THE INFLUENCE OF INCOME ON LIFESTYLES RELATED TO CARDIOVASCULAR HEALTH

Mark David Walker – Michal Valko – Hakan Lane[1]

ABSTRACT: *Changing one's lifestyle is widely promoted as an effective way to reduce cardiovascular disease risk. However, the ability to adopt healthier behaviors is strongly influenced by socioeconomic factors. Data from the European Social Survey were used to examine the relationship between income, lifestyle, and cardiovascular health across Europe. Heart and circulation problems were more prevalent in lower-income deciles. Age was the strongest predictor, while income had a smaller but significant effect. A negative Slope Index of Inequality confirmed that cardiovascular problems were concentrated among lower-income groups. Concentration indices showed that smoking and higher Body Mass Index were more common among poorer groups, whereas exercise and alcohol consumption were concentrated among wealthier groups. Wagstaff decomposition identified income and exercise as key contributors to inequality. Exercise was the strongest protective lifestyle factor (OR=0.798, 95% CI 0.75–0.84), with benefits increasing at higher income levels. These findings indicate that reducing socioeconomic inequality is essential for improving cardiovascular health.*

KEYWORDS: *socioeconomic inequality, cardiovascular disease, income, lifestyle behavior, European Social Survey, health equity*

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INTRODUCTION

Lifestyle modification is widely advocated as being the principal way to improve personal health. This affects a wide variety of conditions including diabetes (Hamman et al. 2006), high blood pressure (Dickinson et al. 2006), and obesity (Galani–Schneider 2007). Engaging in daily exercise, increasing fruit and vegetable consumption, reducing dietary fats, and stopping smoking are all often presented as ways to improve personal health (e.g., Weber et al. 2025).

However, the capacity to initiate and sustain behavior and lifestyle change is not the same for everyone, as income strongly predicts engagement in lifestyle behaviors associated with chronic disease prevention (Blaxter 2003). Higher-income groups tend to follow healthier diets, engage in more leisure-time physical activity, and have lower smoking prevalence, whereas lower-income groups face structural barriers such as food affordability, neighborhood safety, and access to recreational facilities (Darmon–Drewnowski 2008; Pampel et al. 2010). A variety of studies show that socioeconomic status is related to a variety of lifestyles and choices related to health, including the amount of exercise taken (Stalsberg–Pedersen 2010; Leite et al. 2024; Nyberg et al. 2025), diet (Carrasco-Marin et al. 2024), and smoking (Hiscock et al. 2012).

The topic of inequality, in terms of income, education, or general socio-economic status (SES), and its consequent influence on both lifestyle and poor health is of increasing interest to public health professionals and policy makers. Interest in socioeconomic inequality and its influence on health has increased substantially following the influential work of Marmot et al. (2012), which highlighted how structural inequalities shape health outcomes and wellbeing. Their social-determinants theory postulates that behavioral differences arise from broader social and economic constraints rather than from individual motivation alone. Hence, interventions targeting health behavior must also address income-related structural inequities (Marmot et al. 2010). This raises important questions about how structural inequalities and the differences these cause in behavior and lifestyle influence health. There are well-established links between socioeconomic status and a range of physical and mental health conditions (Kivimäki et al. 2020; Barakat–Kostantinidis 2023). Under Marmot's social-determinants framework, income functions as a distal determinant that shapes exposure to behavioral risks, environmental stressors, and healthcare access, thereby amplifying age-related vulnerability (Marmot et al. 2010).

Cardiovascular disease (CVD) is one such condition where the links with lifestyle are well known. Poor diet, lack of exercise, high BMI, smoking and alcohol consumption are all known to increase the risk of CVD (Arnett et al. 2019; Roth et al. 2018). Age is likewise an established biological risk factor for coronary

heart disease (CHD), but socioeconomic status, particularly income, modifies this risk across the life course. Lower-income populations experience significantly higher rates of CHD incidence and mortality, even after adjustment for traditional risk factors, reflecting the combined influence of material deprivation, chronic psycho-social stress, and reduced access to preventive care (Stringhini et al. 2017).

Previous research has often focused either on individual cardiovascular risk factors or on broad socioeconomic gradients in health outcomes. Comparatively less attention has been devoted to examining how income-related inequalities shape lifestyle behaviors associated with cardiovascular disease across European populations using integrated inequality metrics. In addition, many studies analyze lifestyle or socioeconomic variables separately, rather than investigating how lifestyle factors contribute to socioeconomic inequalities in cardiovascular health. The present study contributes to the literature by combining concentration indices, the Slope Index of Inequality (SII), Wagstaff decomposition, and multilevel interaction modeling within a unified analytical framework. This approach enables a more comprehensive understanding not only of whether cardiovascular problems are disproportionately concentrated among lower-income groups, but also of how specific lifestyle behaviors contribute to these inequalities across different European contexts.

The European Social Survey is a biannual survey of households across Europe, providing a unique snapshot of the lives of European citizens, permitting study of issues related to SES and cardiovascular health. The recent 2023/24 Round 11 survey (ESS ERIC 2025) concentrated on health and presents a unique opportunity to examine the relationships between income, socioeconomic status, lifestyle and occurrence of cardiovascular disease. This source is unique in recording not only topics of interest relating to health, but also a wide range of SES indicators and personal lifestyle factors, thus allowing examination of the influence of SES on lifestyle and disease development. Health inequalities across Europe are of increasing concern to the EU (Scholz 2020), and the Joint Action Health Equity Europe (JAHEE) (Bucciardini et al. 2023) and Health 2020 initiatives (WHO 2013) have been established to reduce healthcare inequality.

Although socioeconomic inequalities in cardiovascular health are well documented, previous studies have often focused either on individual cardiovascular risk factors or on broad socioeconomic gradients in health outcomes. Comparatively less attention has been devoted to examining how income-related inequalities shape lifestyle behaviors associated with cardiovascular disease across European populations using integrated inequality metrics. In addition, many studies analyze lifestyle or socioeconomic variables separately, rather than investigating how lifestyle factors contribute to socioeconomic inequalities in cardiovascular health. The present study

contributes to the literature by combining concentration indices, the Slope Index of Inequality, Wagstaff decomposition, and multilevel interaction modeling within a unified analytical framework using harmonized European Social Survey data. This approach enables a more comprehensive understanding not only of whether cardiovascular problems are disproportionately concentrated among lower-income groups, but also of how specific lifestyle behaviors contribute to these inequalities across different European contexts.

For instance, Vaľko et al. (2025) used ESS data to ascertain the relative importance of different broad domains such as education, SES, region, and lifestyles on the prevalence of heart and circulation problems. An obvious next step is to build upon this research by studying the relationship between income and cardiovascular health, as well as the lifestyles identified as important in determining heart health. The specific aims are thus to (1) examine the prevalence of cardiovascular disease among different income groups, (2) study whether differences that are seen in those lifestyles known to be related to cardiovascular disease differ between different income groups, and (3) model the interaction between income and lifestyles on heart health. This study thus extends this initial research by examining in depth how income influences lifestyle and, consequently, the overall effect on circulatory health.

METHOD

Study design and setting

This study employed a cross-sectional, secondary data analysis design using the European Social Survey (ESS) dataset Round 11 v.3.0 to investigate the relationship between relative income and lifestyle behaviors relevant to cardiovascular health. Weighting using the *dweight* and *pweight* variables was used where appropriate to account for country population size and sampling differences.

Participants

The ESS collects detailed information on social, economic, and political conditions. ESS Round 11 data contains data from a total of 46,162 participants aged 15 and older. All statistical procedures were performed using post-

stratification and population weights supplied by ESS (*anweights* variable), thus ensuring nationally representative estimates. All questionnaires, sampling frames, and fieldwork procedures are harmonized. Round 11 contains detailed modules regarding health, lifestyle, social and demographic behaviors, including self-reported cardiovascular conditions.

Variables

Respondents are questioned as to 'Which of the health problems on this card have you had or experienced in the last 12 months?: heart and circulation problems' (hltprhc). This is recorded as not marked (0) or marked (1).

Lifestyle variables were chosen due to their known connection with the development of cardiovascular disease as identified in Val'ko et al. (2025). A BMI variable was derived from height and weight. A brief description of the variables that were used is provided in *Appendix A*.

Participants are questioned as to total household income (hinctnta), with data recorded as the decile position based on each country's total responses. Thus, this measures relative position within each country's income distribution, not absolute wealth.

Statistics

Age-specific heart problem prevalence was compared across age groups and relative income position through production of age-stratified plots. The age-specific prevalence of heart problems was calculated for each country, then pooled across Europe, with the *pweight* and *dweight* variables used to ensure results reflect the actual distribution of people in Europe, not just the distribution of survey respondents.

A generalized regression model, specifically a beta regression model with a logit link, modeling the proportion outcome as a function of age group, income percentile, and country fixed effects, was used to statistically examine the difference in prevalence between age and income groups. Income deciles show relative income within each country and are therefore not comparable across countries, meaning conventional statistical testing between income deciles would not be appropriate. The model was fitted to aggregated data, where each observation represents the weighted mean prevalence within an age group and income decile. Values of 0 and 1 were adjusted to 0.001 and 0.999 to meet beta distribution requirements. Coefficients are reported on the log-odds scale.

The Slope of Inequality Index (SII) provides an absolute measure of the difference in predicted lifestyle outcomes between the lowest and the highest income position (Moreno-Betancur et al. 2015). It is derived from a regression of the health outcome on the relative rank of socioeconomic position. The age-specific prevalence by income quintile is used. Both absolute and relative rates are calculated.

The SII was calculated for each country by estimating the age-specific prevalence of heart problems within each income quintile with survey weights. A weighted regression line was fitted across the income distribution to produce the absolute SII. Country-specific SIIs were then combined using a random-effects meta-analysis in the metafor package. This method estimates a pooled average while allowing for between-country heterogeneity. The relative rate is the absolute SII value divided by the mean rate.

Comparison of lifestyle behaviors for different income groups was studied with an ordinal logistic regression (proportional odds model). As income deciles are country-relative, they were converted into percentiles (0–100), and a country fixed effect was used to account for country differences. For BMI, which is continuous, a linear regression was used.

The Concentration Index captures the extent to which lifestyle behaviors are unequally distributed across the income spectrum (Wagstaff et al. 1991). All respondents were ranked from lowest to highest according to equivalized household income, operationalized as the income decile. These ranks were transformed into a fractional socioeconomic rank:

$$ri = i–0.5/N,$$

where i is the individual's position in the income distribution, and N is the total sample size within the pooled European dataset.

For each outcome (heart and circulatory problems) and each lifestyle variable (BMI, fruit intake, etc.), we computed age-adjusted means using linear regression. The Concentration Index (CI) for each variable was calculated using the covariance formula:

$$ci = \frac{2}{\mu} Cov(yi,ri),$$

where yi is the health or lifestyle outcome for individual i, ri is the individual's fractional income rank, and is the sample mean of the outcome.

The delta method (linearization) was used to estimate the variance and standard error (SE) following O'Donnell et al. (2008). CI values were ascertained per country, then an overall CI across countries was calculated by weighing

each country by its population (*anweights*) to obtain pooled CI values for each lifestyle.

A Wagstaff decomposition (see Wagstaff et al. 2003) was used to break down the Concentration Index and show the contribution of each individual factor to health inequality. This determines the sensitivity of each factor on the outcome. This partitions the contributions of individual determinants, thereby indicating which factors account for observed inequality. It is ascertained with:

$$y = \alpha + \Sigma_k \beta_k x_k + \varepsilon,$$

To assess whether the association between lifestyle behaviors and heart problem prevalence varies by socioeconomic position, generalized linear mixed-effects models (GLMM) (random-effects model) were established. Self-reported heart and circulatory problems were specified as a binary outcome variable. A random intercept for country and income was included to account for heart problems and income differences between countries. Predictor values were z-score standardized prior to modeling.

Models were established in stepwise fashion.

- Model 1: A baseline random intercept model, with a random intercept for country and fixed age and gender variables.
- Model 2: Fixed effects for income and lifestyle were added, providing the average effect of these predictors across Europe, assuming slopes for these are the same everywhere.
- Model 3: Mixed effects model, with random effects for country, assuming the effect of income varies by country.
- Model 4: Interaction terms examining the influence of income with key lifestyle factors being extracted.

The methods used were selected to study not only the level of inequality but also to ascertain and quantify its origin, given the nature of ESS data. The Concentration Index was a useful measure because it quantifies inequality; it is better than using only a simple prevalence rate because it uses the whole income distribution. The Wagstaff decomposition answers a different question, allowing quantification of exactly how much of the observed health inequality is explained by specific lifestyle mediators, thus allowing the identification of specific factors driving inequality, such as exercise or alcohol, rather than simply the direct effect of income itself. Beta and ordinal regressions were utilized due to the nature of the data and its aggregated nature. Nested logistic regressions were used as these are considered the gold standard for social and epidemiological research and allow for the study of the influence that income changes have when lifestyle variables are added.

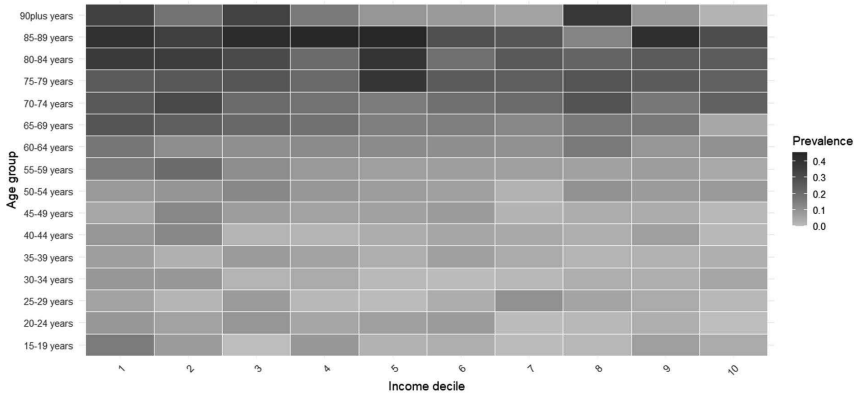
Analyses were performed using R version 4.2.2 (2024). The study used a publicly available dataset; thus, additional ethical approval was not sought.

RESULTS

Age-specific heart problem prevalence at different income deciles

Figure 1 shows a heatmap of the age-specific prevalence of self-reported heart and circulatory problems across income deciles. A clear socioeconomic and age gradient is evident. Across all age groups, individuals in higher income deciles have a lower prevalence of heart and circulatory problems, while prevalence increases markedly with higher age. Exact numerical data are provided in *Online Appendix B.*

Figure 1. *Age-specific prevalence of self-reported heart and circulatory problems for different age ranges and income deciles using ESS data*



Source: Authors' calculations.
Note: Prevalence for each age group and income decile for each country was calculated separately, then overall values were calculated using weighted means to account for country size.

The generalized regression model used to assess whether differences between ages and income were statistically different had coefficients which were consistently positive and increased monotonically across age groups, becoming

statistically significant for the 50 to 54 age group onwards (Table 1). Age emerged as the dominant predictor of heart-related prevalence, rising sharply in older age groups, particularly after the age of 60. Income showed only a weak and borderline-significant negative association, suggesting that higher income is associated with slightly lower prevalence, but the effect is small. Country fixed effects show expected cross-national differences. However, interaction terms indicate little evidence that the income gradient varies across countries. For each one-percentile increase in income rank, the log-odds of heart-risk decrease by about 0.0023. Predictions of the prevalence of heart problems based on this regression are provided (see *Online Appendix C*) and mirror actual data.

Table 1. *Coefficients from a beta regression model with a logit link modeling the proportion outcome as a function of age group, income percentile, and country fixed effects to examine differences in the prevalence of heart disease across different age- and income deciles. Country fixed effects included but not shown*

Predictor	β (SE)	Odds ratio	95% CI	z	p
Intercept	–1.10 (0.05)	0.33	[0.31, 0.37]	–23.54	< 0.001
Age group (ref: 15–19)					
20–24	–0.05 (0.03)	0.95	[0.89, 1.01]	–1.52	0.129
25–29	–0.06 (0.03)	0.94	[0.89, 1.00]	–1.96	0.050
30–34	–0.08 (0.03)	0.93	[0.87, 0.98]	–2.51	0.012
35–39	–0.03 (0.03)	0.97	[0.91, 1.03]	–1.13	0.259
40–44	–0.02 (0.03)	0.98	[0.92, 1.04]	–0.64	0.521
45–49	–0.04 (0.03)	0.96	[0.91, 1.02]	–1.25	0.212
50–54	0.01 (0.03)	1.01	[0.95, 1.07]	0.35	0.730
55–59	0.11 (0.03)	1.12	[1.05, 1.19]	3.58	< 0.001
60–64	0.09 (0.03)	1.09	[1.03, 1.16]	2.90	0.004
65–69	0.30 (0.03)	1.35	[1.27, 1.44]	9.74	< 0.001
70–74	0.31 (0.03)	1.36	[1.28, 1.45]	9.52	< 0.001
75–79	0.32 (0.04)	1.37	[1.27, 1.48]	8.04	< 0.001
80–84	0.50 (0.04)	1.64	[1.52, 1.78]	12.39	< 0.001
85–89	1.15 (0.06)	3.17	[2.83, 3.54]	20.32	< 0.001
90 or above	0.44 (0.10)	1.56	[1.29, 1.89]	4.54	< 0.001
Income percentile	–0.003 (0.00)	0.997	[0.997, 0.998]	–11.62	< 0.001

Source: Authors' calculations.

*Notes: Unstandardized coefficients (b) from beta regression with logit link. † p<0.10, p<0.05, p<0.01, **p<0.001.*

The absolute value for the Slope Index of Inequality was slightly negative at –0.062 (95% CI –0.081 to –0.043), and highly significant. The relative Slope

Index of Inequality was –0.621 (95% CI –0.819 to –0.4241; $p<0.001^{***}$). This suggests that across countries, higher inequality in income is associated with lower heart problem prevalence. Although the pooled inequality estimates were statistically robust, heterogeneity across countries was substantial. Between-country variance was small (absolute: 0.0025 (S.E.=0.0007); relative: 0.284 (S.E.=0.0776)), yet heterogeneity was extremely high (absolute: total heterogeneity/total variability: 99.89%; total variability/sampling variability: 943.47. Relative: total heterogeneity / total variability: 99.88%, total variability/sampling variability: 1046.55), indicating that inequality patterns vary markedly across national contexts. Consequently, pooled SII and RII estimates should be interpreted with caution, and country-specific analyses may provide more meaningful insight.

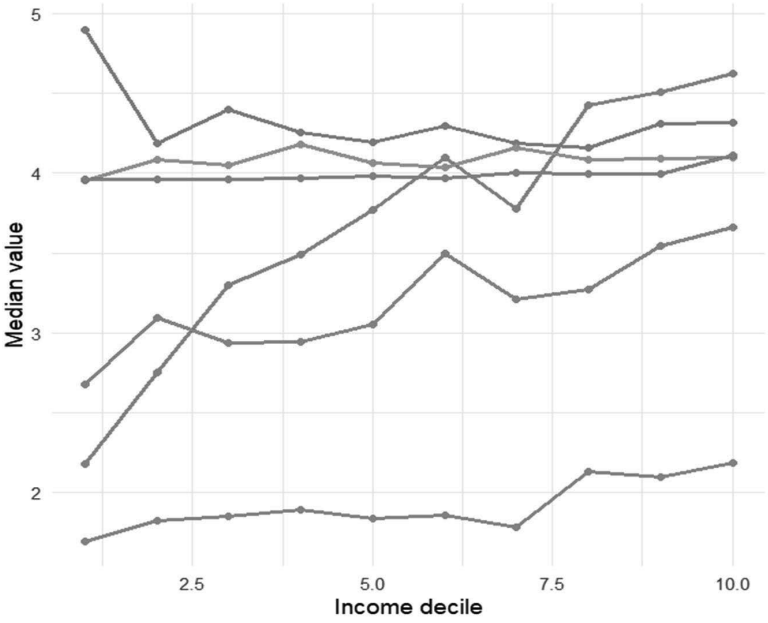
Detailed country-level estimates are reported in *Online Appendix D*. Examination of the Slope Index of Inequality for individual countries revealed significant cross-national differences in the burden of cardiovascular health. Hungary and Germany exhibited the highest absolute inequalities, where heart problems were heavily concentrated among lower-income groups. On the other hand, Sweden had little significant income-based heart health inequality. However, the Relative Index of Inequality (RII) highlights that even in low-prevalence countries, the relative gap between the rich and poor remains substantial, e.g., in Cyprus and Hungary.

It is possible to discern countries with high inequality and where income accounts for large differences in CVD, such as HU, DE, CY, PL, AT, and those with a European-average level where inequality is moderate, such as FI, ES, IS, NL, GB, FR. Further, those where inequality is low, such as SE, BE, BG, IE, where CVD is fairly equally distributed across income groups.

Lifestyles and income

Figure 2 shows the median lifestyle value at each income decile. Individual country values are detailed in *Online Appendix E*.

Figure 2. *Median lifestyles across income deciles, calculated separately for each country*



Source: Authors' calculations.
Note: Key: red – frequent alcohol consumption; brown – binge drinking; green – exercise. light blue – fruit consumption; dark blue – smoking; pink – vegetable consumption.

Table 2. *Results are based on ordinal logistic regression (proportional odds models) for all ordinal lifestyle outcomes and linear regression for BMI, using income percentile and age as predictors and including dummy variables for all 28 countries*

Outcome	Predictor	Odds ratios (ratio of means (RM))	95% CI	z	p-value
Smoking	Income percentile	0.99	[0.98, 0.99]	–5.45	< 0.001
	Age	0.99	[0.99, 0.99]	–5.17	< 0.001
Fruit consumption	Income percentile	1.00	[1.00, 1.01]	4.51	< 0.001
	Age	1.02	[1.01, 1.02]	5.46	< 0.001
Vegetable consumption	Income percentile	1.01	[1.00, 1.01]	5.22	< 0.001
	Age	1.00	[1.00, 1.01]	1.46	0.145
Sport activity	Income percentile	1.00	[1.00, 1.00]	6.55	< 0.001
	Age	0.99	[0.98, 1.00]	–3.2	0.001
Alcohol frequency	Income percentile	1.01	[1.01, 1.01]	12.31	< 0.001
	Age	1.01	[1.01, 1.02]	3.45	< 0.001
Binge drinking	Income percentile	1.00	[1.00, 1.00]	4.03	< 0.001
	Age	0.98	[0.98, 0.99]	–4.94	< 0.001
BMI	Income percentile	1.00	[1.00, 1.00]	–0.24	0.811
	Age	1.05	[1.04, 1.05]	13.2	< 0.001

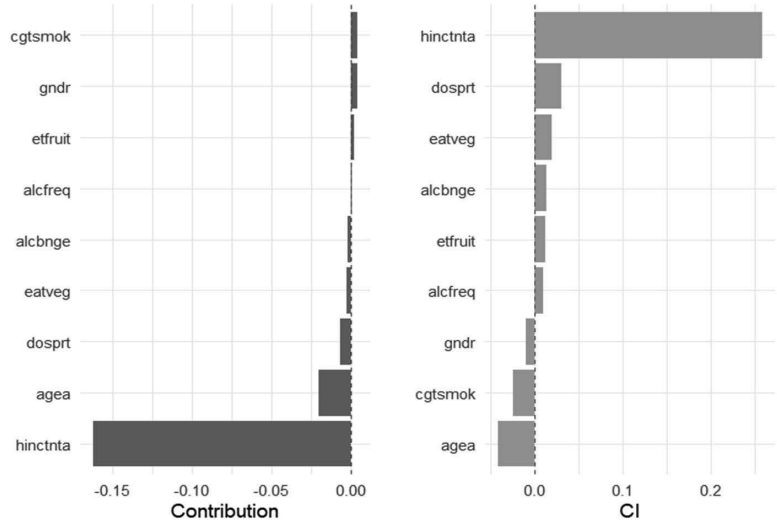
Source: Authors' calculations.
Note: All models include country fixed effects; coefficients are omitted from tables for brevity. Survey-weighted ordinal logistic and linear regression estimates for the associations of income percentile and age with lifestyle outcomes.

Individual country Concentration Index values are available in *Online Appendix D.* Pooled values for the lifestyle variables studied were positive for binge drinking at 0.009 [95% CI 0.027 to 0.016], alcohol frequency 0.051 [95% CI 0.045 to 0.057], exercise 0.032 [95% CI 0.023 to 0.040], eating vegetables 0.015 [95% CI 0.012 to 0.018] and eating fruit 0.009 [95% CI 0.005 to 0.013], and negative for BMI –0.005 [95% CI –0.007 to –0.004] and smoking –0.024 [95% CI –0.028 to –0.020]. Positive values indicate concentration amongst the wealthy, negative values amongst the poorer. All lifestyles were significant ($p<0.05$), apart from vegetable consumption, smoking, and alcohol frequency.

Wagstaff decomposition values were positive for smoking 0.003 [95% CI –0.004 to 0.049], and eating fruit 0.004 [95% CI –0.004 to 0.005]. They were negative for binge drinking [–0.001, 95% CI –0.003 to 0.005], alcohol drinking

frequency [–0.0004, 95% CI –0.009 to 0.005], exercise [–0.007, 95% CI –0.012 to –0.001], and vegetable consumption [–0.002, 95% CI –0.009 to 0.001]. Other notable variables included age [–0.063, 95% CI –0.073 to –0.053], gender [0.004, 95% CI 0.0002 to 0.007], and income [–0.159, 95% CI –0.159 to –0.784].

Figure 3. *Concentration indices and Wagstaff contributions for each lifestyle factor*



Source: Authors' calculations.
Note: The concentration index shows inequality in the distribution of a health variable relative to socioeconomic status. Wagstaff decomposes the overall Concentration Index of Health (hltprhc) into contributions from explanatory variables (age, gender, smoking, diet, etc.). Wagstaff decomposition was performed for each country using bootstrapping, allowing the means, standard errors, confidence intervals, and p-values to be calculated. Country estimates were combined using weighted means provided by the survey. See variable names in Table A1 of the Appendix.

Interaction of income and lifestyles on heart problems

Table 3. *Odds ratios for a multilevel logistic regression model with random intercepts and income slopes by country to estimate the association between income and heart problems*

Predictor	Odds ratios [95% CI]
(Intercept)	0.10 [0.09, 0.12]
Income (z)*	0.84 [0.76, 0.93]
Fruit (z)	1.04 [0.97, 1.12]
Vegetables (z)	0.95 [0.88, 1.02]
Sport (z)*	0.87 [0.81, 0.92]
Smoking (z)	1.03 [0.96, 1.10]
Alcohol frequency (z)	0.95 [0.89, 1.02]
BMI (z)*	1.19 [1.12, 1.27]
Gender (Female)*	0.79 [0.69, 0.90]
Age (z)*	2.51 [2.32, 2.73]
Binge drinking (z)	1.00 [0.93, 1.08]
Interactions	
Income × Fruit	1.00 [0.93, 1.09]
Income × Vegetables	1.03 [0.95, 1.12]
Income × Sport	1.01 [0.94, 1.09]
Income × Smoking*	0.92 [0.86, 0.99]
Income × Alcohol frequency	0.98 [0.91, 1.06]
Income × BMI	1.05 [0.98, 1.12]
Income × Gender (Female)	0.90 [0.78, 1.04]
Income × Age	1.06 [0.97, 1.16]
Income × Binge drinking	0.99 [0.92, 1.07]

Source: Authors' calculations.
*Note: *Significant predictors: age, gender, smoking.*

DISCUSSION

Data from a European social sciences dataset were used to study the influence of income on the prevalence of heart and circulation problems, and on the lifestyles known to influence heart disease.

There was a higher prevalence of heart and circulation problems at lower incomes, even accounting for age. This shows that socioeconomic inequalities in cardiovascular health exist, even after accounting for age-related disease prevalence. The SII, which measures inequality in health and income, confirmed that prevalence is higher for lower- than for higher-income groups.

Across countries, SII was consistently negative, indicating higher heart problem prevalence among lower-income groups. Levels of inequality differed between countries, suggesting that national-level factors are influential. For comparison, Lu et al. (2024) found a higher cross-country SII value (–1.59), associated with hypertension and heart disease. However, these results were on a global scale.

A study of lifestyles found distinct income effects, with clear socioeconomic patterning. In particular, exercise participation was more common among wealthier groups, showing that opportunities for preventive health behaviors are socially stratified. Wagstaff decomposition found that exercise participation, alcohol consumption, binge drinking, and fruit and vegetable consumption are higher at wealthier deciles, while smoking is lower. Thus, while income contributes to differences in lifestyle behaviors, other structural and individual-level factors, such as access to recreational infrastructure, the social environment, and personal preferences, also influence participation in health-related activities.

Modeling found a clear and significant association between income and exercise, and between income and alcohol consumption, but no notable or significant interaction between income and diet, smoking, or alcohol consumption. That lack of interaction between income and diet, smoking, or alcohol consumption suggests that monetary constraints do not hinder the pursuance of a healthy diet. However, the interaction with exercise clearly illustrates the influence income can have on the pursuance of healthy lifestyles. In the European context, time rather than money is a constraint on living a healthy lifestyle. There is good evidence that those in lower income groups do not have the leisure time to pursue exercise (Withall et al. 2011). Lower socioeconomic groups may experience greater time scarcity due to irregular work schedules, multiple jobs, caregiving responsibilities, or occupational exhaustion, which thus limits both the time and energy available for exercise participation. Higher incomes enable greater access to recreational exercise. Higher income groups are engaged in more sedentary work, thus more likely to seek exercise in leisure time. This interpretation aligns with contemporary perspectives on health inequality that emphasize the interaction between material conditions, psychosocial stress, and structural opportunity constraints (Straker et al. 2021).

The negative SII and RII confirm a social gradient: with each increase in income, heart health improves, and Wagstaff decomposition helps show how behavior turns into disease and why income is a gatekeeper to health. Exercise and good diet are concentrated in wealthier deciles, showing that income is a constraint to a healthy lifestyle. While exercise is protective for all, its efficacy in reducing cardiovascular risk appears greater for those with higher incomes.

The principal risk factors are well known (e.g., Roth et al. 2018), and public health professionals advocate an all-round healthy lifestyle featuring low alcohol intake, no smoking, a varied low-fat and sugar diet, and regular exercise. Socioeconomic status, expressed through income, determines access to resources to mitigate risks (Link–Phelan 1995).

Recent studies confirm the importance of exercise, including the outcomes presented by Nyberg et al. (2025). Pereira Silva et al. (2025) examined six risk factors for CVD and found income disparities related to diabetes, high blood pressure, and sedentary lifestyle. Diez-Roux et al. (2020) examined inequality and CVD mortality and four risk factors, finding connections between Body Mass Index, a history of hypertension and sedentarism, but not smoking.

Many theories that account for health inequalities emphasize the economic determinants of health, the core principle being that individual socio-economic status influences health, for example through the ability to purchase healthy foodstuffs (Link–Phelan 1995). Wagstaff decomposition shows better diets for the wealthier but also the opposite influence of increased alcohol consumption and smoking. Exercise was found to be of importance across inequality measures, which suggests that those of lower income may be limited in their ability to engage in exercise. The less affluent may lack ability, access, knowledge, or willpower to engage in healthy activities (Cockerham 2005).

The results are therefore more in accord with Marmot's social determinants of health theory, which sees health status as a reflection of individual living conditions, and thus directly influenced by underlying social status. *The Marmot Review* (Marmot et al. 2010) suggests that tackling the root causes of social inequality is key to improving general population health, while Krieger's eco-social theory suggests that individual social conditions are embodied in lifestyle and health choices (Krieger 2001).

Today, theories of health inequality increasingly emphasize both the psychological and social factors influencing health. While psychological aspects were not examined here, the range of questions available in the ESS data may facilitate such an analysis. Is there a place for 'culture' within these narratives? Features considered cultural may, in fact, reflect underlying social and economic determinants. For example, dietary preferences might be related to economic factors. Krieger (2001) views culture as an important aspect of the embodiment process, with societal differences shaping personal health decisions. Relatedly, societal norms can influence individual health behaviors. Behaviors often regarded as culturally chosen preferences may, in reality, reflect underlying socioeconomic pressures, as suggested by Bourdieu (1984). The ESS data allow for cross-national comparisons, which, if social norms or cultures are considered as nationally determined, may enable future analyses in this area.

Limitations and strengths

Interest in the influence of SES and inequality is growing. Previous research has concentrated on identifying factors associated with heart disease, rather than trying to elucidate underlying reasons. A strength of this research is thus that it concentrates on the influence of income.

ESS data, being a social science-derived dataset, includes variables that are not typically collected in more medically oriented surveys. This may reduce the social desirability bias associated with clinically focused surveys, with respondents reporting health behaviors and experiences more openly. Consequently, the dataset may better capture the social context of cardiovascular health and everyday lived experiences. Given that much cardiovascular research is predominantly biomedical, the use of a social science dataset provides an important complementary perspective and illustrates the close interrelationship between social and medical determinants of health.

As with all research based upon survey data, there are notable limitations. First, the measurement of socioeconomic status that was used is not an absolute value of individual income; the survey utilizes income deciles relative to the national population. This complicates direct cross-national comparisons where the purchasing power of a specific decile varies significantly.

Self-reported health data have the potential to be affected by recall or social desirability bias. Participants may under-report certain lifestyle behaviors, such as alcohol consumption, or be unaware of undiagnosed cardiovascular conditions. This could lead to underestimation of true disease prevalence. The cross-sectional design captures data at a single timepoint, which means that cardiovascular health changes cannot be studied over the long term.

Although associations between income, exercise, and heart health were identified, we cannot definitely determine whether lower income is implicated in the development of cardiovascular issues. Future longitudinal research is required to comprehensively establish this causal pathway.

Income is a fundamental cause of health inequality because it provides access to an array of resources, including knowledge, exercise, and a good diet, that enable the avoidance of risks and the adoption of protective activities such as sport. This helps explain why health gaps persist even as general public health education improves.

In countries with high SII values such as Hungary and Germany, the high national prevalence of heart problems is driven specifically by those in the lowest income deciles. This implies that national improvements in health cannot be achieved at a general population-wide level, but require targeted action to close the gap between the rich and poor.

Implications for practice

This research has clear public health and policy implications. There is growing recognition of the importance of inequality, and of how it influences health, especially for cardiovascular disease. Sørensen and Kristensen (2023) highlight the need for further research. There is growing awareness that measures to mitigate inequality are required across socioeconomic domains. This is exemplified by the EU 'Health in all Policies' initiative, which aims to tackle inequality across government departments leading to population health improvements.

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APPENDIX

Table A1. Variables names and explanation.

Name	Description	Scale/Coding
age	Age of respondent	Calculated
alcbnge	This card shows six different examples of how much alcohol a person might drink on a single occasion. In the last 12 months, how often have you drunk this amount of alcohol or more on a single occasion?	1, Daily/almost daily. 2, weekly. 3, monthly. 4 less than monthly. 5, never.
alcfreq	In the last 12 months, that is since [MONTH, YEAR], how often have you had a drink containing alcohol?	1, Every day. 2, Several times a week. 3, Once a week. 4, 2-3 times a month. 5, Once a month. 6, Less than once a month. 7, never.
cgtsmok	Now thinking about smoking cigarettes. Which of the descriptions on this card best describes your smoking behavior?	1, I smoke daily, 10 or more cigarettes. 2, I smoke daily, 9 or fewer cigarettes. 3, I smoke but not every day. 4, I don't smoke now but I used to. 5, I have only smoked a few times. 6, I have never smoked
dosprt	On how many of the last 7 days did you walk quickly, do sports or other physical activity for 30 minutes or longer?	Scale, 1 to 7.
eatveg	how often eat vegetables and salad, excluding potatoes.	1, three times or more per day. 2, twice per day. 3, once per day. 4, Less than once a day but at least 4 times a week. 5, Less than 4 times a week but at least once a week. 6, Less than once a week. 7, never.
etfruit	how often eat fruit? Excluding fruit juices.	1, three times per day. 2, twice per day. 3, once per day. 4, Less than once a day but at least 4 times a week. 5, Less than 4 times a week but at least once a week. 6, less than once per week. 7, Never.
gender	Gender	Male, 1. Female, 2. No Answer, 9.
hincnta	Income	Decile 1-10.
hltprhc	Heart and circulation problems experienced in the last 12 months	0 not marked/1 marked (binary)

Source: own elaboration