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Exploring socioeconomic status, lifestyle factors, and cardiometabolic disease outcomes in the United States: insights from a population-based cross-sectional study

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Abstract

Background Cardiometabolic diseases are a major global health concern. This study aims to identify areas for targeted interventions and investigate the impact of socioeconomic status and lifestyle as a potential mediator in the context of the US.

Methods Our study analyzed data from the Health Information National Trends Survey 5, a nationwide survey by the National Cancer Institute. Using standardized scales and questions, we examined cardiometabolic disease outcomes, lifestyle factors, and socioeconomic status of non-institutionalized civilians aged 18+ in the US. We analyzed the data using structural equation modelling.

Results Our findings show that socioeconomic status and lifestyle significantly predict cardiometabolic disease outcomes. However, our analysis did not support lifestyle as the primary mediating factor in the association between socioeconomic status and cardiometabolic diseases, suggesting that other factors may significantly influence this relationship.

Conclusions Cardiometabolic diseases require lifestyle and structural interventions addressing socioeconomic factors. Policymakers must consider multifaceted factors to prevent, detect, and manage these diseases effectively and equitably.

Keywords Socioeconomic status, Cardiometabolic diseases, Lifestyle factors, Structural equation modelling, Health disparities

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Background

The relationship between socioeconomic status (SES) and cardiometabolic diseases has been an essential area of public health and medicine research [1, 2]. Cardiometabolic diseases, which include cardiovascular disease, type 2 diabetes, and lung disease, pose a significant public health challenge worldwide [3]. Their prevalence has increased recently, with important implications for individuals, communities, and healthcare systems [3]. SES, a complex determinant, has emerged as a crucial factor associated with the development and progression of these diseases [4].

Despite the growing body of literature exploring the connection between SES and cardiometabolic diseases [1, 2, 5–7], there are still gaps in our understanding. Prior studies have focused on establishing the association itself, often overlooking the complex pathways through which SES affects cardiometabolic health. Moreover, limited attention has been given to the potential role of lifestyle factors as mediators in this intricate relationship. Although some research has explored the individual impacts of lifestyle choices on cardiometabolic diseases [8, 9], there is a lack of comprehensive investigations examining lifestyle's potential to mediate the effects of SES on these health outcomes. Thus, delving deeper into the interplay between SES, lifestyle, and cardiometabolic diseases is important.

It is crucial to understand the impact of socioeconomic status on cardiometabolic diseases, especially in the current context where health disparities persist and evolve [4, 10]. The COVID-19 pandemic has highlighted the vulnerabilities individuals with lower SES face, making this investigation urgent [11, 12].

This study investigates the association between socioeconomic status and cardiometabolic diseases in the United States and how lifestyle factors may mediate this relationship. Data from the Health Information National Trends Survey (HINTS) 5, a nationally representative survey conducted by the National Cancer Institute, will be analyzed. The study hypothesizes that specific lifestyle factors, such as physical activity and smoking, may significantly mediate the relationship between socioeconomic status and cardiometabolic diseases. The findings from this research could provide valuable insights for potential targeted public health interventions and policy strategies aimed at reducing health disparities.

Methods

Participants

This study utilized data from the Health Information National Trends Survey (HINTS) [13], a nationally representative survey conducted by the National Cancer Institute (NCI) since 2003. HINTS provides valuable insights into the American public's knowledge, attitudes, and use of cancer- and health-related information to enhance health communication strategies across diverse populations. The HINTS 5 survey data was used for this study, which targeted non-institutionalized civilians aged 18 years or older residing in the United States. No direct contact was made with the study participants. Therefore, informed consent for the present analysis was not necessary as secondary data analysis does not involve interaction with participants. Ethical approval for HINTS was obtained through expedited review by the Westat Institutional Review Board and subsequently deemed exempt by the U.S. National Institutes of Health Office of Human Subjects Research Protections. HINTS adheres to established international and local ethical standards and protocols. Approval to use the HINTS dataset was granted by the National Cancer Institute. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. They determined that no formal ethical consent was required to conduct research using this data source.

The study was conducted by sending a self-administered questionnaire to a sample of addresses in the United States. The addresses were randomly selected from a database maintained by Marketing Systems Group (MSG), which contains all non-vacant residential addresses in the United States, including P.O. boxes and seasonal addresses. A modified Dillman approach used for the mailing protocol included an initial questionnaire dispatch, a reminder postcard, and up to two more questionnaire mailings for households that did not respond. Respondents were given toll-free telephone numbers for inquiries or concerns. The sampling strategy consisted of a two-stage plan, where a stratified sample of residential addresses was selected, considering both rural and urban areas and areas with high and low concentrations of minority adult populations. The sampling frame was divided into four explicit sampling strata, enabling oversampling of high-minority and rural strata to enhance estimates for these subpopulations. Within each stratum, an equal probability sample of addresses was chosen, totalling 29,600 addresses for HINTS 5. Data for HINTS 5 was compiled between April 6 and May 11, 2021, which is still relevant for our research objectives.

Measures

To determine the respondents' socioeconomic status, their education level, household income, and occupation were taken into account. Respondents were asked about their highest level of education using a 5-point Likert scale. The choices ranged from "Less than high school" to "post-baccalaureate degree." Similarly, household income was assessed using a 5-point Likert scale ranging from

"Less than $20,000" to "$75,000 or More." Occupation classifications included employed, homemaker, student, retired, disabled, multiple occupation status, unemployed for one year or more, unemployed for less than one year, and other occupations. In our study, socioeconomic status (SES) is defined and measured as a composite variable that includes educational level, household income, and occupation status. These specific demographic characteristics were selected based on their established importance in the literature as key indicators of socioeconomic position.

Additionally, lifestyle factors such as physical activity, alcohol consumption, and smoking were considered. The number of minutes per week of at least moderate-intensity exercise was used to determine physical activity, and respondents were categorized as either active (>150 min) or inactive (≤150 min) based on guidelines from established organizations like the World Health Organization (WHO) [14]. It's worth noting that this cutoff is commonly used in epidemiological studies [14, 15]. Alcohol consumption was categorized as either never or currently, and smoking was categorized as current, former, or non-smokers. Respondents' self-reported frequency and quantity were recorded for alcohol consumption and smoking to provide a more comprehensive picture of these lifestyle factors.

Cardiometabolic diseases were assessed based on diabetes, heart conditions, and lung disease. To determine diabetes, respondents were asked if a doctor or other health professional had ever told them that they had diabetes or high blood sugar. The response options were "yes" and "no". The presence of a heart condition was assessed by asking respondents if a doctor or other health professional had ever diagnosed them with a heart condition such as heart attack, angina, or congestive heart failure. Finally, respondents were asked whether they had ever been diagnosed with chronic lung disease, asthma, emphysema, or chronic bronchitis to measure lung disease.

This study also considered other relevant variables, such as race and perceived discrimination. Respondents were asked to select their race from the options: Non-Hispanic White, Non-Hispanic Black or African American, Hispanic, Non-Hispanic Asian, and Non-Hispanic Other. To measure perceived discrimination, respondents were asked if they had ever received unfair treatment or discrimination in medical care because of their race or ethnicity. They had the option to choose "yes" or "no". This measure helps assess the potential impact of perceived discrimination on health outcomes, including cardiometabolic diseases.

The sociodemographic variables considered in this study include age, gender, and marital status. Age was classified into five ranges, gender as male or female, and marital status as married, divorced/separated, widowed, or single/never married.

Statistical analysis

This study analysed the data using STATA SE version 14.2 (Stata Corp, College Station, TX) and Intellectus Statistics [16]. The data [17] was first analyzed descriptively to summarise the relevant variables. A regression analysis was conducted to investigate the association between socioeconomic status and cardiometabolic diseases. This regression aimed to determine the relationship between the independent variable (socioeconomic status) and the dependent variable (Cardiometabolic diseases). Furthermore, structural equation modelling (SEM) was utilized to explore the role of lifestyle as a mediator in the association between socioeconomic status and cardiometabolic diseases. SEM is a statistical technique that examines complex relationships between multiple variables.

The regression analysis between socioeconomic status (independent variable) and cardiometabolic diseases (dependent variable) can be written as $Y=\beta_0+\beta_1{}^*X+\varepsilon$. Here, Y represents Cardiometabolic diseases (dependent variable), X represents socioeconomic status (independent variable), β_0 is the intercept (representing the expected value of Y when X is equal to 0), β_1 is the regression coefficient (representing the change in Y associated with a one-unit change in X), and ε means the error term (accounting for the variability in Y that the model does not explain).

The SEM equation can be written as follows: Cardiometabolic diseases$=\lambda_0+\lambda_1$Socioeconomic status$+\lambda_2$Lifestyle$+\delta$. Here, cardiometabolic diseases represent the dependent variable, Socioeconomic status represents the independent variable, Lifestyle represents the mediating variable, λ_0 represents the direct effect of the intercept on cardiometabolic diseases, λ_1 represents the direct effect of socioeconomic status on cardiometabolic diseases, λ_2 represents the direct effect of lifestyle on cardiometabolic diseases, and δ represents the error term (accounting for the variability in cardiometabolic diseases that the model does not explain).

The analysis assessed the reliability and validity of the sample size. Multicollinearity was conducted to examine the squared multiple correlations (R^2) and the determinant of the correlation matrix. No variables had $R^2 > 0.90$, and the determinant was 0.56, indicating no multicollinearity. A Chi-Square Goodness of Fit Test was conducted to determine if the Structural Equation Model (SEM) accurately fits the data. It is a standard practice to include the Chi-square test in SEM. However, this test is highly sensitive to sample size, which almost always rejects the null hypothesis and indicates a poor model fit when the sample size is large [18]. Additionally, fit indices such as the Root Mean Square Error of Approximation

(RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Standardized Root Mean Square Residual (SRMR) were employed to evaluate the model fit. The significance level for the statistical tests was 0.05. Results with $p \leq .05$ were considered statistically significant.

Results

The results presented in Table 1 gives a detailed description of the demographic and health-related characteristics of the surveyed individuals. The results suggest a more significant proportion of people in the 50–64 age group compared to the 18–34 age category, while fewer people in the 65–74 and 75+ age groups. Furthermore, most respondents are females, making up 57% of the population. Educational attainment appears to be evenly distributed, which suggests that the participants come from diverse educational backgrounds.

Regarding household income, 41.5% of participants earn "$75,000 or more," which implies that the surveyed population may be skewed towards higher economic brackets. Occupational status is also noteworthy, as retirees comprise a substantial 26.4% of the group, indicating that the participants may be older or financially stable. Additionally, there is a near parity in alcohol consumption and smoking habits, which could merit further investigation into the group's lifestyle choices or social norms. Chronic illnesses are prevalent, with 19.9% and 14.8% of participants experiencing diabetes and lung disease, respectively. Additionally, 10.3% reported heart-related ailments.

This study used a Structural Equation Modeling (SEM) approach to evaluate the effectiveness of latent variables, including socioeconomic status, lifestyle, and cardiometabolic diseases. Firstly, the model's reliability was established based on the sample size. Subsequently, the Chi-square goodness-of-fit test and fit indices were applied to evaluate the results, detailed in Table 2. The correlations between latent variables are presented in Table 3, and the node diagram is illustrated in Fig. 1.

Regressions were analyzed using an alpha level of 0.05. Socioeconomic status was found to be a significant predictor for CMD (cardiometabolic diseases), with $B=0.06$, $z=8.13$, $p<.001$, indicating that a unit rise in socioeconomic status is associated with a 0.06 unit increase in expected CMD. However, socioeconomic status was not found to have a significant connection with lifestyle, $B=0.07$, $z=0.90$, $p=.371$, indicating the absence of a direct relationship. Interestingly, lifestyle was a significant predictor for CMD, $B=0.02$, $z=2.16$, $p=.030$, suggesting that improving lifestyle factors could marginally increase CMD by 0.02 units.

Although there is no direct link between socioeconomic status (SES) and lifestyle, conducting a mediation analysis is important. This is because lifestyle factors are believed to play a significant role in the connection between SES and cardiometabolic diseases (CMD). Previous research indicates that lifestyle behaviors often mediate the relationship between SES and health outcomes [19, 20]. By investigating these pathways, we can determine whether SES influences CMD through its impact on lifestyle, providing a more thorough understanding of these complex connections. Including lifestyle as a mediator ensures that our model accurately reflects the proposed relationships and allows us to test our theoretical framework rigorously.

The mediation analysis examined whether lifestyle acted as an intermediary between socioeconomic status and cardiometabolic diseases. The direct effect between socioeconomic status and CMD negated the possibility of full mediation by lifestyle, but left room for potential partial mediation. This hypothesis was explored further using the indirect and total effects. The indirect impact of lifestyle on the relationship between socioeconomic status and CMD was insignificant, $B=0.001$, $z=0.86$, $p=.390$, indicating that socioeconomic status does not influence CMD through lifestyle changes. In contrast, the total effect was significant, $B=0.06$, $z=8.34$, $p<.001$, showing that socioeconomic status independently affects the prevalence of CMD. The non-significance of the indirect effect implies that lifestyle does not support partial mediation, necessitating further exploration into other potential mediating factors. "B" represents the unstandardized regression coefficient, and "z" refers to the z-value, a test statistic for the regression coefficient.

The numbers shown in Fig. 1 represent the path coefficients (standardized regression weights) in the structural equation model (SEM). These coefficients indicate the strength and direction of relationships between socioeconomic status (SES), lifestyle factors, and cardiometabolic diseases (CMD). Higher coefficients indicate stronger relationships, with positive or negative values reflecting the direction of these relationships. The numbers next to the endogenous variables represent the squared multiple correlations (R^2), which show the proportion of variance explained by the predictor variables in the model.

The following fit indices were used to assess the model fit: root mean square error of approximation (RMSEA), comparative fit index (CFI), Tucker-Lewis index (TLI), and standardized root mean square residual (SRMR). The TLI was only 0.69, indicating a poor model fit, while the CFI was 0.79, suggesting a poor fit. However, the RMSEA index was 0.07, with a 90% CI of [0.06, 0.08], indicating a good model fit, and the SRMR was 0.06, implying that the model fits the data adequately. The fit indices are illustrated in Table 4. The Chi-square goodness of fit test results were significant, $\chi^2(24)=352.43$, $p<.001$, indicating that the model did not fit the data accurately.

Table 1 Demographic and health-related factors within the studied population

Variables	Proportion	Std. Err.	[95% Conf.	Interval]
Age group				
18–34	15.3%	0.007	0.140	0.167
35–49	21.3%	0.008	0.198	0.229
50–64	30.5%	0.009	0.288	0.322
65–74	22.2%	0.008	0.207	0.238
75+	10.7%	0.006	0.096	0.119
Gender				
Male	43.0%	0.009	0.412	0.448
Female	57.0%	0.009	0.552	0.588
Marital Status				
Married	55.8%	0.009	0.539	0.576
Divorced/Separated	17.5%	0.007	0.162	0.190
Widowed	8.9%	0.005	0.079	0.100
Single	17.8%	0.007	0.165	0.193
Race				
Non-Hispanic White	62.6%	0.009	0.608	0.644
Non-Hispanic Black or African American	12.5%	0.006	0.113	0.138
Hispanic	16.5%	0.007	0.152	0.179
Non-Hispanic Asian	4.7%	0.004	0.040	0.055
Non-Hispanic Other	3.7%	0.004	0.031	0.045
Education level				
Less than High school	5.7%	0.004	0.049	0.067
High school graduate	15.9%	0.007	0.145	0.172
Some College	29.5%	0.009	0.278	0.312
Bachelor's degree	28.2%	0.008	0.265	0.298
Post - Baccalaureate degree	20.8%	0.008	0.193	0.223
Household income				
Less than $20,000	14.6%	0.007	0.133	0.159
$20,000 to < $35,000	12.7%	0.006	0.115	0.139
$35,000 to < $50,000	13.1%	0.006	0.119	0.144
$50,000 to < $75,000	18.2%	0.007	0.168	0.197
$75,000 or more	41.5%	0.009	0.396	0.433
Occupation				
Employed only	49.4%	0.009	0.475	0.512
Homemaker only	3.5%	0.003	0.029	0.042
Student only	1.0%	0.002	0.007	0.014
Retired only	26.4%	0.008	0.248	0.280
Disabled only	4.3%	0.004	0.036	0.051
Multiple Occupation statuses selected	10.8%	0.006	0.097	0.120
Unemployed for 1 year or more only	1.9%	0.003	0.014	0.025
Unemployed for less than 1 year only	2.0%	0.003	0.016	0.026
Other Occupation only	0.8%	0.002	0.005	0.012
Alcohol intake				
Never	52.0%	0.009	0.502	0.539
Current	48.0%	0.009	0.461	0.498
Smoking				
Current	11.2%	0.006	0.101	0.124
Former	25.1%	0.008	0.235	0.267
Never	63.7%	0.009	0.619	0.655
Physical activity				
Inactive	62.1%	0.009	0.602	0.638
Active	37.9%	0.009	0.362	0.398
Diabetes				

Table 1 (continued)

Variables	Proportion	Std. Err.	[95% Conf.	Interval]
Yes	19.9%	0.008	0.184	0.214
No	80.1%	0.008	0.786	0.816
Lung Disease				
Yes	14.8%	0.007	0.135	0.161
No	85.2%	0.007	0.839	0.865
Heart Condition				
Yes	10.3%	0.006	0.092	0.115
No	89.7%	0.006	0.885	0.908

Std. Err = Standard Eroor; 95% Conf. Interval = 95% confidence interval

Table 2 Unstandardized loadings (standard errors), standardized loadings, and significance levels for each parameter in the structural equation model ($N = 2820$)

Parameter Estimate	Unstandardized	Standardized	*p*
Loadings			
SES → Household income	1.00(0.00)	0.82	< 0.001
SES → Education	0.49(0.03)	0.52	< 0.001
SES → Occupation	-0.72(0.05)	-0.41	< 0.001
Lifestyle → Alcohol intake	1.00(0.00)	0.15	< 0.001
Lifestyle → Smoking	-0.04(0.02)	-0.06	0.041
Lifestyle → Physical activity	0.738(0.04)	0.71	0.350
CMD → Diabetes	1.00(0.00)	0.44	< 0.001
CMD → lung disease	0.54(0.08)	0.26	< 0.001
CMD → Heart condition	0.80(0.10)	0.46	< 0.001
Regressions			
SES → CMD	0.06(0.007)	0.42	< 0.001
SES → Lifestyle	0.07(0.08)	0.08	0.371
Lifestyle → CMD	0.02(0.008)	0.10	0.030
Indirect Effect of SES on CMD by Lifestyle	0.001(0.001)	0.008	0.390
Total Effect of SES on CMD	0.06(0.007)	0.43	< 0.001
Errors			
Error in SES	1.47(0.11)	1.00	< 0.001
Error in Lifestyle	1.12(1.23)	0.99	0.361
Error in CMD	0.02(0.004)	0.81	< 0.001
Error in Occupation	3.73(0.11)	0.83	< 0.001
Error in Household income	0.73(0.10)	0.33	< 0.001
Error in Education	0.97(0.03)	0.73	< 0.001
Error in Physical activity	1.634(1.85)	0.50	0.348
Error in Alcohol intake	0.456(1.78)	0.98	< 0.001
Error in Smoking	0.47(0.01)	1.00	< 0.001
Error in Heart condition	0.07(0.003)	0.79	< 0.001
Error in Diabetes	0.13(0.005)	0.81	< 0.001
Error in Lung Disease	0.12(0.003)	0.93	< 0.001

$\chi^2(24) = 352.43$, p = Significance level; SES = Socioeconomic status; CMD = Cardiometabolic diseases

Table 3 Correlation table for the latent variables

Variable	SES	Lifestyle	CMD
SES	1.00	--	--
Lifestyle	0.08	1.00	--
CMD	0.43	0.14	1.00

SES = Socioeconomic status; CMD = Cardiometabolic diseases

Discussion

This study had 134 participants for every 1 item, with a sample size of 2,820 and 21 variables included. According to the *N: q* ratio rule of thumb, this sample size is sufficient to produce reliable results. Our study shows that physical activity levels present a significant health concern, as a troubling 62.1% of participants admit to being sedentary, outnumbering the 37.9% active. This suggests a potential need for targeted health interventions to

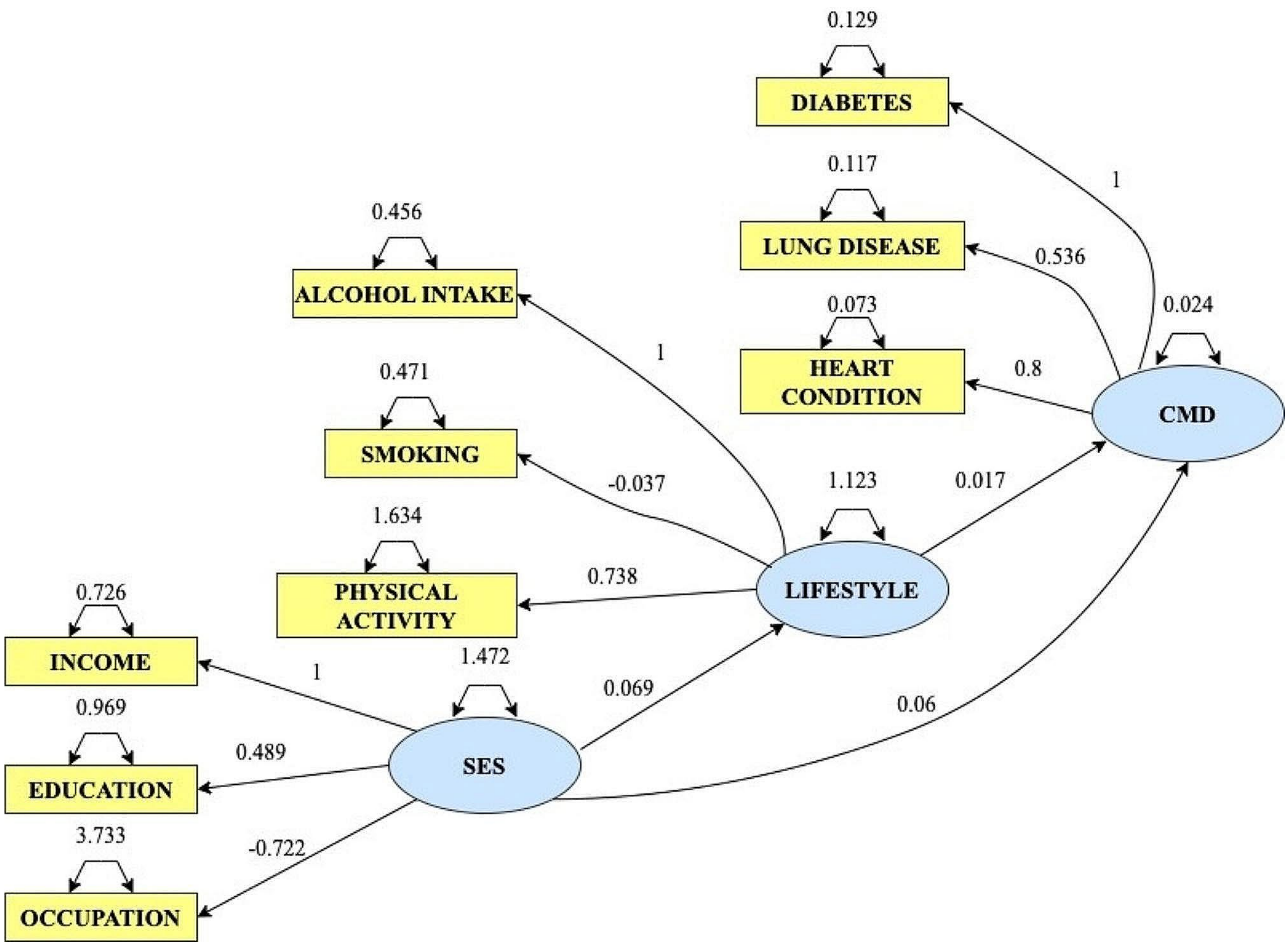

Fig. 1 Structural Equation Model (SEM) depicting the relationships among Socioeconomic Status (SES), Lifestyle, and Cardiometabolic Diseases (CMD)

Table 4 Fit indices for the structural equation model

NFI	TLI	CFI	RMSEA	SRMR
0.78	0.69	0.79	0.07	0.06

NFI = Normed Fit Index; TLI = Tucker-Lewis index; CFI = Comparative Fit Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual

promote physical activity, although research is required to confirm these findings.

Further, this study explored the relationship between socioeconomic status (SES), lifestyle, and cardiometabolic diseases (CMD). Results from the structural equation model (SEM) showed significant associations and gave insights into the mediation effects of lifestyle on the relationship between SES and CMD.

Regarding the mediation results, it was discovered that lifestyle didn't fully mediate the relationship between SES and CMD. Although there was a significant direct effect of SES on CMD, there was no significant indirect effect through lifestyle. This suggests that lifestyle factors may not be the primary mechanism through which SES is associated with CMD risk, as measured in this study. These findings align with previous studies that have reported mixed results regarding the mediation effects of lifestyle between SES and health outcomes [21–23]. However, due to the self-reported nature of the data, these results should be interpreted with caution. The complexity of the relationship between these variables, with lifestyle factors influenced by various social, economic, and cultural factors, makes it challenging to establish a clear mediating role [10, 24]. Additionally, unmeasured variables may contribute to the relationship between SES and CMD, thus attenuating the mediating effect of lifestyle [1, 25].

Hicks et al. (2021) studied the relationship between lifestyle factors, and cardiovascular disease risk [26]. They found that lifestyle factors may partially mediate the association between SES and cardiovascular disease risk, supporting the idea that lifestyle behaviours explain some socioeconomic disparities in health outcomes. In contrast, Liu et al. (2023) conducted a similar study and reported no significant mediating effect of lifestyle on the relationship between SES and health outcomes [27]. These contrasting findings highlight the complexity of the relationship and suggest that other factors beyond lifestyle may also play a role in the socioeconomic disparities in CMD [28–30].

Furthermore, the present study revealed significant associations between SES, lifestyle, and CMD individually. SES was significantly associated with CMD, suggesting that higher SES is associated with an increased risk of CMD, contrary to the common belief that higher SES is generally linked to better health outcomes [19, 31, 32]. However, it aligns with previous studies that reported similar associations between higher SES and increased CMD risk [33]. The prevalence of risk factors such as a sedentary lifestyle and psychosocial stressors among individuals with higher SES may contribute to this association. In our research, we define higher socioeconomic status (SES) as individuals who score higher on the composite measure of SES, which takes into account their educational level, household income, and occupation status. Specifically, people with higher SES typically have higher levels of education, greater household income, and are more likely to have prestigious or stable occupations.

Lifestyle was significantly associated with CMD, suggesting that individuals with unhealthier lifestyles have a higher risk of CMD. This result is consistent with a vast body of literature linking unhealthy behaviours, such as physical inactivity, smoking, and excessive alcohol consumption, with increased risk of CMD [34–37]. Numerous studies have consistently demonstrated the detrimental effects of unhealthy lifestyle factors on cardiovascular health and CMD outcomes [34–37].

The results of this study provide important insights into the associations between lifestyle, SES, and CMD. The findings suggest that while lifestyle factors play a role in CMD risk, they may not fully mediate the relationship between SES and CMD. This suggests that other factors, such as psychosocial stressors, access to healthcare, environmental factors, and genetic predispositions, may contribute to the socioeconomic disparities in CMD [21, 38–40]. Future research should explore these additional factors to understand better the complex associations between SES, lifestyle, and CMD, using more robust methods to mitigate the limitations of self-reported data.

The findings of this study have significant policy implications for addressing cardiometabolic diseases and reducing socioeconomic disparities in health outcomes. The findings of this study emphasize the relevance of public health by highlighting the complex relationship between socioeconomic status (SES), lifestyle factors, and cardiometabolic diseases (CMD). Using a robust structural equation model (SEM) to analyze data from a large, nationally representative sample, our research offers new insights into the associations between SES, CMD, and lifestyle behaviors. These insights are essential for designing specific public health interventions to address the disparities in CMD prevalence associated with SES. Significantly, this study adds to the existing body of research by showing that while lifestyle factors are significantly associated with CMD risk, they do not fully mediate the SES-CMD relationship. This suggests the need for comprehensive strategies that consider multiple health determinants. The novelty of this paper lies in its thorough examination of the role of lifestyle in the SES-CMD link, its focus on the complexity of these relationships, and its implications for creating comprehensive public health policies that address both behavioral and structural health determinants.

Although the mediation analysis did not support lifestyle as the primary mechanism that explains the relationship between SES and CMD, it does not undermine the importance of lifestyle interventions in preventing and managing CMD [41–44]. Public health policies and interventions may consider promoting healthy lifestyles and addressing the risk factors associated with CMD while acknowledging the preliminary nature of these findings due to the reliance on self-reported data. However, it is crucial to recognize that multifaceted factors beyond lifestyle may influence socioeconomic disparities in CMD [24, 45]. Policymakers should consider implementing broader structural interventions to tackle the underlying socioeconomic determinants of health. This could involve improving access to healthcare services, addressing social inequalities, reducing poverty, and providing educational and employment opportunities to individuals from disadvantaged socioeconomic backgrounds [46, 47]. Additionally, efforts should be made to raise awareness about the complex relationship between lifestyle, SES, and CMD among healthcare professionals, policymakers, and the general population. To develop effective and fair strategies for preventing, early detecting, and managing cardiovascular and metabolic diseases, it may be necessary to take a holistic approach that considers the various factors contributing to socioeconomic disparities. However, it is essential to make these suggestions cautiously and support them with further research.

The study has several strengths that contribute to its validity. Firstly, structural equation modelling allowed for a comprehensive analysis of the complex relationships among socioeconomic status, lifestyle, and cardiometabolic diseases. This approach provides a robust statistical framework to evaluate the hypothesized associations, although caution is warranted in interpreting the findings due to reliance on self-reported data. Additionally, the introduction of multiple measures and using validated scales enhance the reliability and validity of the study's findings.

However, it is essential to acknowledge some limitations. Firstly, the study relied on self-report measures, which might introduce response biases and recall errors. Future research could incorporate objective measures, such as clinical assessments and biomarkers, to enhance the accuracy of the data. Secondly, the study's cross-sectional design limits the ability to establish causal relationships among the variables. Longitudinal or interventional studies would provide more robust evidence regarding the directionality of the associations. Lastly, the study was conducted in a specific population, which may limit the generalizability of the findings to other demographics or cultural contexts.

Conclusion

This study explored the link between socioeconomic status, lifestyle, and cardiometabolic diseases (CMD). The results revealed that socioeconomic status significantly predicted CMD, while lifestyle significantly predicted cardiometabolic diseases. However, the mediation analysis failed to produce significant results, indicating that lifestyle did not fully mediate the link between SES and CMD. The study emphasizes addressing socioeconomic disparities and promoting healthy lifestyles to prevent and manage cardiometabolic diseases. Policymakers should prioritise interventions aimed at reducing inequalities and encouraging healthier lifestyles. Although the study has some limitations, its findings contribute to the growing body of knowledge in this field and highlight the need for further research to comprehend the complex relationship between these factors fully.

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Author contributions
L.Z. and J.A.N. conceived the study. J.A.N. and E.L. provided the software and conducted statistical analyses. S.A. and L.Z. assisted with statistical analyses and interpretation of results. A.K.G. prepared the literature review. J.A.N. Y.C. wrote original draft. J.K. and E.L. made critical revisions to the final manuscript. L.Z. supervised the research. All the authors read and approved the final submission of the study.

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Data availability
The datasets generated and analyzed during the current study article are available from the National Cncer Institute website (https://hints.cancer.gov/data/default.aspx).

Declarations

Ethics approval and consent to participate
The study is based on publicly available secondary data obtained from datasets provided by the Health Information National Trends Survey (HINTS). No direct contact was made with the study participants. Therefore, informed consent for the present analysis was not necessary as secondary data analysis does not involve interaction with participants. Ethical approval for the HINTS was obtained through expedited review by the Westat Institutional Review Board and subsequently deemed exempt by the U.S. National Institutes of Health Office of Human Subjects Research Protections. HINTS adheres to established international and local ethical standards and protocols in its surveys. Approval to use the HINTS dataset was granted by the National Cancer Institute. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. They determined that no formal ethical consent was required to conduct research using this data source.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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