dietary behaviours

Unhealthy diet: Unhealthy diet was assessed using the question: "How would you describe your current diet?" with the response options Very unhealthy, Somewhat unhealthy, A little unhealthy, A little healthy, Somewhat healthy, and Very healthy. Participants who described their diet as very unhealthy, somewhat unhealthy, or a little unhealthy were classified as having an unhealthy diet.

3.5 Physical activity

Physical inactivity: Participants were asked: "*In a usual week, how many days do you engage in vigorous leisure-time physical activities for at least 30 minutes that cause heavy*

sweating or large increases in breathing or heart rate?" Consistent with World Health Organization (WHO) guidelines, which recommend a minimum of 150 min of moderate-intensity (or equivalent) physical activity per week, participants reporting less than 5 days (equivalent to fewer than 150 min per week) were classified as physically inactive [32].

3.6 Sleep

Inadequate sleep: Inadequate sleep was measured by asking participants: "*On average, how many hours of sleep do you get in a 24-hour period?*" Participants who reported sleeping fewer than seven hours per day were classified as having inadequate sleep [33].

3.7 Food insecurity

Food insecurity: Food insecurity was assessed by asking participants: "*In the past 12 months, was there any time you ran out of food and were unable to purchase more?*" Those who answered "yes" were classified as food insecure [6, 34].

3.8 Statistical analysis

Prevalence estimates were calculated overall and further stratified by various characteristics, including race, financial difficulty, gender, and several other demographic variables. An ordinal logistic regression was used to estimate the odds of reporting an increasing number of lifestyle risk behaviours. An ordinal logistic regression model was employed because the outcome variable was computed as the sum of individual lifestyle risk behaviours, each coded as binary indicators (0 = absence, 1 = presence), with the tally of possible answers ranging from 0 to 5, where 0 indicates no lifestyle risk behaviours and 5 indicates the presence of all five risk factors assessed.

To examine the association between the clustering of lifestyle risk behaviours and food insecurity, a binary logistic regression model was fitted for self-reported food insecurity over the past 12 months.

All regression analyses were multivariable, adjusting for race, financial difficulty, gender, education, marital status, and employment status. Interaction terms between sociodemographic factors and lifestyle risk behaviours were not included due to potential small cell sizes in combined exposure categories, since this study was not statistically powered to examine interactions.

A priori, the regression-based clustering variable was restricted to behaviours that plausibly involve recurrent monetary expenditure and therefore may be linked to household financial strain.

Accordingly, in this analysis, we focused on clustering of heavy alcohol drinking and frequent polytobacco use, as these behaviours are more likely to entail regular out-of-pocket costs that may compete with resources needed for food, particularly during periods of economic stress.

We created a categorical variable capturing different patterns of alcohol and polytobacco use, with individuals reporting no alcohol or polytobacco use serving as the reference group. Other lifestyle risk behaviours, including inadequate sleep, poor diet, and physical inactivity, were included in descriptive analyses to characterise overall behavioural patterns, but were excluded from the regression-based clustering variable because

they do not directly involve comparable financial expenditures hypothesised to be likely associated with food insecurity.

All statistical analyses were conducted using Stata version 17 (StataCorp LLC, College Station, TX, USA), with statistical significance set at $p < 0.05$.

4 Results

4.1 Characteristics of the study population

The study population was predominantly Black African (78.2%), followed by White (9.7%), Coloured (9.1%) and Indian/Asian (3.0%),. Gender distribution was nearly even, with 51.9% female and 48.1% male. Most participants (59.7%) experienced moderate financial difficulty, while 30.1% did not experience financial difficulties. In terms of education, 63.6% had higher than high school education. Nearly 43.0% were married or cohabiting, and 60.4% were employed. Further details are in Table 1.

4.2 Prevalence of individual risk factors

The overall prevalence of current tobacco or nicotine product use was 36.7% (95% CI: 33.08–40.23). The proportion of individuals reporting unhealthy diet was 36.0% (95% CI: 32.39–39.54). Heavy drinking was reported by 58.7% (95% CI: 54.90–62.58) of participants. Inadequate sleep was observed in 53.3% (95% CI: 49.52–57.12) of the population. Lastly, physical inactivity was the most prevalent risk factor, reported by 85.7% (95% CI: 82.43–88.99) of South African adults.

Table 1 Characteristics of the study population

Characteristic	Number of respondents (*n*)	Percent (%)
Race		
Black African	3859	78.23
Indian/Asian	1652	2.99
Coloured	961	9.10
White	4621	9.68
Financial status in the past 12 months		
No difficulty	3754	30.08
Some difficulty	6571	59.68
Severe difficulty	897	10.24
Gender		
Female	6026	51.86
Male	5143	48.14
Educational level		
[a]Less than high school	520	4.88
Completed high school	4166	31.54
Higher than high school	6538	63.59
Marital status		
Cohabiting/married	6158	42.74
Widowed	311	3.44
Divorced	1241	8.27
Single (never married)	3511	45.56
Employment status		
Employed	7685	60.39
Unemployed	2776	31.02
[b]Other	763	8.59

All raw counts (n) are unweighted and all percentages (%) are weighted

[a]Includes those with no school, less than primary school, and those with some high school education

[b]Includes those retired, homemakers, or very disabled and unable to work, or attending school

By race, current tobacco/nicotine product use was most prevalent among individuals who self-identified as Coloured (47.4%: 95% CI: 38.97–55.91) and Indian/Asian (47.0%; 95% CI: 39.66–54.32). Unhealthy eating was most common among those who self-identified as Indian/Asian (46.6%; 95% CI: 39.25–53.86), while heavy drinking was highest among Black Africans (62.5%; 95% CI: 57.74–67.25). Inadequate sleep was most prevalent among Coloured individuals (59.2%; 95% CI: 50.98–67.43). Physical inactivity exceeded 80.0% in all racial groups, with the highest prevalence among Indian/Asian participants (93.1%; 95% CI: 90.65–95.45).

Those experiencing moderate financial difficulties reported the highest prevalence of current tobacco/nicotine product use (39.7%: 95% CI: 34.92–44.54), while unhealthy diets were more prevalent among those who reported severe financial difficulties (54.3%; 95% CI: 41.19–67.43). The prevalence of heavy drinking exceeded 50% across all levels of financial difficulty, from those reporting no difficulty to those with severe financial strain.

By gender, males had a higher prevalence of current tobacco/nicotine product use (46.0%, 95% CI: 40.56–51.34) and heavy drinking (66.2%, 95% CI: 61.30–71.06), while females had a higher prevalence of unhealthy diets (41.3%; 95% CI: 35.97–46.66).

By education status, the prevalence of current tobacco/nicotine product use was highest among those with less than high school education (49.5%; 95% CI: 33.34–65.63), while unhealthy diets were most prevalent among those who completed high school (40.9%; 95% CI: 34.75–46.96). Physical inactivity was above 80% for those who completed high school and those who had higher than high school education.

Those who reported being divorced had a highest prevalence of current tobacco/nicotine product use (46.9%; 95% CI: 33.06–60.82); unhealthy diets and heavy drinking were more prevalent among those who reported being single at 40.7%, 95% CI: 34.88–46.60 and 61.1%; 95% CI: 55.06–67.17 respectively. Inadequate sleep was higher among those who were divorced and widowed, above 60% for both groups. Further details are provided in Table 2.

4.3 Co-occurrence of multiple lifestyle risk behaviours

Of the studied adult population, 84.1% (95% CI: 72.90–96.65) were found to engage in two or more risk behaviours: 30.3% (95% CI: 26.89–33.95) reported engaging in two, 26.9% (95% CI: 23.69–30.28) in three, 19.9% (95% CI: 17.03–23.12) in four, and 7.0% (95% CI: 5.29–9.30) in all five. Several combinations of lifestyle risk behaviours were notably prevalent among South African adults (Table 3). The most common combination was physical inactivity and inadequate sleep (10.8%, 95% CI: 8.17–14.10), followed by physical inactivity and heavy drinking (8.6%, 95% CI: 6.95–10.64), physical inactivity, inadequate sleep, and heavy drinking (7.2%, 95% CI: 5.21–9.97). Approximately 7.1% (95% CI: 5.32–9.36) of respondents reported all five risk behaviours. The overall prevalence of polytobacco use in the population was 18.5% (95% CI: 15.76–21.64).

4.4 Ordinal logistic regression analysis of factors associated with increasing co-occurrence of multiple lifestyle risk behaviours

Consistent with the analytic approach described in the Methods, regression analyses focused on clustering of heavy alcohol drinking and frequent polytobacco use. In the ordinal logistic regression analysis, individuals identifying as Indian/Asian had

Table 2 Overall and stratified prevalence estimates of various lifestyle risk behaviours

Characteristics	Current tobacco or nicotine product use[a]	Unhealthy diet[b]	Heavy drinking[c]	Inadequate sleep[d]	Physically inactive[e]
Overall	**36.65 (33.08–40.23)**	**35.96 (32.39–39.54)**	**58.74 (54.90–62.58)**	**53.32 (49.52–57.12)**	**85.71 (82.43–88.99)**
Race					
Black African	34.94 (30.55–39.34)	36.19 (31.74–40.64)	62.49 (57.74–67.25)	54.48 (49.82–59.15)	84.84 (80.74–88.95)
Indian/Asian	46.99 (39.66–54.32)	46.55 (39.25–53.86)	50.56 (43.02–58.10)	53.17 (45.68–60.66)	93.05 (90.65–95.45
Coloured	47.44 (38.97–55.91)	34.40 (27.44–41.36)	38.74 (30.76–46.71)	59.21 (50.98–67.43)	85.09 78 (87–91.31)
White	37.06 (31.98–42.14)	32.34 (27.37–37.31)	49.91 (44.50–55.31)	38.50 (33.26–43.73)	90.98 (88.17–93.79)
Financial status in the past 12 months					
No difficulty	32.14 (26.18–38.09)	29.30 (24.48–34.12)	57.80 (51.06–64.54)	45.77 (38.94–52.59)	87.49 (84.33–90.65)
Some difficulty	39.73 (34.92–44.54)	36.22 (31.69–40.75)	60.57 (55.54–65.60)	54.31 (49.43–59.19)	83.76 (78.65–88.87)
Severe difficulty	32.01 (21.67–42.36)	54.31 (41.19–67.43)	50.76 (36.99–64.52)	69.99 (60.52–79.46)	91.87 (87.97–95.77)
Gender					
Female	28.04 (23.75–32.33)	41.32 (35.97–46.66)	51.85 (46.28–57.42)	53.17 (47.78–58.56)	87.56 (82.44–92.68)
Male	45.95 (40.56–51.34)	30.18 (25.63–34.74)	66.18 (61.30–71.06)	53.49 (48.14–58.83)	83.71 (79.63–87.78)
Educational level					
[f]Less than high school	49.49 (33.34–65.63)	32.78 (19.02–46.55)	50.35 (34.28–66.43)	56.74 (40.65–72.82)	77.56 (61.98–93.14)
Completed high school	42.02 (35.70–48.33)	40.86 (34.75–46.96)	57.26 (51.36–63.15)	50.07 (43.93–56.21)	89.75 (87.09–92.40)
Higher than high school	33.03 (28.77–37.30)	33.78 (29.25–38.31)	60.10 (54.92–65.28)	54.67 (49.73–59.61)	84.32 (79.56–89.09)
Marital status					
Cohabiting/married	36.93 (31.89–41.98)	31.77 (27.27–36.27)	58.66 (53.31–64.02)	50.60 (45.22–55.98)	90.24 (87.55–92.93)
Widowed	33.82 (12.10–55.53)	24.99 (9.32–40.66)	35.02 (13.34–56.70)	61.65 (39.18–84.13)	91.78 (84.03–99.52)
Divorced	46.94 (33.06–60.82)	36.04 (21.86–50.22)	56.01 (43.22–68.80)	60.48 (48.08–72.89)	89.15 (82.52–95.79)
Single (never married)	34.73 (29.44–40.02)	40.74 (34.88–46.60)	61.12 (55.06–67.17)	53.94 (47.97–59.90)	80.35 (74.03–86.66)
Employment status					
Employed	37.39 (32.84–41.93)	36.22 (31.60–40.85)	63.57 (58.76–68.38)	55.33 (50.45–60.20)	85.89 (82.34–89.44)

Table 2 (continued)

Characteristics	Current tobacco or nicotine product use[a]	Unhealthy diet[b]	Heavy drinking[c]	Inadequate sleep[d]	Physically inactive[e]
Unemployed	33.28 (27.35–39.21)	35.79 (29.99–41.60)	50.40 (43.79–57.01)	46.87 (40.15–53.58)	84.22 (76.45–91.98)
[g]Other	43.56 (28.42–58.70)	34.75 (19.48–50.01)	54.63 (40.12–69.14)	62.30 (49.78–74.83)	89.78 (84.42–95.14)

[a]This category includes both combustible tobacco products (manufactured cigarettes, roll-your-own cigarettes, cigars, pipe tobacco, hookah/water pipes) and non-combustible tobacco or nicotine products (e-cigarettes, heated tobacco products (HTPs), snuff, oral tobacco, and other smokeless tobacco products) [29, 30]

[b]Participants who described their diet as very unhealthy, somewhat unhealthy, and a little unhealthy

[c]The prevalence of heavy drinking was defined according to the National Institute on Alcohol Abuse and Alcoholism (NIAAA) criteria—consuming 5 or more drinks (men) or 4 or more drinks (women) on any single day—within the past 30 days [31]

[d]Inadequate sleep was measured by asking participants: "On average, how many hours of sleep do you get in a 24-hour period?" Participants who reported sleeping fewer than seven hours per day were classified as having inadequate sleep [33]

[e]Those reporting less than 5 days or fewer than 150 min of physical activity per week [32]

[f]Includes those with no school, less than primary school, and those with some high school education

[g]Includes those retired, homemakers, or very disabled and unable to work, or attending school

Table 3 Prevalence of lifestyle risk behaviour combinations

Combination/category	Proportion (%)	95% CI
Physical inactivity + inadequate sleep	10.79	8.17–14.10
Physical inactivity + alcohol	8.62	6.95–10.64
Physical inactivity only	8.40	6.91–10.17
Physical inactivity + inadequate sleep + alcohol	7.24	5.21–9.97
Physical inactivity + alcohol + tobacco	7.16	5.32–9.56
All risk behaviours[a]	7.08	5.32–9.36
Physical inactivity + inadequate sleep + alcohol + diet	6.04	4.01–9.00
Physical inactivity + inadequate sleep + alcohol + tobacco	5.59	4.48–6.94
Physical inactivity + alcohol + diet + tobacco	5.01	3.90–6.41
Physical inactivity + inadequate sleep + diet	4.38	3.39–5.64
Physical inactivity + diet	4.32	3.36–5.52
Physical inactivity + alcohol + diet	3.56	2.89–4.38
Physical inactivity + inadequate sleep + diet + tobacco	2.79	1.77–4.37
Inadequate sleep + alcohol	2.59	1.49–4.47
Alcohol only	2.18	1.22–3.89
Physical inactivity + inadequate sleep + tobacco	2.16	1.48–3.14
Inadequate sleep only	2.15	0.76–5.91
None	1.93	1.00–3.69
Physical inactivity + tobacco	1.90	1.29–2.80
Alcohol + tobacco	1.22	0.72–2.04
Inadequate sleep + alcohol + tobacco	1.22	0.54–2.71
Tobacco only	0.67	0.18–2.46
Physical inactivity + diet + tobacco	0.69	0.52–0.93
Inadequate sleep + alcohol + diet + tobacco	0.52	0.15–1.77
Diet only	0.42	0.16–1.10
Inadequate sleep + diet	0.29	0.12–0.72
Alcohol + diet + tobacco	0.27	0.17–0.44
Alcohol + diet	0.25	0.15–0.42
Inadequate sleep + tobacco	0.23	0.12–0.46
Inadequate sleep + alcohol + diet	0.20	0.09–0.44
Diet + tobacco	0.08	0.04–0.17
Inadequate sleep + diet + tobacco	0.07	0.04–0.12

[a]All risk behaviours include physical inactivity, inadequate sleep, alcohol, tobacco and poor diet

significantly higher odds of reporting a greater co-occurrence of lifestyle risk behaviours compared to White individuals (OR = 1.75, 95% CI: 1.24–2.47, $p = 0.002$).

In terms of financial difficulty, the results indicate a clear trend: as financial difficulty increases, so do the odds of reporting a greater co-occurrence of lifestyle risk behaviours. Individuals experiencing some financial difficulty had 1.49 times higher odds (95% CI: 1.16–1.92, $p = 0.002$), while those experiencing severe financial difficulty had 2.49 times higher odds (95% CI: 1.42–4.37, $p = 0.001$) compared to those who reported no financial difficulty.

Males had 1.32 times higher odds of reporting a higher co-occurrence of lifestyle risk behaviours compared to females (95% CI: 1.02–1.69, $p = 0.032$). With respect to employment, unemployed individuals had significantly lower odds of reporting co-occurring lifestyle risk behaviours compared to employed individuals (OR = 0.55, 95% CI: 0.39–0.76, $p < 0.001$). Other factors, including education and marital status, were not significantly associated with lifestyle risk factor co-occurrence (Table 4).

4.5 Relationship between costly lifestyle risk behaviours (daily polytobacco use and heavy drinking) and self-reported food insecurity

In the adjusted model, individuals who reported both alcohol use and daily polytobacco use had significantly higher odds of experiencing food insecurity (OR = 2.20; 95% CI: 1.10–4.40; $p = 0.027$) compared to those reporting no alcohol or polytobacco use. No significant associations were observed for alcohol use only or for non-daily polytobacco use, with or without alcohol.

Among covariates, financial difficulty and race showed strong associations with food insecurity. Participants who reported some financial difficulty (OR = 4.10; 95% CI: 2.78–6.06; $p < 0.001$) or not coping (OR = 9.30; 95% CI: 4.78–18.11; $p < 0.001$) had substantially higher odds. Compared to White participants, Black African (OR = 8.94; 95%

Table 4 Factors associated with reporting co-occurring multiple lifestyle risk behaviours within ordinal logistic regression model that assessed on a continuum of one to five different behaviours

Factor	Category	Adjusted OR (95% CI)	*P*-value[a]
Race	White (ref.)		
	Black African	1.37 (0.97–1.94)	0.075
	Indian/Asian	1.75 (1.24–2.47)	**0.002**
	Coloured	1.12 (0.79–1.60)	0.524
Financial status	No difficulty (ref.)		
	Some difficulty	1.49 (1.16–1.92)	**0.002**
	Severe difficulty	2.49 (1.42–4.37)	**0.001**
Gender	Female (ref.)		
	Male	1.32 (1.02–1.69)	**0.032**
Education	> High school (ref.)		
	High school	1.21 (0.89–1.61)	0.225
	< Highschool	1.05 (0.53–1.82)	0.893
Marital status	Single (ref.)		
	Widowed	0.74 (0.35–1.35)	0.428
	Divorce/separated	1.22 (0.64–2.32)	0.544
	Married/Cohabiting	0.97 (0.73–1.30)	0.830
Employment	Employed (ref.)		
	Unemployed	0.55 (0.39–0.76)	**< 0.001**
	Other	1.10 (0.54–2.25)	0.792

[a]All tests were deemed significant at $p < 0.05$

[b]Includes those retired, homemakers, or very disabled and unable to work, or attending school

CI: 6.44–12.43; $p < 0.001$), Indian/Asian (OR = 3.47; 95% CI: 2.34–5.15; $p < 0.001$), and Coloured (OR = 3.25; 95% CI: 2.18–4.85; $p < 0.001$) individuals also had significantly higher odds.

Participants with less than high school education (OR = 2.90; 95% CI: 1.46–5.77; $p = 0.002$) and those with high school education (OR = 1.66; 95% CI: 1.15–2.40; $p = 0.006$) were more likely to report food insecurity compared to those with post-secondary education. Unemployed individuals had higher odds (OR = 1.60; 95% CI: 1.13–2.26; $p = 0.008$) compared to those employed. Full results are presented in Table 5.

5 Discussion

This study provides new evidence on the clustering of lifestyle risk behaviours and their relationship with food insecurity among South African adults during the COVID-19 pandemic. The findings reveal high prevalence of clustered NCD risk behaviours and highlight a pattern of co-occurring risk behaviours, especially daily polytobacco use combined with heavy drinking, strongly associated with food insecurity, even after controlling for socioeconomic variables. The findings underscore how behavioural risks intersect with structural inequalities such as race, education, and financial hardship to shape food access and overall health vulnerability in the low- and middle-income country context.

5.1 Clustering of lifestyle risk behaviours

About 80% of the participants engaged in two or more unhealthy lifestyle behaviours, with about one in five adults in this study reporting engaging in four or more unhealthy lifestyle behaviours. The most common clustering involved physical inactivity, inadequate sleep, and heavy drinking—reflecting global evidence that unhealthy habits tend to co-occur rather than act independently. Indian/Asian and male participants had significantly higher odds of multiple concurrent risk behaviours. This racial and gender pattern aligns with global clustering studies that identify social context, stress, and cultural norms as key determinants of risk behaviour accumulation [24, 35].

Tobacco use prevalence was highest among Coloured and Indian/Asian South Africans, consistent with previous national surveys [35–37]. These population groups have historically exhibited higher rates of smoking and other nicotine use, partly reflecting targeted tobacco industry marketing and long-standing socioeconomic vulnerabilities [38]. Notably, our study found that Black African participants, although less likely to smoke overall, were more likely to report polytobacco use, a finding suggesting adaptive consumption to sustain nicotine dependence at a lower cost, such as combining roll-your-own cigarettes with smokeless tobacco. This pattern has been documented elsewhere in LMICs, where economic constraints encourage diversification of tobacco use [20, 39].

Heavy drinking was widespread, particularly among employed men and Black Africans. Earlier South African studies have linked alcohol use to both cultural drinking norms and coping responses to psychosocial stress [40–42]. Although COVID-19 restrictions temporarily limited alcohol availability, evidence suggests that many individuals engaged in stockpiling and binge drinking [43]. In our data, periods of unemployment may indicate that access to income increases alcohol affordability, while

Table 5 Relationship between costly lifestyle risk behaviours and the odds of reporting food insecurity

Predictor	Category	Past 12-month food access challenge/ food insecurity[a]	
		OR (95% CI)	*P*-value[b]
Clustering of heavy drinking and polytobacco use	Lifestyle risk behaviours		
	Alcohol only	1.04 (0.73–1.48)	0.817
	Nondaily polytobacco only	0,75 (0.29–1,94)	0.557
	Daily polytobacco only	2,04 (0.90–4.62)	0.087
	Alcohol + nondaily polytobacco	1.17 (0.63–2.19)	0.613
	Alcohol + daily polytobacco	2.20 (1.10–4.40)	**0.027**
Frequency of Polytobacco use	Single/never/former (ref.)		
	Nondaily use	0.98 (0.57–1.70)	0.955
	Daily use	1.92 (1.03–3.57)	**0.039**
Race	White (ref.)		
	Black African	8.94 (6.44–12.43)	**< 0.001**
	Indian/Asian	3.47 (2.34–5.15)	**< 0.001**
	Coloured	3.25 (2.18–4.85)	**< 0.001**
Financial status	No difficulty (ref.)		
	Some difficulty	4.10 (2.78–6.06)	**< 0.001**
	Severe difficulty	9.30 (4.78–18.11)	**< 0.001**
Gender	Female (ref.)		
	Male	0.69 (0.40–0.95)	0.066
Education	> High school (ref.)		
	High school	1.66 (1.15–2.40)	**0.006**
	< High school	2.90 (1.46–5.77)	**0.002**
Marital status	Single (ref.)		
	Cohabit/married	0.83 (0.57–1.19)	0.308
	Widowed	0.17 (0.06–0.52)	**0.002**
	Divorce/separated	1.05 (0.60–1.81)	0.875
Employment status	Employed (ref.)		
	Unemployed	1.60 (1.13–2.26)	**0.008**
	Other	1.27 (0.73–2.22)	0.411

[a]Those who responded 'yes' to: In the past 12 months. was there any time you have run out of food and not been able to purchase more?

[b]All tests were deemed significant at $p < 0.05$

[c]The prevalence of heavy drinking was defined according to the National Institute on Alcohol Abuse and Alcoholism (NIAAA) criteria—consuming 5 or more drinks (men) or 4 or more drinks (women) on any single day—within the past 30 days [31]

[d]The concurrent use of two or more tobacco products. including manufactured cigarettes. roll-your-own cigarettes. cigars. pipe tobacco. hookah/water pipes. HTPs. snuff. oral tobacco. and other smokeless tobacco products. Participants reporting the use of more than one of these products "every day" or "some days" were classified as polytobacco users

psychological stressors associated with precarious employment conditions could also contribute to increased consumption.[42]

The extraordinarily high prevalence of physical inactivity (> 80%) mirrors other pandemic-era findings from both South Africa and other countries with stringent lockdowns [15, 44, 45]. Restrictions on movement, gym closures, and anxiety over infection collectively reduced activity levels. Combined with inadequate sleep and unhealthy diets, this represents a syndemic of behavioural risks that, if sustained, could amplify future NCD burdens [45]. The pandemic therefore not only exacerbated immediate food and financial insecurity but also likely worsened behavioural determinants of chronic disease.

5.2 Socioeconomic patterning and racial disparities

Financial difficulty emerged as a dominant determinant across all outcomes, linked to both clustering of risk behaviours and food insecurity. Individuals with severe financial hardship had over nine times the odds of food insecurity compared to those reporting no difficulty. This strong gradient underscores the tight coupling between economic insecurity and nutrition access, a pattern similarly reported in national surveys [3–5]. Education and employment also played significant roles: lower educational attainment and unemployment were associated with higher risk of both behavioural clustering and food insecurity, consistent with studies showing that socioeconomic position shapes health behaviour opportunities and dietary choices [46, 47].

Racial disparities remained pronounced. Black African participants were nearly nine times more likely to experience food insecurity than White participants. This gap reflects South Africa's deeply entrenched structural inequalities, where race continues to predict economic disadvantage, residential segregation, and differential access to social safety nets [1, 2, 48]. These systemic inequities likely mediate behavioural risk clustering through stress exposure, limited access to recreational spaces, and constrained dietary options [49, 50]. Addressing behavioural risks in isolation is therefore insufficient; structural reforms in income support, education, and community infrastructure remain essential.

5.3 Behavioural intensity and food insecurity

A key contribution of this study lies in demonstrating that it is the intensity and co-occurrence of costly behaviours——specifically daily polytobacco use combined with heavy drinking——rather than their mere presence, which is significantly associated with food insecurity. Individuals engaging in this combination had over twice the odds of reporting food insecurity, independent of financial or employment status. This finding is consistent with the "competing financial demand" hypothesis: frequent spending on tobacco and alcohol may be associated with reduced disposable income for food and other essentials [12, 51]. Evidence from the United States and South Africa similarly shows that households with smokers are more likely to experience food shortages even when income levels are comparable [51–53].

While previous research has also posited that food insecurity may increase substance use as a coping mechanism [51, 52, 54], the present findings are more consistent with an association in which excessive consumption co-occurs with greater food insecurity, particularly given the daily frequency of use observed. However, given the cross-sectional design, reverse or bidirectional relationships cannot be excluded. The daily frequency of use observed here is suggestive of habitual expenditure patterns rather than occasional stress-related use. Moreover, the persistence of food insecurity despite controlling for financial status suggests that patterns of behavioural expenditure may be relevant in understanding nutritional deprivation.

5.4 Public health implications

The co-occurrence of behavioural risks in this study highlights the need for integrated intervention strategies rather than siloed programmes. Tobacco and alcohol control efforts should be coupled with food security and social protection policies. For example, taxation of tobacco and alcohol products could serve dual purposes:

reducing consumption and generating earmarked revenue for food assistance and community nutrition programmes. At the same time, cessation interventions should explicitly address financial and psychological stress, given the observed association between hardship, sleep problems, and substance use [55, 56].

Consistent with the SDG framework [57] multisectoral collaboration is essential to break the feedback loop between poverty, unhealthy behaviours, and food insecurity. Urban planning policies that promote physical activity through safe community spaces, and social development initiatives that expand income support for the working inadequate, would complement traditional health-sector responses. Gender-sensitive programming is also crucial, given the higher burden of alcohol and tobacco use among men and elevated food insecurity among women. Ultimately, tackling food insecurity in South Africa and similar settings in LMICs, requires addressing the root causes of financial hardship and the behavioural pathways through which hardship compounds health risks.

5.5 Study limitations

This study's cross-sectional design precludes causal inference, and its web-based convenience sampling may underrepresent poorer households without internet access, leading to conservative estimates of food insecurity prevalence. As a result, the magnitude of food insecurity and its co-occurrence with intensive risk behaviours may be underestimated, particularly among the most socioeconomically vulnerable groups. Nonetheless, post-stratification weighting by demographic variables enhances representativeness.

The use of self-reported measures introduces potential recall and social desirability bias, which may attenuate reported levels of substance use and behavioural clustering, further contributing to conservative association estimates. In addition, the single-item food-insecurity question limits comparability with standard multi-item scales, potentially obscuring more severe or chronic forms of food insecurity [32].

The proportional odds assumption underlying the ordinal logistic regression was not formally assessed, and violation of this assumption could not be ruled out. As a result, the estimated odds ratios should be interpreted as summary associations across increasing levels of lifestyle risk behaviours, and potential differences in predictor effects across specific outcome thresholds may not have been captured. However, given that the ordinal model was used to characterise overall behavioural burden rather than to estimate category-specific effects, this limitation is unlikely to materially affect the main conclusions of the study.

The study was not powered to assess interaction effects between sociodemographic characteristics and lifestyle risk behaviours; future studies with larger samples should examine these relationships.

Finally, behavioural measures reflected use over the past 30 days, whereas food insecurity was assessed over the past 12 months. This temporal mismatch may weaken observed associations if behaviours varied over the recall period for food insecurity, biasing estimates toward the null. Taken together, these limitations suggest that the reported associations likely represent conservative estimates of both food insecurity and behavioural clustering rather than overstatements of effect.

Future longitudinal studies using probability-based sampling are needed to clarify causal directions and examine how behavioural clustering evolves post-pandemic.

Qualitative studies could further illuminate the decision-making trade-offs that link substance use with food acquisition under economic stress.

6 Conclusion

Overall, this study contributes to a growing body of evidence that food insecurity and health-risk behaviours are not separate problems but interdependent outcomes of structural inequality and behavioural coping strategies. Interventions addressing financial hardship, racial disparities, and the clustering of tobacco and alcohol use will be essential for improving population health and achieving equitable recovery in post-pandemic South Africa.

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Author contributions
LN conceptualised the study; LN performed data extraction and analysis and drafted the initial manuscript, including data interpretation, while OAY also contributed to the data analysis and data interpretation. All authors reviewed multiple drafts of the manuscript and approved the submission of the final version.

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Data availability
The data supporting the findings of this study are available from the Principal investigator, Prof. Olalekan Ayo-Yusuf, upon reasonable request (Email: Lekan.Ayo-Yusuf@up.ac.za).

Declarations

Ethics approval and consent to participate
The study protocol received approval from the Sefako Makgatho Health Sciences University Research Ethics Committee (SMUREC/D/157/2021:IR), following the Declaration of Helsinki and SMU REC ethical guidelines.

Consent for publication
All participants provided digital written informed consent prior to completing the study questionnaires.

Competing interests
The authors declare no competing interests.

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