BMC Public Health

RESEARCH

Open Access

The silent epidemic: unravelling NCD risk clusters and socioeconomic determinants in Zambia

Aaron Kobina Christian[1*], Egerson Daniel[1] and Olutobi Adekunle Sanuade[2]

Abstract

Introduction Non-communicable diseases (NCDs) are a public health challenge in Zambia. This is driven by economic transitions, urbanization, and lifestyle changes. This study examines how NCDs cluster and relate to socioeconomic factors such as education, income, and employment.

Methodology Using data from the 2017 Zambia WHO STEPS survey ($N = 4,302$ adults, mean age: 36.57 years), Latent Class Analysis identified NCD risk profiles, and multinomial logistic regression assessed their associations with socioeconomic determinants.

Results Three NCD risk groups emerged: Low-Risk (12.0%), Intermediate-Risk (64.3%), and High-Risk (23.7%). The Low-Risk group maintained healthy lifestyles. The Intermediate-Risk group, the most prevalent, showed borderline metabolic indicators and occasional unhealthy behaviours. The High-Risk group exhibited multiple risk factors, including obesity, hypertension, diabetes, and substance use. Males had 22.8 times higher odds of being in the High-Risk group than females. Surprisingly, higher education increased the odds of being in the Moderate- and High-Risk groups.

Conclusion NCD prevention in Zambia requires risk-stratified strategies: primary prevention for Intermediate-Risk groups and intensive intervention for High-Risk populations. Critical policy actions include taxing tobacco, alcohol, and unhealthy foods; expanding universal screening; integrating NCD care into primary health systems; and addressing urbanization, cultural practices, and healthcare disparities.

Keywords NCDs, Socioeconomic determinants of health, Latent class analysis (LCA), Zambia

*Correspondence:
Aaron Kobina Christian
akchristian@ug.edu.gh
[1]Regional Institute for Population Studies, University of Ghana, P. O. Box LG 96, Legon- Accra, Accra, Ghana
[2]Department of Population Health Sciences, Division of Health System Innovation and Research Spencer Fox Eccles School of Medicine University of Utah, Salt Lake City, UT, USA

Introduction

Non-communicable diseases (NCDs) account for approximately 70% of deaths globally, making them the primary cause of mortality worldwide [1]. Recognizing the growing burden of NCDs, Sustainable Development Goal (SDG) 3.4 aims to reduce premature mortality from NCDs by one-third by 2030 [2]. However, achieving this target is becoming increasingly challenging as sub-Saharan Africa (SSA) undergoes a rapid epidemiological transition, characterized by a rising burden of NCDs [3]. NCDs pose a significant threat to sustainable development and health equity globally, with a disproportionate burden in SSA. Additionally, WHO projections indicate a 10% increase in NCD-related mortality in low and middle-income countries (LMICs) between 2015 and 2030 [4]. These projections suggest that SSA will experience one of the largest surges in NCD-related mortality by 2030 unless urgent policy and public health interventions are implemented.

Zambia is no exception to the global trend of increasing NCDs, with cardiovascular diseases, diabetes, chronic respiratory diseases, and cancers becoming increasingly prevalent. Musonda et al., 2024 estimated that nearly one-third of overall deaths reported in Zambia was attributed to NCDs [5]. The primary behavioural and metabolic risk factors for NCDs—including tobacco use, harmful alcohol consumption, unhealthy diet, physical inactivity, obesity, hypertension, hyperglycaemia, and dyslipidaemia—may be socially patterned [6, 7]. Evidence suggests that socioeconomic position plays a critical role in shaping the burden of behavioural risk factors for NCDs, particularly in LMICs [6, 8, 9]. These behavioural and metabolic risk factors reflect broader structural inequalities, emphasizing the need for an equity-focused approach to NCD prevention and control.

Like many countries in SSA, Zambia is undergoing nutrition and lifestyle transitions, compounded by economic restructuring, urbanization, and environmental changes [10]. These transitions are reshaping health risk profiles and fuelling clustering of multiple NCD risk factors within certain population groups based on age, sex etc. While existing research often analyses these risk factors individually, emerging evidence suggests that NCD risk factors frequently co-occur, forming distinct multi-risk profiles that are strongly shaped by social determinants [11]. Understanding these risk clusters and their socioeconomic drivers is crucial for designing targeted prevention strategies that address both individual behaviours and their underlying structural determinants [7].

This study aims to fill this gap by analysing nationally representative data from the 2017 Zambia WHO STEPS survey to: (1) Identify distinct clusters of NCD risk factors among adults in Zambia, and (2) Examine how these clusters relate to key socioeconomic determinants, including education, income, and employment. By adopting a social determinants lens and moving beyond single risk factor analyses, this study contributes new evidence on the social patterning of NCD risks in Zambia.

Unlike notable studies such as [12], which quantify NCD risk factors through a simple count of individual risk factors, this study employs latent class analysis (LCA) to identify distinct clusters of risk accumulation. This approach provides a more nuanced understanding of how behavioural and metabolic risk factors co-occur within specific subpopulations. By detecting hidden patterns in risk factor aggregation, this approach enables targeted interventions for groups at different stages of NCD risk accumulation, rather than assuming all individuals with multiple risk factors share similar health trajectories or intervention needs. The findings will provide insights to inform SDG-aligned policies that promote health equity and sustainable development in the country.

Conceptual framework for examining NCD risk clusters and socioeconomic determinant

This study adopts the social determinants of health (SDH) framework, which emphasizes that health outcomes are influenced by economic, social, and environmental factors beyond medical care [13]. Several conceptual models and frameworks have been developed to explain and address SDH. These models help in understanding the mechanisms and causal pathways through which SDH affect health inequalities [14]. The WHO model further highlights how structural and intermediary determinants contribute to health inequalities, providing a basis for policy interventions to reduce these disparities [15, 16].

The SDH framework is integrated with the epidemiological transition theory to understand how socioeconomic position (age, education, income, employment) shapes NCD risk accumulation. In Zambia, higher socioeconomic status (SES) is often associated with greater exposure to processed foods, sedentary lifestyles, and urbanization, leading to higher NCD prevalence among wealthier groups. Over time, as economies develop, this burden shifts toward lower-income populations, mirroring trends observed in high-income countries (HICs). Through latent class analysis (LCA), this study identifies distinct NCD risk clusters and examines how socioeconomic determinants influence risk accumulation.

Building on this framework, in Fig. 1, we hypothesize that education level, employment status, and income level have direct associations with behavioral and metabolic risk factors, operating through intermediate lifestyle and metabolic mechanisms. Individuals with lower SES may experience greater exposure to unhealthy behaviors, such as poor diet, physical inactivity, and substance use, due to limited access to health resources, food insecurity, or occupational constraints. Similarly, metabolic risks

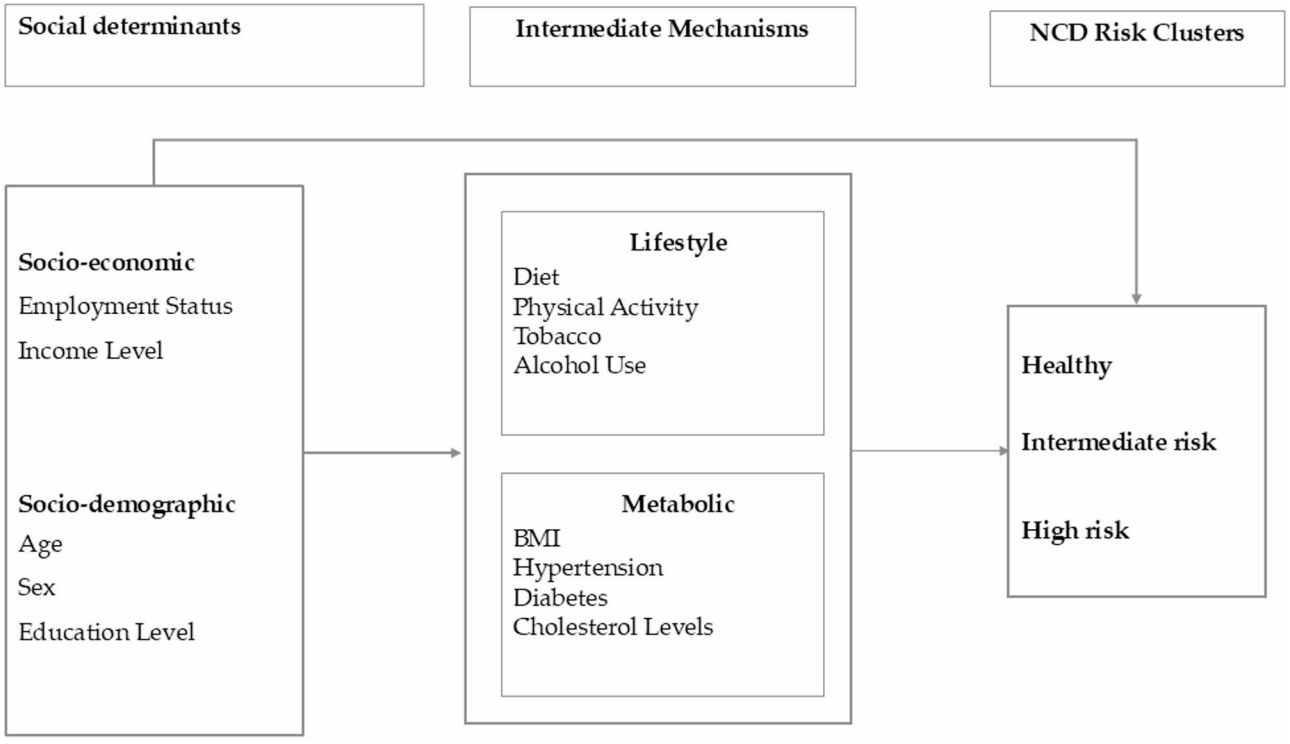

Fig. 1 Conceptual framework

including obesity, hypertension, diabetes, and elevated cholesterol, are expected to vary by socioeconomic position, reflecting disparities in healthcare access, stress-related physiological responses, and long-term lifestyle behaviors. These behavioral and metabolic risks interact to form latent NCD risk clusters, categorized as healthy, intermediate risk, and high risk, capturing patterns of risk accumulation within the population.

Individuals in the healthy group exhibit minimal or no risk factors for non-communicable diseases (NCDs), maintaining a balanced diet, engaging in regular physical activity, and avoiding tobacco use and harmful alcohol consumption. They present with normal body weight, optimal blood pressure, and healthy glucose and lipid profiles, benefiting from preventive healthcare and low exposure to chronic stressors. The intermediate risk group includes individuals with moderate accumulation of risk factors, such as occasional unhealthy behaviours, mild alcohol use, or past tobacco use, alongside borderline obesity, prehypertension, mild dyslipidaemia, or impaired glucose tolerance. Although they have not yet reached clinical thresholds for chronic disease, they are at increased risk due to accumulating metabolic and behavioural factors. In contrast, the high-risk group consists of individuals with multiple, sustained risk factors, including a history of tobacco use, harmful alcohol consumption, unhealthy diet, and physical inactivity, compounded by obesity, hypertension, diabetes, and dyslipidaemia. These individuals often face greater physiological stress, limited healthcare. On the other hand, those belonging to a higher-risk cluster may reinforce socioeconomic disadvantage, as individuals with poor health outcomes face challenges such as decreased productivity, job loss, or increased healthcare expenses. This conceptual model provides a structured approach to analyzing how NCD risks are socially patterned in Zambia, offering critical insights for targeted interventions and policy recommendations aimed at promoting health equity.

Methods

Study design and data source

This was a cross-sectional, population-based survey. The study utilized data from Zambia's most recent WHO STEPS survey 2017, a nationally representative, cross-sectional survey designed to collect data on key NCD risk factors using the standardized STEPwise Approach to Surveillance (STEPS) developed by the World Health Organization [17]. The Zambia STEPS methodology collects information across three steps: (1) self-reported behavioural risk factors (e.g., tobacco use, alcohol consumption, diet, physical activity), (2) physical measurements (e.g., blood pressure, height, weight, waist circumference), and (3) biochemical measurements (e.g., blood glucose and cholesterol levels).

Sampling and participants

The Zambia STEPS survey employed a multi-stage cluster sampling design to ensure national representativeness of adults aged 18 years and older. Sampling followed WHO guidelines, with primary sampling units drawn from census enumeration areas, followed by household selection and random selection of one eligible adult per household [18]. Participants provided informed consent prior to participation.

Ethical considerations

The STEPS survey was ethically approved by the Biomedical Research Ethics Committee at the University of Zambia (UNZABREC) and the Zambia National Health Research Authority (ZNHRA). Permission to conduct the survey was also granted by Zambia's Ministry of Health (MoH) and the local WHO office. All participants provided informed consent before inclusion in the survey. This research adhered to ethical standards outlined in the Declaration of Helsinki.

Measures

Non-communicable disease risk factors

The outcome variables for the clustering analysis included eight key NCD risk factors, consistent with WHO STEPS core indicators:

- Current tobacco use (any form, including cigarettes, cigars, pipes, smokeless tobacco).
- Harmful alcohol consumption (≥ 6 standard drinks on a single occasion in the past 30 days).
- Inadequate fruit and vegetable intake (< 5 servings per day).
- Physical inactivity (defined using WHO thresholds for insufficient physical activity across work, transport, and leisure domains).
- Overweight/obesity (BMI ≥ 25 kg/m^2).
- Raised blood pressure (systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg, or current use of antihypertensive medication).
- Raised fasting blood glucose (≥ 7.0 mmol/L or current use of diabetes medication).
- Raised total cholesterol (≥ 5.0 mmol/L or current use of lipid-lowering medication).

Socioeconomic determinants

Key exposure variables in this study included educational attainment, which was categorized into no formal schooling, primary, secondary, or tertiary education. Employment status was assessed across multiple categories, including employed, unemployed, homemaker, retired, and student. Additionally, respondent income was captured based monthly income.

Statistical analysis

Descriptive analysis

Participant characteristics, NCD risk factors, and socioeconomic variables were summarized using means (standard deviation) normally distributed continuous variables or medians (interquartile range) for skewed continuous variables, and frequencies (percentages) for categorical variables. Socioeconomic differences across NCD risk factors were assessed using chi-square tests (categorical variables) and t-tests or ANOVA (continuous variables).

Clustering analysis

To identify distinct clusters of NCD risk factors, we employed LCA, a model-based clustering technique suitable for identifying subgroups within a population based on observed categorical risk factors [19–21]. LCA is a person-centred technique and an appropriate method for explaining the clustering of health risk behaviours [22]. This technique has been used to explore NCD patterns among older adults using large nationally represented sample in Kenya [23].

Model selection was guided by multiple criteria including the Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), entropy, and likelihood ratio tests [24, 25]. While fit improved slightly with more classes, the 3-class solution offered the best balance between model fit and parsimony (BIC = 33,084.04; AIC = 32,918.5). Entropy was 0.82, indicating acceptable classification accuracy. The Lo-Mendell-Rubin (LMR) and bootstrapped likelihood ratio tests (BLRT) confirmed that the 3-class model significantly improved over the 2-class model ($p < 0.001$) but further increases in classes did not yield significant improvement. Thus, the 3-class model was selected based on statistical fit and interpretability.

Association between clusters and socioeconomic factors

The association between cluster membership and socioeconomic determinants was assessed using multinomial logistic regression, adjusting for age, sex and income. To address right-skewness in self-reported income, we natural-log-transformed reported incomes. This improved distribution normality and reduced sensitivity to outliers in regression models. Results were expressed as adjusted odds ratios (aOR) with 95% confidence intervals (CI), quantifying the likelihood of belonging to each risk cluster relative to a reference cluster, conditional on socioeconomic position.

Results

Sociodemographic characteristics

The study included a total of 4,302 participants, with a mean age of 36.6 years (SD = 13.9). The majority of

Table 1 Behavioural and metabolic risk factors

Variable	Percentage (%)	Frequency (*n*)
Tobacco Use		
Non-user	89.0	3,826
Current User	11.0	475
Harmful Alcohol Use		
No Binge Drinking	91.8	3,949
Binge Drinking	8.2	353
Fruit & Vegetable Intake		
Adequate Intake (≥ 5 servings/day)	18.1	778
Inadequate Intake (< 5 servings/day)	81.9	3,524
Physical Activity		
Inactive	29.5	1,270
Active	70.5	3,032
Overweight/Obesity		
Normal Weight	69.4	2,986
Overweight/Obese	30.6	1,316
Raised Blood Pressure		-
Normal BP	61.0	2,625
Raised BP	39.0	1,677
Raised Glucose		
Normal Glucose	77.7	3,342
Raised Glucose	22.3	960
Raised Cholesterol		
Normal Cholesterol	78.6	3,383
Raised Cholesterol	21.4	919
Age (Mean, SD)	36.6 (13.9)	4,302

Values are presented as frequency (n) and percentage (%), except for Age, which is Mean (SD)

participants were women (62.5%), while men accounted for 37.5%. The population exhibited diverse educational attainment levels: 26.1% had less than primary education, 24.1% completed primary education, 7.2% had college/university education, and only 0.4% held a postgraduate qualification. Regarding employment status, 39.7% of participants were self-employed, while 6.8% were engaged in non-government employment and 3.4% in government employment. A significant proportion of the population were unemployed and unable to work (5.8%), with 24.5% being able to work, and 5.8% unable to work. Additionally, 7.9% identified as homemakers, and 6.4% were students.

Behavioural and metabolic risk factors

Among the participants, 11.0% were current tobacco users, and 8.2% reported engaging in harmful alcohol consumption (Table 1). Dietary intake was suboptimal, with 81.9% reporting inadequate fruit and vegetable consumption. Furthermore, 29.5% were physically inactive. Regarding metabolic risk factors, 30.6% were overweight or obese, 39.0% had raised blood pressure, 22.3% had raised blood glucose levels, and 21.4% had elevated cholesterol levels.

Table 2 Latent class analysis risk factor results

Risk Factor	Class 1 (Healthy)	Class 2 (Intermediate)	Class 3 (High Risk)
Tobacco Use	1.17	−14.32	−2.46***
Harmful Alcohol	−0.83***	−3.13 ***	−2.46***
Low Fruit & Veg Intake	1.39***	1.67***	1.20 ***
Physical Inactivity	1.41***	0.92***	0.53***
Overweight/Obesity	−2.73***	−1.02 ***	0.17 **
Raised BP	−0.31**	−0.62 ***	−0.07
Raised Glucose	−2.23***	−2.90 ***	1.11***
Raised Cholesterol	−3.23***	−3.73 ***	1.51***

***$p < 0.001$:**$p < 0.01$: *$p < 0.05$

Latent class analysis

The results of the LCA identified three distinct NCD risk profiles among Zambian adults. The estimated coefficients for class membership, with Class 1 serving as the reference category (base outcome) (see supplementary table).

The coefficients for Class 2 (1.675, $p < 0.001$) and Class 3 (0.676, $p < 0.001$) indicate that these groups exhibit significantly different NCD risk clustering patterns compared to Class 1.

- Class 1 (Healthy Group): Characterized by a low prevalence of most NCD risk factors, including harmful alcohol use, overweight/obesity, raised blood pressure, and raised cholesterol.
- Class 2 (Intermediate Group): Exhibits moderate levels of physical inactivity and poor diet but has lower odds of overweight/obesity and raised glucose compared to Class 3.
- Class 3 (High-Risk Group): Has the highest prevalence of metabolic and dietary risks, including raised glucose, raised cholesterol, and poor diet, with significantly higher obesity rates compared to the other classes.

Clustering of NCD risk factors

Table 2 presents the log-odds estimates of individual non-communicable disease (NCD) risk factors within each latent class, providing insights into how risk factors cluster across the population.

Class 1 ("healthy Group") This group exhibits the lowest prevalence of behavioural and metabolic risk factors. Negative coefficients for harmful alcohol use (−0.83, $p < 0.001$), overweight/obesity (−2.73, $p < 0.001$), and raised glucose (−2.23, $p < 0.001$) suggest that individuals in this class are at the lowest risk of developing NCDs.

Class 2 ("intermediate Group") This group exhibits a moderate risk profile for developing NCDs. Negative coefficients for harmful alcohol use (−3.13, $p < 0.001$),

Table 3 Latent class prevalence

Latent Class	Prevalence (%)	95% CI
Class 1 (Low-Risk)	12.0	8.6–16.6
Class 2 (Intermediate-Risk)	64.3	59.5–68.8
Class 3 (High-Risk)	23.7	21.2–26.4
Model Fit Criterion *(Goodness-of-fit statistics for the latent class model*	Value	
Akaike Information Criterion (AIC)	32,918.5	
Bayesian Information Criterion (BIC)	33,084.04	

overweight/obesity (−1.02, $p < 0.001$), and raised glucose (−2.90, $p < 0.001$) suggest that individuals in this class have lower metabolic and behavioural risk factors than Class 3. However, positive coefficients for low fruit and vegetable intake (1.67, $p < 0.001$) and physical inactivity (0.92, $p < 0.001$) indicate that poor dietary habits and sedentary lifestyles are still prevalent, contributing to moderate NCD risk.

Class 3 ("High-Risk Group") This group exhibits the highest prevalence of behavioral and metabolic risk factors, placing them at the greatest risk of developing NCDs. Positive coefficients for overweight/obesity (0.17, $p < 0.01$), raised glucose (1.11, $p < 0.001$), and raised cholesterol (1.51, $p < 0.001$) highlight increased metabolic risks. Although coefficients for harmful alcohol use (−2.46, $p < 0.001$) and tobacco use (−2.46, $p < 0.001$) suggest lower substance use compared to Class 1, poor dietary intake (1.20, $p < 0.001$) and moderate physical inactivity (0.53, $p < 0.001$) further elevate the risk of NCDs.

Latent class prevalence

Table 3 shows the latent class prevalence and shows that the model achieved a good fit. The results indicate that Class 2 (Intermediate-Risk) is the most prevalent, comprising 64.3% of participants (95% CI: 59.5–68.8%) (Table 4). This group represents individuals with moderate NCD risk factors, requiring early preventive interventions. Class 3 (High-Risk) accounts for 23.7% of the population (95% CI: 21.2–26.4%) and is characterized by multiple co-occurring metabolic and behavioural risk factors, suggesting a heightened likelihood of developing non-communicable diseases. The smallest proportion (12.0%) was assigned to Class 1 (Low-Risk) (95% CI: 8.6–16.6%), indicating that only a minority of individuals exhibit minimal NCD risk factors.

Socioeconomic determinants and NCD risk clustering

Table 4 presents the results of the multinomial logistic regression model assessing the association between socioeconomic determinants and NCD risk clustering. The Low-Risk group serves as the reference category, and adjusted odds ratios (aOR) with 95% confidence intervals (CI) are reported.

Education Higher education levels were positively associated with increased odds of being in the Moderate and High-Risk clusters.

Compared to individuals with no formal schooling, those with a college/university education had 3.4 times greater odds of being in the Moderate Risk cluster (aOR = 3.4,

Table 4 Multinomial logistic regression of factors associated with NCD risk clusters

Predictor	Moderate Risk vs. Low Risk (aOR, 95% CI)	High Risk vs. Low Risk (aOR, 95% CI)
Formal Education *(Ref: No Education)*		
Less than Primary	1.12 (0.61–1.55)	0.98 (0.61–1.45)
Primary Completed	1.75 (1.10–2.61)**	1.76 (1.08–2.81)**
Secondary Completed	1.95 (1.21–2.97)***	1.99 (1.30–3.05)***
High School Completed	2.74 (1.59–3.88)***	2.94 (1.79–4.33)***
College/University	3.35 (1.67–4.98)***	4.57 (2.19–6.81)***
Postgraduate	4.01 (0.46–6.71)	4.27 (0.42–7.29)
Type of employment (*Ref: Govt. Employee)*		
Non-Govt Employee	0.34 (0.09–0.91)**	0.35 (0.09–1.01)*
Self-Employed	0.41 (0.09–1.01)*	0.46 (0.11–1.17)
Non-Paid	0.35 (0.10–1.02)*	0.97 (0.29–1.28)
Student	1.59 (0.39–3.20)	1.21 (0.41–2.80)
Homemaker	0.54 (0.28–1.48)	0.76 (0.34–1.88)
Retired	0.47 (0.18–1.30)	0.63 (0.22–1.60)
Unemployed (Able)	0.50 (0.21–1.07)	0.39 (0.14–1.05)
Unemployed (Unable)	0.32 (0.09–0.98)**	0.44 (0.19–1.08)
Age	0.99 (0.98–0.99)***	1.01 (0.99–1.03)
Male (vs. Female)	19.10 (13.60–28.50)***	22.75 (15.90–31.75)***
Log (Income)	1.01 (0.98–1.05)	1.03 (0.98–1.07)

Ref Reference Category, *aOR* Adjusted Odds Ratio, *CI* Confidence Interval

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

95% CI: 1.67–4.98) and 4.6 times greater odds of being in the High-Risk cluster (aOR = 4.6, 95% CI: 2.19–6.81).

Employment status Those in non-government employment occupations had significantly lower odds of belonging to both the Moderate and High-Risk clusters compared to government employees. Unemployed individuals (unable to work) had significantly lower odds of being in the Moderate Risk cluster (aOR = 0.3, 95% CI: 0.09–0.98), indicating potential protective effects of employment stability.

Income While not statistically significant, income showed a slight trend toward increased risk, particularly in the High-Risk group (aOR = 1.0, 95% CI: 0.98–1.07).

Sex Being male was the strongest predictor of High-Risk cluster membership, with men having 19.1 odds of being in the moderate risk and 22.75 times higher odds of being in the High-Risk group compared to women (aOR = 22.75, 95% CI: 15.90–31.75). Age: Each additional year of age slightly increased the odds of High-Risk membership (aOR = 1.01, 95% CI: 0.99–1.03), though this effect was not statistically significant.

Discussion

The findings from this study highlight distinct patterns in the clustering of non-communicable disease risk factors in Zambia, shedding light on their association with socioeconomic determinants. The identification of three latent risk classes (i.e., low-risk, intermediate-risk, and high-risk) demonstrates the heterogeneity of NCD risk factor accumulation, a pattern observed in global studies [26].This stratification underscores the need for tailored public health interventions that account for varying levels of risk exposure.

The implications of these risk classifications are significant. The low-risk group, though the smallest, suggests the presence of protective lifestyle behaviors that should be reinforced through public health initiatives. The intermediate-risk group, which constitutes the majority, indicates a substantial portion of the population is already exhibiting risk behaviors that could escalate into metabolic disorders if left unchecked. Most concerning is the high-risk group, which comprises nearly one in four individuals. This signals an urgent need for targeted interventions to prevent the onset of severe non-communicable diseases (NCDs), as this group faces a heightened risk of conditions such as cardiovascular disease and diabetes. Addressing these risks through early prevention and management strategies is crucial to mitigating the long-term health and economic burden of NCDs in Zambia.

The study emphasizes the need for targeted prevention strategies that are tailored to the distinct stages of NCD risk accumulation. Specific interventions are necessary to address the challenges faced by different risk groups. For individuals in the high-risk group, urgent interventions are required, including regular screening, clinical management, and behavior modification programs aimed at controlling risk factors such as high blood pressure, cholesterol, and glucose levels. In addition, promoting healthier lifestyles through smoking cessation programs, alcohol reduction policies, and access to affordable, healthy food options should be prioritized. For the majority in the intermediate-risk group, the focus should shift to preventive health policies designed to reduce modifiable risk factors before they progress to more severe metabolic disorders. Community-based interventions, such as public awareness campaigns on the importance of physical activity and balanced diets, can help prevent further risk accumulation. The adoption of the WHO Essential NCD Intervention Package, which includes early diagnosis, management strategies, and comprehensive health education, will be vital in curbing the rising incidence of NCDs in Zambia. These targeted strategies not only align with global best practices, as seen in studies from Europe, North America, and high-income Asian countries [27, 28] but are also specifically tailored to address Zambia's unique context and health challenges.

Our study found that harmful alcohol consumption and tobacco use were significantly associated with the high-risk group (Class 3), mirroring global trends where substance use is a key contributor to NCD risk clustering. This aligns with previous reviews that have demonstrated smoking's potential to adversely impact various factors involved in glucose and lipid metabolism all of which play critical roles in metabolic regulation, thus NCDs [29].

Socioeconomic determinants of NCD risk clustering

Findings of this study demonstrate that education, income, employment status plays significant roles in shaping NCD risk clustering. Higher education levels were associated with increased odds of being in the moderate- and high-risk groups. This finding aligns with existing research demonstrating that educational status plays a crucial role in the trajectory of non-communicable diseases (NCDs) in low- and middle-income countries (LMICs) [30–32].

In many LMICs undergoing economic transition, higher education has oddly been linked with greater risk of non-communicable diseases (NCDs). This contrasts with high-income countries, where more education usually means better health. Researchers have dubbed this an "education paradox". In transitioning economies such as SSA, formal education often opens the door to urban, sedentary jobs and higher-income lifestyles. These shifts can encourage less physical activity and diets richer in processed foods and salt, as well as greater exposure to

alcohol and tobacco [33]. These lifestyle modifications will most likely lead to a rise in NCDs.

Non-communicable diseases (NCDs) tend to be more prevalent among higher socioeconomic status groups, though this is influenced by specific diseases and a country's economic status. In India, a study by Kundu and Chakraborty (2023) from 2017 to 2018 found that while the prevalence of communicable diseases was higher among poorer older adults, NCDs were more prevalent among wealthier older adults, with a significant degree of inequality. Specifically, 45.5% of older adults suffered from NCDs, with a higher concentration among the rich, including conditions such as bone disorders, cardiovascular diseases (CVD), diabetes, cancer, and chronic obstructive pulmonary disease (COPD). Research by Hosseinpoor et al., (2012) in low- and middle-income countries (LMICs) reveals that diabetes prevalence is higher among wealthier and more educated individuals, especially in low-income countries (LICs). This contrasts with other NCDs like angina, arthritis, asthma, and depression, which are often more prevalent among individuals with lower wealth and education levels [34, 35]. While some NCDs, such as diabetes, may initially be more common among wealthier individuals, the overall burden of NCDs often shifts towards lower-income groups over time due to epidemiological and socioeconomic transitions [36, 37]. This is however the reverse in most high income (HICs) countries where higher education is associated with increased NCD risk factors and incidence [38]. This could be attributed to the fact that in SSA, higher education is linked to increased NCD risk due to urbanization, sedentary jobs, and Westernized diets. Consequently, the very opportunities that education affords may paradoxically amplify exposure to diet- and activity-related risk factor such as greater consumption of ultra-processed foods, reliance on motorised transport, and prolonged sedentary screen time thereby accelerating the rise of non-communicable diseases in these populations. In HICs, higher education is associated with lower NCD risk due to health awareness, better healthcare access, and healthier lifestyles, reflecting different epidemiological transitions.

Employment status has been associated with the clustering of non-communicable disease (NCD) risk factors. Government employees tend to have higher odds of being in high-risk clusters compared to their non-government counterparts, potentially due to differences in occupational activity levels and dietary habits. A study in Biratnagar, Nepal, found that 99.6% of government employees had at least one established risk factor for NCDs, with an overall prevalence of high blood pressure, diabetes, and cardiovascular diseases at 22.3% [39]. Similarly, a study of university employees in Nigeria identified inadequate fruit and vegetable intake, physical inactivity, and dyslipidemia as common NCD risk factors [40]. These findings emphasize the need for targeted interventions to address lifestyle and behavioral risks among government employees.

In sub-Saharan Africa (SSA), the dynamics of healthcare access and NCD management differ significantly from other regions. While government employment can provide stability and access to certain benefits, systemic challenges—such as corruption, inequitable health systems, and resource limitations—often undermine these advantages [41]. Healthcare systems in SSA frequently lack equity, disproportionately impacting the most vulnerable populations [42]. As a result, even government employees may face substantial barriers to accessing quality healthcare, particularly in areas with weak or non-existent healthcare infrastructure. Additionally, factors such as ineligibility for government support and limited flexibility in health services can exacerbate the economic burden of managing chronic illnesses.

Despite these challenges, government jobs generally offer greater job security than private-sector employment, providing employees with economic stability, particularly during periods of financial downturn [43]. However, ensuring that this stability translates into better health outcomes requires comprehensive workplace health programs and policy interventions that address the specific risk factors associated with government employment.

Sex differences in NCD risk clustering

Current findings highlight significant gender disparities in NCD risk clustering, reinforcing the need for sex-specific health interventions. Targeted campaigns can be done to address distinct risk behaviours, improve healthcare access through mobile clinics and screenings, and integrate psychological support to enhance treatment adherence and overall health outcomes [44].

Men were significantly more likely to be classified into Class 3 (High-Risk Group), while a higher proportion of women were in Class 2 (Intermediate-Risk Group). Existing research on gender disparities in NCD risk has shown mixed results. Higher incidence of NCDs among men compared to women can be attributed to differences to lifestyle factors, obesity rates post-childbirth, and behavioural patterns [5]. In Kazakhstan, men exhibited higher rates of smoking and alcohol consumption, whereas women had a greater prevalence of physical inactivity and obesity [44]. Similarly, a study among medical students in Nepal found that men had significantly more clustered modifiable NCD risk factors [45]. Another study in Nepal reported that older women (40–49 years) were more likely to accumulate multiple NCD risk factors compared to younger women (15–29 years) [46].

Previous studies have consistently reported gender-based differences in health behaviors and associated

outcomes. For instance [47], found that among Brazilian adolescents, girls exhibited higher rates of insufficient physical activity, whereas boys demonstrated lower fruit and vegetable consumption alongside higher alcohol intake. Similarly [48],, analyzing data from the Global School-based Student Health Survey (2007–2016) encompassing 304,779 adolescents aged 11–17 years (52.2% female) from 89 countries, observed distinct gendered patterns in the clustering of modifiable risk factors for non-communicable diseases (NCDs). While both sexes exhibited a combination of physical inactivity and inadequate fruit and vegetable intake, the co-occurrence of multiple risk factors—including smoking, alcohol consumption, physical inactivity, and poor diet—was more pronounced among females (165% higher than expected) compared to males (110% higher than expected). These findings underscore the importance of early, gender-specific prevention strategies to mitigate the future burden of NCDs.

Further supporting these observations [49],, in their Norwegian Counties Study, found that although the overall patterns of NCD risk factors were comparable between men and women, men exhibited a higher prevalence of hypercholesterolemia, hypertension, hypertriglyceridemia, and multiple risk factors. Notably, men were overrepresented among individuals with an increasing-to-decreasing blood pressure trajectory and constituted two-thirds of those following a moderate-to-vigorous-to-moderate leisure-time physical activity trajectory. These findings align with broader epidemiological evidence indicating that men are more likely to engage in behaviors such as tobacco smoking, excessive alcohol consumption, and unhealthy dietary practices [50]. Given these gender-specific risk factor distributions, there is an urgent need for targeted interventions tailored to address these disparities. Implementing such strategies is crucial in reducing the overall burden of NCDs and fostering healthier lifestyles for both men and women. This approach aligns with the WHO's global call for strengthened commitments to combat NCDs, ensuring equitable health outcomes across genders and age groups [50].

Public health and policy implications

The identification of three distinct NCD risk profiles has critical implications for public health interventions. Given that Class 2 (Intermediate-Risk) is the most prevalent, preventive policies should prioritize early intervention strategies, such as health education, dietary improvements, and promotion of physical activity to reduce the likelihood of progression to Class 3 (High-Risk). The Ministry of Health has responded to NCD risks through the National NCD Strategic Plan 2021–2025 [51]. This plan prioritizes the prevention and management of major NCDs, including diabetes, cardiovascular diseases, cancer, and respiratory diseases, while addressing key risk factors such as tobacco use, alcohol abuse, and unhealthy diets, in line with the WHO Global Action Plan for NCDs 2013–2030 [52].

However, policy gaps limit the effectiveness of these efforts. Challenges include inadequate baseline data, weak integration of international guidelines, and underutilization of health education strategies. Many health facilities lack resources to manage NCDs, and the current plan does not comprehensively address all prevalent NCDs. Additionally, the absence of locally representative research and reliance on generic targets reduce policy impact. To address these gaps, strengthening data collection, integrating non-health stakeholders, and domesticating international guidelines to fit Zambia's health system are critical. Leveraging routinely collected data for decision-making and prioritizing community-based interventions (e.g., accessible health education, dietary changes, and lifestyle improvements) can help curb disease progression and ease Zambia's NCD burden. An example of a community-led initiative could be training local volunteers to conduct peer-support groups for hypertension management, combining culturally adapted nutrition workshops with shared blood pressure monitoring using low-literacy pictogram guides.

Our results align with the Social Determinants of Health (SDH) framework, underscoring how non-medical factors, markedly economic security and social support systems—critically shape wellbeing in chronic illness. The significant wellbeing gains observed among people living NCD transitioning from low to middle wealth (vs. minimal returns at higher wealth tiers) reflect SDH's emphasis on material deprivation as a fundamental health driver. Similarly, the gendered buffering effect of social grants and limited protective role of structural social capital highlight how SDH domains like social position and socioeconomic context interact uniquely with health conditions. This reinforces SDH's core tenet: equitable health outcomes require policies addressing intersecting socioeconomic vulnerabilities alongside biomedical care.

Conclusion

This study shows that NCD risk factors cluster into distinct latent classes, with significant socioeconomic disparities influencing risk accumulation. The findings underscore the need for primary prevention strategies for individuals in the Intermediate-Risk group and targeted treatment and prevention strategies for those in the High-Risk group. Given the significant burden of metabolic and behavioral risk factors observed, policy-driven approaches will be critical in mitigating the rising NCD epidemic in Zambia.

Effective policy measures should include strengthening taxation and regulatory policies on tobacco, alcohol, and unhealthy foods, as well as implementing nationwide health promotion campaigns to encourage physical activity and healthy diets. Expanding universal health coverage to improve access to early screening, diagnosis, and treatment of NCDs will be crucial. Additionally, integrating NCD prevention into primary healthcare services and strengthening community-based health programs can enhance early detection and management. Addressing contextual factors such as urbanization, cultural practices, and healthcare disparities through localized interventions will be essential for designing effective and sustainable solutions.

Limitations

While this study provides valuable insights, it is not without limitations. The cross-sectional design limits our ability to establish causal relationships between risk factors and NCD outcomes. The generalizability of findings to other regions in SSA may be limited due to variations in cultural, economic, and healthcare systems. Additionally, there are always concerns of self-reported behavioural data. Given given that the data employed in current work was collected in 2017, trends and pattern may have changed slightly over the years and this must be acknowledged. Future longitudinal studies are needed to better understand the progression of NCD risk accumulation and the effectiveness of targeted interventions.

Abbreviations

NCDs	Non communicable diseases
WHO	World health Organisation
SSA	Sub-Saharan Africa
LCA	Latent class analysis

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-23769-y.

Supplementary Material 1.

Acknowledgements

We thank the World Health Organization's Data management team for their access and permission to use the dataset in their NCD Microdata Repository.

Authors' contributions

AKC designed the study in collaboration with ED and OAS. AKC and ED conducted all the statistical analyses. All authors contributed to writing and approved the final manuscript.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sector.

Data availability

The datasets analysed during the current study can be accessed upon request via the World Health Organization's website at: https://extranet.who.int/ncdsmicrodata/index.php/catalog/935.

Declarations

Ethical approval and consent to participate

The STEPS survey was ethically approved by the Biomedical Research Ethics Committee at the University of Zambia (UNZABREC) and the Zambia National Health Research Authority (ZNHRA). Permission to conduct the survey was also granted by Zambia's Ministry of Health (MoH) and the local WHO office. All participants provided informed consent before inclusion in the survey. This research adhered to ethical standards outlined in the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 3 April 2025 / Accepted: 26 June 2025
Published online: 23 July 2025

References

1. World Health Organization. Tobacco use falling: WHO urges countries to invest in helping more people to quit tobacco. https://www.who.int/news/item/16-11-2021-tobacco-use-falling-who-urges-countries-to-invest-in-helping-more-people-to-quit-tobacco. Accessed 14 Mar 2025.
2. United Nations. Sustainable Development Goals: 17 Goals to Transform our World| United Nations. https://www.un.org/en/exhibits/page/sdgs-17-goals-transform-world. Accessed 14 Mar 2025.
3. Wekwete NN, Mangombe K. Causes of death and the double burden of disease in africa: evidence from the sub-Saharan Africa. In: Teller C, Hailemariam A, editors. The Routledge Handbook of African Demography. 1st ed. Abingdon: Routledge; 2022. p. 731–44.
4. Kohrt BA, Mistry AS, Anand N, Beecroft B, Nuwayhid I. Health research in humanitarian crises: an urgent global imperative. BMJ Glob Health. 2019;4:1870.
5. Musonda E, Mumba P, Malungo JRS. Mortality from non-communicable diseases and associated risk factors in zambia; analysis of the sample vital registration with verbal autopsy 2015/2016. BMC Public Health. 2024;24:1–11.
6. Stringhini S, Bovet P. Socioeconomic status and risk factors for non-communicable diseases in low-income and lower-middle-income countries. Lancet Glob Health. 2017;5:e230–1.
7. Marmot M, Bell R. Social determinants and non-communicable diseases: time for integrated action. BMJ. 2019;364:l251.
8. Christian AK, Sanuade OA, Okyere MA, Adjaye-Gbewonyo K. Social capital is associated with improved subjective well-being of older adults with chronic non-communicable disease in six low- and middle-income countries. Global Health. 2020;16:1–11.
9. Christian AK, Osei-Appaw AA, Sawyerr RT, Wiredu Agyekum M. Hypertension, diabetes, and cardiovascular disease nexus: investigating the role of urbanization and lifestyle in Cabo Verde. Glob Health Action. 2024;17:2414524.
10. Yiga P, Tan PY, Chomba C, Menefe A, Shannon C, Kalenga P, et al. Food environment transformations and policy landscape in Zambia: a qualitative inquiry of the ongoing nutrition transition. Proceedings of the Nutrition Society. 2024;83:E297.
11. Sakaria N, Indongo N. Socioeconomic and behavioural factors that contribute to the co-occurrence of risk factors for noncommunicable diseases. BMC Public Health. 2025;25:165.
12. Pengpid S, Peltzer K. Prevalence and correlates of multiple non-communicable disease risk factors among adults in zambia: results of the first National STEPS survey in 2017. Pan Afr Med J. 2020;37:265.
13. Hacker K, Auerbach J, Ikeda R, Philip C, Houry D. Social determinants of Health - An approach taken at CDC. J Public Health Manage Pract. 2022;28:589–94.
14. Shokouh SMH, Arab M, Emamgholipour S, Rashidian A, Montazeri A, Zaboli R. Conceptual models of social determinants of health: A narrative review. Iran J Public Health. 2017;46:435.
15. U.S. Department of Health and Human Services. Social Determinants of Health - Healthy People 2030| odphp.health.gov. https://odphp.health.gov/healthypeople/priority-areas/social-determinants-health. Accessed 14 Mar 2025.

16. World Health Organization. Social determinants of health. https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1. Accessed 14 Mar 2025.
17. World Health Organization. Noncommunicable Disease Surveillance, Monitoring and Reporting. https://www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/steps. Accessed 14 Mar 2025.
18. Umuhoza SM, Ataguba JE. Inequalities in health and health risk factors in the Southern African development community: evidence from world health surveys. Int J Equity Health. 2018;17:1–15.
19. Sinha P, Calfee CS, Delucchi KL. Practitioner's guide to latent class analysis: methodological considerations and common pitfalls. Crit Care Med. 2021;49:e63.
20. Naldi L, Cazzaniga S. Research techniques made simple: latent class analysis. J Invest Dermatology. 2020;140:1676–e16801.
21. Lanza ST, Collins LM, Lemmon DR, Schafer JL. PROC LCA: A SAS procedure for latent class analysis. Struct Equ Model. 2007;14:671–94.
22. Marbaniang SP, Lhungdim H, Chungkham HS. Identifying the latent classes of modifiable risk behaviours among diabetic and hypertensive individuals in Northeastern india: a population-based cross-sectional study. BMJ Open. 2022;12:e053757.
23. Mkuu RS, Gilreath TD, Barry AE, Nafukho FM, Rahman J, Chowdhury MAB, et al. Identifying individuals with multiple non-communicable disease risk factors in kenya: a latent class analysis. Public Health. 2021;198:180–6.
24. Weller BE, Bowen NK, Faubert SJ. Latent class analysis: A guide to best practice. J Black Psychol. 2020;46:287–311.
25. Lanza ST, Rhoades BL. Latent class analysis: an alternative perspective on subgroup analysis in prevention and treatment. Prev Sci. 2013;14:157–68.
26. Atorkey P, Asante KO. Clustering of multiple health risk factors among a sample of adolescents in liberia: a latent class analysis. J Public Health (Germany). 2022;30:1389–97.
27. Li Y, Schoufour J, Wang DD, Dhana K, Pan A, Liu X, et al. Healthy lifestyle and life expectancy free of cancer, cardiovascular disease, and type 2 diabetes: prospective cohort study. BMJ. 2020;368:1669.
28. Lahti-Koski M, Pietinen P, Heliövaara M, Vartiainen E. Associations of body mass index and obesity with physical activity, food choices, alcohol intake, and smoking in the 1982–1997 FINRISK studies. Am J Clin Nutr. 2002;75:809–17.
29. Behl TA, Stamford BA, Moffatt RJ. The effects of smoking on the diagnostic characteristics of metabolic syndrome: A review. Am J Lifestyle Med. 2022;17:397–412.
30. Mtintsilana A, Craig A, Mapanga W, Dlamini SN, Norris SA. Association between socio-economic status and non-communicable disease risk in young adults from kenya, South africa, and the united Kingdom. Sci Rep 2023. 2023;13:1.
31. Williams J, Allen L, Wickramasinghe K, Mikkelsen B, Roberts N, Townsend N. A systematic review of associations between non-communicable diseases and socioeconomic status within low- and lower-middle-income countries. J Glob Health. 2018;8:020409.
32. Niessen LW, Mohan D, Akuoku JK, Mirelman AJ, Ahmed S, Koehlmoos TP, et al. Tackling socioeconomic inequalities and non-communicable diseases in low-income and middle-income countries under the sustainable development agenda. Lancet. 2018;391:2036–46.
33. Allen L, Williams J, Townsend N,Mikkelsen B, Roberts N, Foster C, et al. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. Lancet Glob Health. 2017;5(3):e277–89.
34. Hosseinpoor AR, Bergen N, Mendis S, Harper S, Verdes E, Kunst A, et al. Socioeconomic inequality in the prevalence of noncommunicable diseases in low- and middle-income countries: results from the world health survey. BMC Public Health. 2012;12:1–13.
35. Kundu J, Chakraborty R. Socio-economic inequalities in burden of communicable and non-communicable diseases among older adults in india: evidence from longitudinal ageing study in india, 2017–18. PLoS ONE. 2023;18:e0283385.
36. Reddy KS, Prabhakaran D, Jeemon P, Thankappan KR, Joshi P, Chaturvedi V, et al. Educational status and cardiovascular risk profile in Indians. Proc Natl Acad Sci. 2007;104:16263–8.
37. Bhopal R, Hayes L, White M, Unwin N, Harland J, Ayis S, et al. Ethnic and socioeconomic inequalities in coronary heart disease, diabetes and risk factors in Europeans and South Asians. J Public Health Med. 2002;24:95–105.
38. Lago - Peñas S, Rivera B, Cantarero D, Casal B, Pascual M, Blázquez-Fernández C, et al. The impact of socioeconomic position on non-communicable diseases: what do we know about it? Perspect Public Health. 2021;141:158–76.
39. Neupane R, Bhandari TR. Prevalence of Non-Communicable diseases and its associate factors among government employees in biratnagar, Nepal. JNMA J Nepal Med Assoc. 2018;56:497.
40. Agaba EI, Akanbi MO, Okeke EN, Agaba PA, Ocheke AN, Gimba ZM, et al. A survey of non-communicable diseases and their risk factors among university employees: a single institutional study. Cardiovasc J Afr. 2017;28:377.
41. Dowhaniuk N. Exploring country-wide equitable government health care facility access in Uganda. Int J Equity Health. 2021;20:1–19.
42. Van Hout MC, Akugizibwe M, Shayo EH, Namulundu M, Kasujja FX, Namakoola I, et al. Decentralising chronic disease management in sub-Saharan africa: a protocol for the qualitative process evaluation of community-based integrated management of HIV, diabetes and hypertension in Tanzania and Uganda. BMJ Open. 2024;14:e078044.
43. Private vs. Public Sector Benefits: What You Need to Know - Bentek. https://mybentek.com/employee-benefits/private-vs-public-sector-benefits-what-you-need-to-know/. Accessed 2 Apr 2025.
44. Sreedevi A, Rakesh PS, Philip S, Editorial. A gendered approach for accelerating prevention and control of NCDs. Front Public Health. 2024;12:1484592.
45. Shakya A, Mishra SR, Giri S, Paudel K, Neupane D. Gender differences and clustering of modifiable risk factors of Non-communicable diseases among medical students: A cross sectional study in Nepal. J Community Health. 2015;40:147–52.
46. Singh BK, Mishra SR, Khatri RB. Trends and determinants of clustering for non-communicable disease risk factors in women of reproductive age in Nepal. PLoS ONE. 2024;19:e0309322.
47. Silva KS, Barbosa Filho VC, Del Duca GF, de Anselmo Peres MA, Mota J, Lopes A da. Gender differences in the clustering patterns of risk behaviours associated with non-communicable diseases in Brazilian adolescents. Prev Med (Baltim). 2014;65:77–81.
48. Uddin R, Lee EY, Khan SR, Tremblay MS, Khan A. Clustering of lifestyle risk factors for non-communicable diseases in 304,779 adolescents from 89 countries: A global perspective. Prev Med (Baltim). 2020;131:105955.
49. Dalene KE, Lergenmuller S, Sund ER, Hopstock LA, Robsahm TE, Nilssen Y, et al. Clustering and trajectories of key noncommunicable disease risk factors in norway: the NCDNOR project. Sci Rep 2023. 2023;13:1.
50. New data from WHO/Europe. shows links between gender and noncommunicable diseases. https://www.who.int/europe/news/item/09-12-2020-new-data-from-who-europe-shows-links-between-gender-and-noncommunicable-diseases. Accessed 2 Apr 2025.
51. Launch of Zambia Non-Communicable Disease Alliance's National NCD Strategic Implementation Plan| NCD Alliance. https://ncdalliance.org/news-events/news/launch-of-zambia-non-communicable-disease-alliance-national-ncd-strategic-implementation-plan. Accessed 2 Apr 2025.
52. Mukanu MM, Zulu JM, Mweemba C, Mutale W. Responding to non-communicable diseases in zambia: a policy analysis. Health Res Policy Syst. 2017;15:34.

Publisher's Note