Public Health 248 (2025) 105978

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

# The burden of inequity: Income related disparities in cardiovascular risk factors in Europe

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ARTICLE INFO

*Keywords:*
Health inequities
Socioeconomic disparities in health
Cardiovascular diseases
Public health

ABSTRACT

*Objectives:* To assess intercountry differences in social inequities related to cardiovascular risk factors across European countries in 2020.

*Study design:* Observational, cross-sectional study.

*Methods:* We analyzed data from the European Health Interview Survey (EHIS 3) (2018–2020) across 31 European countries. Focusing on adults over 40, with a sample of 248,420 participants. Socioeconomic position was assessed by net equivalised monthly income, analyzing six cardiovascular risk factors: dyslipidemia, diabetes, high blood pressure, obesity, smoking, and sedentary lifestyle. Descriptive analyses, prevalence estimation along with Poisson regression models and relative inequity indexes (RII) for quantification of health inequity among groups were calculated, considering survey weights.

*Results:* Significant geographical heterogeneity in prevalence and inequity indexes of all cardiovascular risk factors throughout Europe were found. Income presents a linear dose-response relationship with the prevalence of these factors (maximum for Diabetes, High blood pressure and Sedentary lifestyle), revealing some positive and inverse inequities (deviating from expected social gradient). Maximum gender disparity was found for Diabetes in women (RII = 2.265 [95 % CI]: 2.427–2.838) versus Men (RII = 1.785 [95 % CI]: 1.653–1.928) and inverse inequity (RII<1) for smoking habits in Bulgaria, Lithuania, Portugal and Romania.

*Conclusions:* This study highlighted significant income-related inequities in cardiovascular risk factors, with lower-income individuals exhibiting higher prevalence of dyslipidemia, diabetes, high blood pressure, obesity, smoking, and sedentary lifestyle. Country-specific variations were noted, with some countries experiencing a greater inequity, while others showed less pronounced inequity or even inverse inequalities. These findings highlight the need for equity-oriented healthcare services to reduce cardiovascular disease burden and address significant socioeconomic disparities.

## 1. Introduction

Cardiovascular disease (CVD) is the leading cause of mortality worldwide and also a major contributor to years of life lost and years lived with disability.[1–3] This heavy burden on health will remain in the future unless powerful action is taken on prevention of CVD.[4] The major determinants of cardiovascular disease are a complex interplay of genetic, environmental, social and lifestyle factors.[5]

Social determinants of health (SDoH) have a major role on individual and collective health, being the circumstances on which people are born,

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https://doi.org/10.1016/j.puhe.2025.105978
Received 18 April 2025; Received in revised form 11 July 2025; Accepted 19 September 2025

grow, live, work and age.[6,7] Therefore, SDoH contributes significantly to mortality, morbidity and inequity.[8,9] Among the well-studied SDoH are factors such as gender, age, ethnicity, income, education, access to health services, and social support, among others.[10]

The phenomenon of health inequity revolves around three core concepts: it is socially produced (and thus modifiable), systematic, and inherently unfair.[6,11] Many of the SDoH related to inequity exhibit a direct correlation between socioeconomic status (SES) and health outcomes.[10,12] These SDoH implicated in SES interact in a complex manner, collectively shaping health status. A discernible gradient emerges, where health status improves with the ascent of social position.

Racial and ethnic disparities in cardiovascular disease (CVD) are profound, with some groups of the population experiencing higher CVD risk and poorer outcomes due to social disadvantages and structural racism.[13] Discrimination and social isolation are also significant contributors to these disparities.[2] Gender, distinct from sex assigned at birth, also influences CVD risk through social roles, behaviors, and stressors. Gender-related stress, such as trauma and financial stress, impacts cardiovascular health.[14]

Mortality statistics in Europe have witnessed a significant overall decrease in the past decades, although this decline has not been uniform across different social groups.[15] For instance, in Italy, researchers have identified a less pronounced decrease in mortality among individuals with lower education and residing in poorer housing conditions.[9] Morbidity, a crucial factor in predicting the quality of life and disability-free life expectancy, has been explored in Finland, where lower levels of education are associated with a reduced number of years of disability-free life, particularly when compared to women with higher levels of education.[16,17]

Addressing disparities and diminishing the social gradient is anticipated to result in a reduction in both morbidity and mortality.[4,6] As previously studied by J.P. Mackenbach, the magnitude of inequalities might be reduced by improving educational opportunities, income distribution, health related behaviour or access to healthcare.[12]

This study aims to estimate the prevalence of six cardiovascular risk factors and to assess cross-sectional and intercountry differences in social inequities in cardiovascular risk factors among European countries in 2020. By comparing how these inequities vary from one country to another, we seek to uncover the social, economic, and cultural factors driving these differences. Ultimately, our analysis could highlight specific areas for targeted intervention to reduce cardiovascular disparities throughout Europe.

## 2. Methods

### 2.1. Study design

An observational, descriptive, cross sectional study. This study used a representative country-level dataset obtained from the third wave of the European Health Interview Survey (EHIS 3), conducted across all European Union (EU) countries between 2018 and 2020, predating the COVID-19 pandemic. Prior to authorization from EUROSTAT, all data underwent thorough compilation and processing to ensure the masking of any private and sensitive information. United Kingdom (UK) Data Service also provided data for this EHIS wave after authorization of the research project.

Conducted through individual interviews, EHIS 3 gathers comprehensive data on demographic statistics and health-related information for the EU population. The collected variables encompass Social Determinants of Health (SDH), including socioeconomic status, lifestyles, health habits, and health system utilisation. Additional information about the sampling strategy and details of EHIS are publicly accessible online.[18]

### 2.2. Study population

This was a cross-sectional study using data collected as part of the survey conducted by the European Commission with the support of Eurostat (EuropeanHealth Interview Survey: EHIS wave 3). It included 31 European countries (n: 433,437). The survey included a national representative population probability sample from each participant country in 2019. Questionnaires were administered face-to-face, by telephone or self-administered and sent by mail or internet. The detailed description of each variable, the handling of missing data by Eurostat, and the type of response possible for each question can be consulted in the survey manual, which has been published.[18] In this study, the selected population included adults above 40 years old considering SCORE2[19] and SCORE2-OP[20] Guidelines of European Society of Cardiology on cardiovascular risk assessment. Participants belonged to EU members plus Iceland, Norway and the United.

Kingdom. Country of residence gathers data of participants from the following Europeans countries: Belgium, Bulgaria, Cyprus, Czech Republic, Germany, Denmark, Estonia, Greece, Spain, Finland, France, Croatia, Hungary, Ireland, Iceland, Italy, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Sweden, Slovenia, Slovakia and United Kingdom. This study is reported as per the strengthening the Reporting of Observational Routinely collected health Data (RECORD) Statement[21] (see Supplementary file 1 RECORD Checklist) and following Sex and Gender Equity in Research (SAGER) Guidelines.[22] Final analytic sample was of 248,420 participants.

### 2.3. Variables

As the main measure of socioeconomic position, we used the net equivalised income of the month for each country, which refers to the total income of a household after taxes and social contributions, adjusted for household size and composition. After an equalisation process, income based on the number of adults and children in the household accounts for differences among household members, allowing comparability across different national contexts. The mathematical formula for equivalised income gathers total house income, tax and social deductions and equivalent size considering that additional adults require more resources than children. After statistical treatment, monthly net monthly equivalised income data is coded in quintile form, in such a way that lower than Quintile 1 represents participants with lowest incomes and between fourth and fifth quintiles represents participants with higher incomes. Additional information about methodology and variable construction of EHIS are publicly accessible online.[18]

### 2.4. Outcomes

We used data on six cardiovascular risk factors: dyslipidemia, diabetes mellitus, high blood pressure, obesity, smoking and sedentary lifestyle. Dyslipidemia, diabetes, high blood pressure and smoking were identified via self-reported diagnosis based on EHIS 3 questionnaire items. Obesity was defined using calculated BMI from self-reported weight and height, and sedentary lifestyle was based on the absence of reported physical activity in the past week. Obesity was obtained by calculating body mass index from participants provided data on weight and height. Sedentary lifestyle was defined by absence of physical activity (sports, fitness or recreational physical activities that cause at least a small increase in breathing or heart rate for at least 10 min) on a weekly basis.

### 2.5. Covariates

Self-reported data on age, gender and country of residence. Age was reclassified into 4 categories with 15-years intervals. Starting at ages from 40 to 54 years old as first category and with final category as older than 75 years old. Gender was reflected on the identifying sex of the participant.

### 2.6. Statistical analyses

Firstly, we performed a descriptive analysis of sociodemographic variables and cardiovascular risk factors by calculating survey weighted means and proportions of continuous and categorical variables, respectively, men/women/total. T-test for continuous variables and chi squared test for categorical variables was performed taking into account survey weights. We estimated survey weighted prevalence and confidence intervals of six cardiovascular factors (Dyslipidemia, Diabetes, High blood pressure, Obesity, Smoking and Sedentary lifestyle) and additional descriptive variables like diagnosis of established cardiovascular disease, good self-perceived health and diagnosis of depression by all the European countries gathered on EHIS 3 microdata.

Secondly, we calculated the relative index of Inequality (RII)[23] by estimating prevalence ratios of each cardiovascular risk factor across income quintiles using survey-weighted Poisson regression models with robust standard errors. We used a log-linear dose–response specification, treating income as an ordinal variable. All RII models were stratified by gender to explore sex-specific patterns. To account for the complex survey design and the clustering of individuals within countries, we adjusted the estimation of standard errors accordingly. Country was not included as an explicit covariate in the models. We considered net equivalised income of the month as an ordinal variable in which analysis revealed a log-linear dose response between the previous six previous cardiovascular risk factors and income level. RII above one indicates a tangible inequity from lower to higher grade (RII >2 indicating that lowest socioeconomic group bears more than twice the risk of the adverse outcome compared with the highest), and RII below one indicates an inverse gradient inequity (which deviate from social gradient and higher income groups exhibit higher prevalence of risk factors). STATA 18 was used to perform all microdata analysis, table and figure construction of the final model results. Also, for visual representation of obtained data geographical maps regarding RII were constructed on Microsoft Excel.

## 3. Results

A total of 248,420 inquired adults aged 40 years old or more of which 54.4 % were women and 45.6 % were men. The majority of the participants were aged between 40 and 54 years old (40.7 %) and there were more senior women than men, aged 75 or more years old (16.6 % and 12.6 %, respectively). Net monthly equivalised income of the household was unevenly distributed by sex, approximately 20 % women participants having the lowest group income when compared to 17 % of men and higher proportion of men in the highest income group (23 % compared to 19 % of women). About 7 % of participants had at least one diagnosed cardiovascular disease (myocardial infarction and/or angina pectoris and/or ischemic heart disease and/or stroke). Sociodemographic characteristics of the participants are summarized on Table 1.

Fig. 1 illustrates a linear dose-response relationship between the prevalence of cardiovascular risk factors and income quintiles, highlighting gender disparities (see Table 2). The prevalence remains higher at lower income levels and tends to decrease as income levels rise. Supplementary Table 1 shows the adjusted distribution of the previous cardiovascular risk factors by each European country.

RII was statistically significant for all cardiovascular risk factors, highest for diabetes (RII = 2.088; 95 % confidence interval [95 % CI]: 1.977–2.206) and lowest for dyslipidemia (RII = 1.285; 95 % CI: 1.236–1.335). Additionally, significant intra class gender inequity was found, revealing significant gender disparities within the same socioeconomic groups across all cardiovascular risk factors ($p < 0.001$). Women endure higher levels of inequity compared to men for all cardiovascular risk factors, with the notable exceptions of smoking and sedentary lifestyle.

**Table 1**
Weighted characteristics of selected participants from European Health Inquiry 3 (N = 248,420).

| | Sex of respondent | | |
|---|---|---|---|
| | Total | Male | Female |
| N | 248,420 (100.0 %) | 113,221 (45.6 %) | 135,199 (54.4 %) |
| Age | | | |
| 40–54 | (40.7 %) | (42.6 %) | (39.1 %) |
| 55–64 | (24.8 %) | (25.4 %) | (24.2 %) |
| 65–75 | (19.8 %) | (19.4 %) | (20.1 %) |
| >75 | (14.7 %) | (12.6 %) | (16.6 %) |
| Net monthly equivalised income of the household | | | |
| Below 1st quintile | (17.3 %) | (15.7 %) | (18.8 %) |
| Between 1st and 2nd quintile | (20.1 %) | (18.6 %) | (21.5 %) |
| Between 2nd and 3rd quintile | (20.1 %) | (20.4 %) | (19.8 %) |
| Between 3rd and 4th quintile | (21.0 %) | (21.9 %) | (20.2 %) |
| Between 4th and 5th quintile | (21.4 %) | (23.4 %) | (19.7 %) |
| Dyslipidemia | (19.3 %) | (19.2 %) | (19.4 %) |
| Diabetes | (10.6 %) | (11.7 %) | (9.6 %) |
| High blood pressure | (31.1 %) | (30.4 %) | (31.7 %) |
| Body mass index | | | |
| Underweight | (3.2 %) | (2.6 %) | (3.6 %) |
| Normal | (36.9 %) | (30.8 %) | (42.4 %) |
| Overweight | (37.8 %) | (44.8 %) | (31.6 %) |
| Obese | (22.1 %) | (21.8 %) | (22.4 %) |
| Smoking | (20.8 %) | (24.9 %) | (17.1 %) |
| Sedentary lifestyle | (56.5 %) | (55.6 %) | (57.3 %) |
| Cardiovascular disease | (7.7 %) | (8.6 %) | (6.8 %) |
| Good self-perceived health | (60.4 %) | (62.9 %) | (58.2 %) |
| Depression | (8.8 %) | (6.7 %) | (10.6 %) |

Fig. 2 displays geographical representation of RII coefficients for each studied country. Supplementary Fig. 1 displays RII coefficients along with respective confidence intervals, for each European country. Wider health inequity deviates from value one in which higher RII means that is a significant difference of prevalence of cardiovascular risk factors amongst social class (income level), whereas near one value of RII indicates less health inequity and below one inverted social gradient. Regional heterogeneity was observed on all analyzed variables. For dyslipidemia, Ireland had the highest inequity (RII = 3.147; 95 % CI: 2.075–4.771) followed by the United Kingdom (RII = 2.658; 95 % CI: 2.318–3.049). Ireland also displays highest inequities for diabetes (RII = 5.831; 95 % CI: 3.144–10.814). Estonia, Ireland, Lithuania, Malta and the United Kingdom revealed major high blood pressure inequity values (RII>2). Highest inequity on obesity was found in the Netherlands (RII = 2.262; 95 % CI: 1.919–2.666) whereas Slovakia had the lowest RII on obesity. (RII = 0.967; 95 % CI: 0.825–1.133). Regarding unhealthy habits (smoking and sedentary lifestyle), smoking displayed an inverted social gradient in Bulgaria, Lithuania, Portugal and Romania. Highest smoking inequity was found in the Netherlands and the United Kingdom (RII = 3.977; 95 % CI: 3.387–4.671 and RII = 3.145; 95 % CI: 2.571–3.848 respectively). Regarding sedentary lifestyle, higher inequity (RII>2) was found in Austria, Germany, Ireland, Iceland, Luxembourg, Norway, Sweden and the United Kingdom.

## 4. Discussion

We identified significant inequities on cardiovascular risk factors by income level across 31 european countries: individuals with less income present higher prevalence of dyslipidemia, diabetes, high blood pressure, obesity, smoking and sedentary lifestyle. Moreover, we found heterogeneity on inequity analysis by country with some countries presenting wider or even inverse inequality in cardiovascular risk

**Table 2**
Relative Index of Inequity (RII) by sex. Associations between increasing income level and cardiovascular risk factors survey weighted prevalence. All p-values are statistically significant (p-value <0.001).

| | Total | | Men | | Women | |
|---|---|---|---|---|---|---|
| | RII | CI 95 % | RII | CI 95 % | RII | CI 95 % |
| Dyslipidemia | 1.285 | 1.236–1.335 | 1.154 | 1.088–1.224 | 1.414 | 1.342–1.489 |
| Diabetes | 2.088 | 1.977–2.206 | 1.785 | 1.653–1.928 | 2.625 | 2.427–2.838 |
| High blood pressure | 1.503 | 1.462–1.545 | 1.263 | 1.211–1.317 | 1.742 | 1.679–1.808 |
| Obesity | 1.439 | 1.386–1.493 | 1.254 | 1.186–1.325 | 1.622 | 1.542–1.707 |
| Smoking | 1.426 | 1.371–1.483 | 1.643 | 1.562–1.729 | 1.290 | 1.215–1.370 |
| Sedentary lifestyle | 1.547 | 1.522–1.573 | 1.548 | 1.510–1.587 | 1.544 | 1.510–1.579 |

factors than others (e.g. higher prevalence of dyslipidemia and diabetes in women with lower income or inverse inequity in smoking habits in Bulgaria and Portugal).

This study offers a comprehensive examination of cardiovascular health inequities across Europe. Covering multiple populations, it allows for an appreciation of how these inequities develop. While previous research has highlighted social inequities between European countries,[12–15,24] few have specifically focused on cardiovascular health.[25]

Our findings pair up with previous studies from Timmiis et al.[26] on Cardiovascular Disease Statistics, showing similar trends in the prevalence of major cardiovascular risk factors. We found strong inequities on all the analyzed cardiovascular risk factors and its prevalence amongst different income levels. Throughout Europe people with lower income have higher prevalence of dyslipidemia, diabetes mellitus, high blood pressure, obesity, smoking habits and sedentary lifestyles. Declining trends in prevalence of socially favoured groups reflect favourable health related behaviours and also healthcare effectiveness and access. These findings also align with previous mortality and inequity studies from Mackenbach et al.[12,15,24,25]

Gender remains a very important factor on health inequity,[14,27–29] we found that cardiovascular inequity is stronger in women when compared to men with the exception of smoking habits and sedentary lifestyle. This suggests the importance of integrating an intersectional approach to uncover the relationship between different axes of inequality, such as gender and economic status.[30]

Also, despite its decreasing tendency over the last decades, men smoke more than women.[31] It is also important to emphasize on sedentary lifestyle, as it was the only analyzed factor that we did not find significant gender differences. Perhaps both men and women face similar leisure-time constraints as dual-earner households become the norm nowadays and cultural norms around work and productivity discourage active use of free time regardless of gender.[32] Time-use studies in gender and health behaviour theory (Guthold et al., 2018)[33] reveal that women's physical activity increasingly occurs through unpaid domestic and caregiving tasks, whereas men's sedentary time has climbed with the spread of office-based, screen-intensive jobs.

As displayed on Fig. 1, overall country prevalence of high blood pressure and obesity decreases with higher income among women. In contrast, men exhibit less variability in these cardiovascular risk factors across lower income quintiles (Q1-Q3), suggesting that income and its influence on lifestyle behaviours have a less significant impact on their prevalence when compared to women.

Additionally, our findings uncovered substantial heterogeneity in cardiovascular inequity across European countries, as depicted in Fig. 2 and Supplementary Fig. 1. For instance, the United Kingdom and Ireland exhibit the highest RII for high blood pressure, whereas Finland, Spain, and Italy show the lowest RII. Regarding High blood pressure in European countries, Regidor et al.,[34] found higher prevalence of the previous cardiovascular risk factor in subjects of disadvantaged social class. Cultural lifestyle patterns, such as daily diet, fat and protein intake, and regular exercise or access to healthy surroundings, play a significant role in influencing dyslipidemia, diabetes, high blood pressure, and obesity. These factors should be considered when analyzing the results.

Dyslipidemia is a major target of primary prevention of cardiovascular disease as its linear dose response of cardiovascular events is well known.[26] Notably, not all RII tend to be lower in southern-mediterranean countries as expected.[25] RII for dyslipidemia, diabetes and high blood pressure tend to 1 in southern countries such as Spain, Italy and Greece but not in Portugal, Malta or Cyprus. These changes may be significantly linked to income inequality and its consequences, as recent data indicates that these countries had lower gross incomes in 2020, suggesting that income inequality plays a crucial role in the variations of RII for dyslipidemia, diabetes, and high blood pressure. Southern European nations are gradually straying from the time-honored Mediterranean diet in favor of less nutritious alternatives. This profound shift is driven by the interplay of modern lifestyle transformations, the widespread influence of global food markets, economic pressures, and evolving socio-cultural values.[35,36]

Of all the analyzed factors, least country heterogeneity was found on obesity inequities, which could reflect the growing complexity of obesity as a global issue and the widespread shifts in dietary habits (food availability and affordability, trends in unhealthy foods) and lifestyles across different countries.[37] Nonetheless, the pattern of sedentary lifestyles varies significantly across Europe, as illustrated in Fig. 2. Inequities in this unhealthy behavior are most pronounced in Slovakia, Austria, and Hungary, while the lowest RII is observed in Portugal. This disparity may reflect cultural attitudes towards regular physical activity and access to health-promoting environments that persist across social classes. For instance, the prevalence of sedentary lifestyles in Portugal is among the highest in Europe (72.6 %; 95 % CI: 71.3–74.0), in contrast to Northern countries like Norway (15.1 %; 95 % CI: 14.0–16.3). While Northern European countries generally perform well in terms of housing and educational opportunities, significant inequalities still persist in health and income.[38]

In terms of smoking, two distinct gradients of inequity are evident: gender and a west-east pattern of higher consumption.[25] Overall, men tend to smoke more than women, a finding consistent with previous research demonstrating cohort effects in the association between income and smoking behaviors stratified by gender.[4] Likewise, Eastern countries like Serbia, Bulgaria and Romania have a significantly higher prevalence of smoking population when compared to the remaining European countries, of which the last two present inverse inequity of smoking habits. This pattern underscores the impact of stringent anti-smoking policies, as countries with more rigorous regulations on tobacco consumption tend to exhibit lower smoking rates and reduced disparities in smoking behaviors.[31]

It is important to acknowledge that this is a descriptive cross-sectional study in which causality cannot be inferred, however the results of the study are consistent with previous findings in some European countries. Measuring cardiovascular risk factors based upon self-reported diagnoses or measures can lead up to information bias. Nevertheless, self reported data on cardiovascular risk factors is commonly used as a cost-effective population wide studies.[39] We cannot determine whether low income builds up risk factor prevalence or whether existing health burdens erode household earnings. Secondly, all

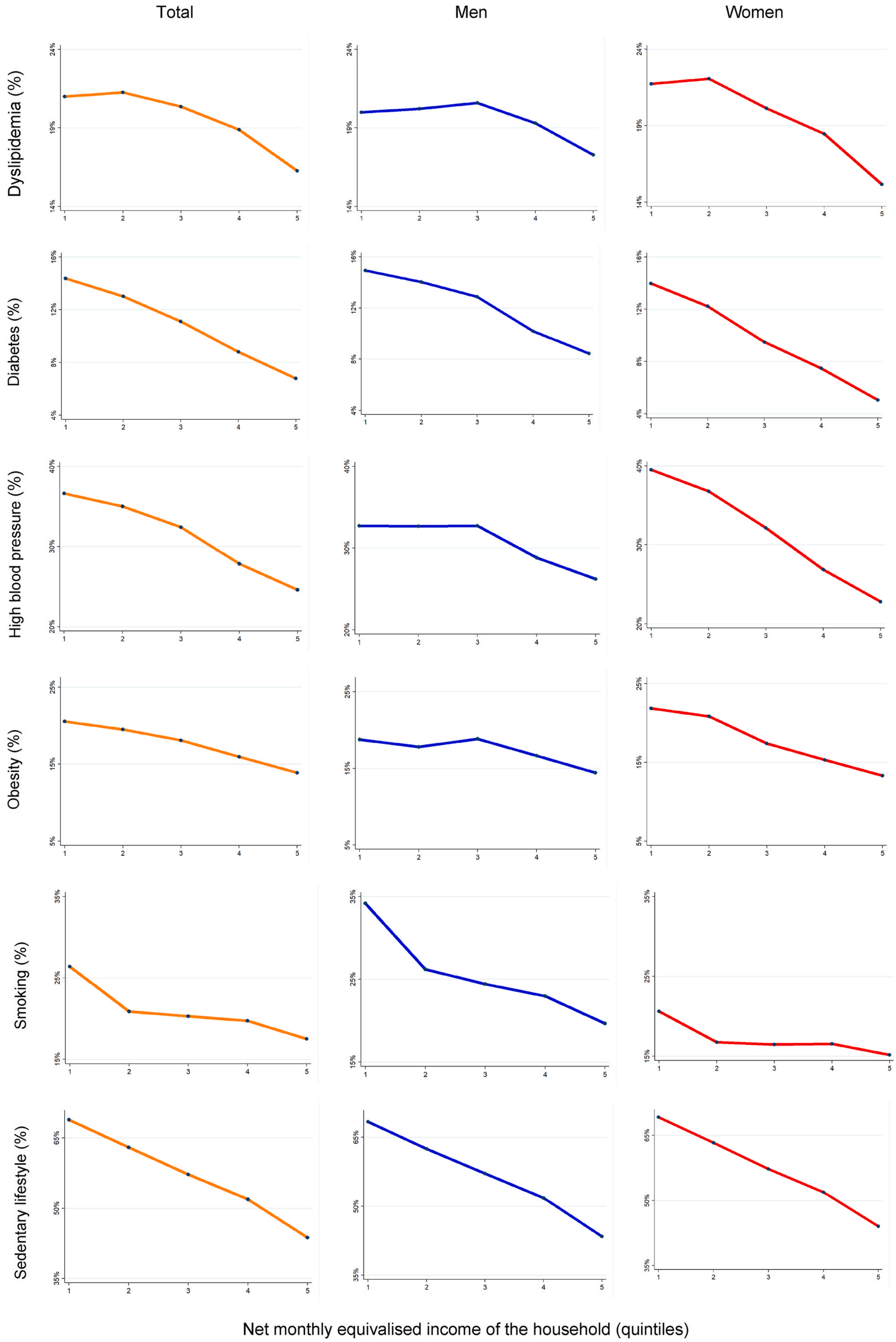


**Fig. 1.** Prevalence of cardiovascular risk factors by income quintiles, overall, in men and women. Net monthly equivalised income of the household is displayed by quintiles from 1 to 5, from lowest income to highest income.

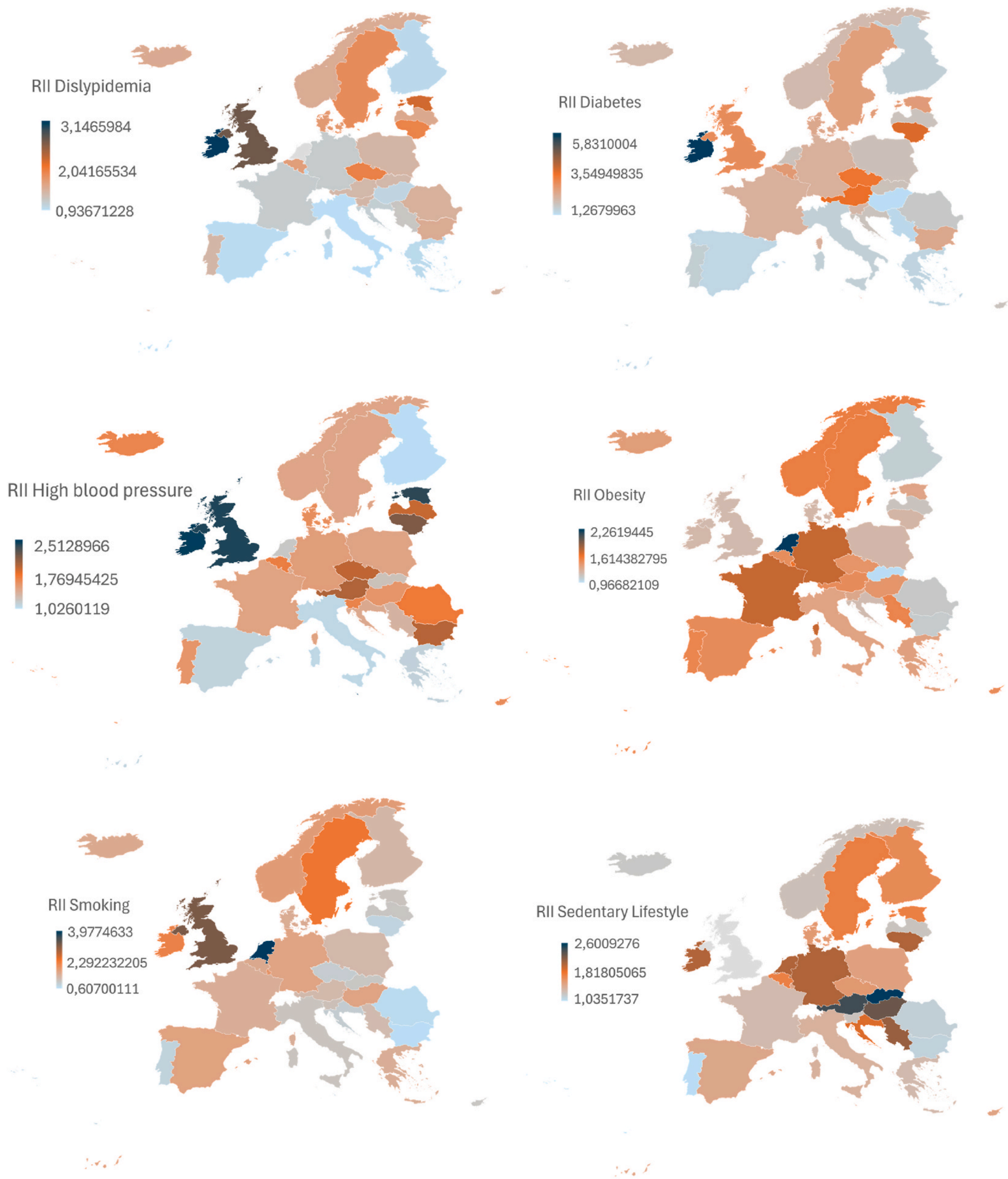


**Fig. 2.** Geographical heterogeneity in the Relative Index of Inequity (RII) by country. Associations between income level (increasing social class) and cardiovascular risk factors prevalence.

risk factors were self-reported by previous study design, which introduces the potential for misclassification and reporting bias as differential diagnosis awareness or willingness to report by income group could over- or under-estimate true social gradients. Thirdly, despite adjustment for age, sex, and country, residual confounding by unmeasured determinants as some social determinants of health (e.g., education, employment status, ethnicity, psychosocial stressors) may persist. The absence of longitudinal data does not allow assessment of changes in inequity over time or the impact of relevant economic regional phenomena. Finally, differential country survey of non-response and missing data—particularly if related to both income and health status—could limit generalisability. Nevertheless, the large, probability-based sample and harmonized data collection across 31 countries strengthens the robustness of our cardiovascular risk factors prevalence and RII estimates.

In this study we found inequity on cardiovascular risk factors prevalences that varied between European countries, some presenting wider social inequities than others. Thus its great value and potential for further implications on public health policies. Social class represents the cumulative experiences and exposures over life course, reflecting access to material resources crucial for health. Equity-oriented healthcare services and professionals, with an appropriate emphasis on both prevention and treatment, have the potential to further reduce the burden of cardiovascular disease. Beyond individual socioeconomic position, structural factors such as national health expenditure per capita and investment in preventive care may also contribute to the observed cross-country differences in prevalence and inequity. Future studies could integrate macro-level indicators to better understand the interplay between health system characteristics and social gradients in cardiovascular risk.

Expanding towards an equity lens on cardiovascular disease prevention programs should not focus only on coverage or outcomes but also metrics like income, gender, and region as well as tracking if policy changes narrow or widen inequity over time. Tackling CV inequity should start by defining important social determinants of health that are barriers to healthy living (e.g. education, housing, access to primary health care, lifestyle) and end up with targeted interventions. After exploring the results of this study, some interventions of interest could be strengthening tobacco-cessation policies (higher taxation, free quit-lines, limit media campaigns) in Eastern Europe countries or in Mediterranean countries that are drifting from traditional healthier diets, subsidize fruits and vegetables, restrict marketing of ultra-processed foods, and support nutrition education. In Northern and Western Europe, where obesity and sedentary behaviours are high, policymakers should pair investments in active-transport infrastructure and wellness incentives with community-based social prescribing to embed regular activity into everyday life. This type of equity-oriented approach can help narrow the substantial gap that still exists between socioeconomic groups in most countries.

## Author statements

### Ethical approval

This study received approval for "Compliance of Preventive Services in Europe: European Health Interview Survey wave 2 and 3" from the Comité de Ética de Investigación del HOSPITAL UNIVERSITARIO 12 DE OCTUBRE (CEIm No. 23/045).

### Funding

No external funding was obtained for the design, analysis, or preparation of this manuscript.

### Declaration on interests

The authors declare no conflict of interest.

### Contributors

JARL and AMPS accessed the underlying data and carried out the data analysis.

All authors were involved in the design, interpretation of information and drafting of the manuscript. Submission of the final version was decided after critical review of all authors.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2025.105978.

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The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

| | Item No. | STROBE items | Location in manuscript where items are reported | RECORD items | Location in manuscript where items are reported |
|---|---|---|---|---|---|
| Title and abstract | | | | | |
| | 1 | (a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found | 1(a): "(...) observational, descriptive, cross-sectional study (...)" - page 1 | RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included.<br><br>RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract.<br><br>RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract. | 1.1: "(...) using data from the European Health Interview Survey (EHIS 3) (...)" - page 1<br><br>1.2: "(...) conducted between 2018 and 2020 across 31 European countries (...)"- page 1<br><br>1.3: not applicable |
| Introduction | | | | | |
| Background rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 2: "Cardiovascular disease (CVD) is the leading cause of mortality worldwide and also a major contributor to morbidity, disability and premature death" - page 3 | | |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 3: "(...) assess (...) differences in (...) | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | inequities in (...) risk factors (...)" - page 4 | | |
| Methods | | | | | |
| Study Design | 4 | Present key elements of study design early in the paper | 4: See content of "Study design" - page 5 | | |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5: See content of "Study design" and "Study population" - pages 5,6 | | |
| Participants | 6 | *(a)* *Cohort study* - Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up<br><br>*Case-control study* - Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study* - Give the eligibility criteria, and the sources and methods of selection of participants<br><br>*(b)* *Cohort study* - For matched studies, give matching criteria and number of exposed and unexposed *Case-control study* - For matched studies, give matching criteria and the number of controls per case | 6(a): not applicable<br>6(b): not applicable | RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided.<br><br>RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided.<br><br>RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage. | 6.1: See content of "Study population" - pages 5,6<br><br>6.2: "Prior to authorization from EUROSTAT, all data underwent thorough compilation and processing to ensure the masking of any private and sensitive information." -page 5<br><br>6.3: not applicable |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. | 7: See content of " Variables", "Outcomes" and "Covariates" - pages 6,7 | RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers | 7.1: See content of "Variables", "Outcomes" and |

| | | | | | |
|---|---|---|---|---|---|
| | | | | should be provided. If these cannot be reported, an explanation should be provided. | "Covariates" - pages 6,7 |
| Data sources/ measurement | 8 | For each variable of interest, give sources of data and details of methods of assessment (measurement).<br><br>Describe comparability of assessment methods if there is more than one group | 8: See content of "Study population", "Variables" and "Covariates" - pages 6,7 | | |
| Bias | 9 | Describe any efforts to address potential sources of bias | 9: "Questionnaires were administered face-to-face, by telephone or self-administered and sent by mail or internet. The detailed description of each variable, the handling of missing data by Eurostat (...) can be consulted in the survey manual, which has been published." - page 5 | | |
| Study size | 10 | Explain how the study size was arrived at | 10: "(...) selected population included adults above 40 years old considering SCORE220 and SCORE2-OP21 Guidelines (...)" and "(...) resulting in a final sample of 248,420 participants." - page 5 | | |

| | | | | | |
|---|---|---|---|---|---|
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why | 11: "(…) descriptive analysis of (…) variables (…) by calculating survey weighted means and proportions of continuous and categorical variables. T-test for continuous variables and chi squared test for categorical variables (…)" - page 7 | | |
| Statistical methods | 12 | (a) Describe all statistical methods, including those used to control for confounding<br><br>(b) Describe any methods used to examine subgroups and interactions<br><br>(c) Explain how missing data were addressed<br><br>(d) Cohort study - If applicable, explain how loss to follow-up was addressed<br><br>Case-control study - If applicable, explain how matching of cases and controls was addressed<br><br>Cross-sectional study - If applicable, describe analytical methods taking account of sampling strategy<br><br>(e) Describe any sensitivity analyses | 12(a): See content of Statistical analyses - page 7<br>12(b): See content of Statistical analyses -page 7<br>12(c): "(…) handling of missing data by Eurostat, (…) can be consulted in the survey manual, which has been published"<br>12(d): "(…)was performed taking into account survey weights." - page 5<br>12(e): not applicable | | |
| Data access and cleaning methods | | .. | | RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population. | 12.1: Authors have full access to anonymized database |

| | | | | | |
|---|---|---|---|---|---|
| | | | | RECORD 12.2: Authors should provide information on the data cleaning methods used in the study. | 12.2: See content of "Study Population" - page 5 |
| Linkage | | .. | | RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided. | 12.3: not applicable |

| Results | | | | | |
|---|---|---|---|---|---|
| Participants | 13 | (a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed)<br>(b) Give reasons for nonparticipation at each stage. (c) Consider use of a flow diagram | 13(a): "A total of 248,420 inquired adults (…)" - page 8<br><br>13(b): not applicable | RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram. | 13.1: "A total of 248,420 inquired adults aged 40 years old or more (…)" - page 8 |
| Descriptive data | 14 | (a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders<br>(b) Indicate the number of participants with missing data for each variable of interest (c) *Cohort study* - summarise follow-up time (*e.g.*, average and total amount) | 14(a): See contents of "Results" - pages 8-13<br><br>14(b): not applicable | | |
| Outcome data | 15 | *Cohort study* - Report numbers of outcome events or summary measures over time<br>*Case-control study* - Report numbers in each exposure category, or summary measures of exposure | 15: See contents of Table 1 | | |

| | | | | | |
|---|---|---|---|---|---|
| | | *Cross-sectional study* - Report numbers of outcome events or summary measures | | | |
| Main results | 16 | (a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>(b) Report category boundaries when continuous variables were categorized<br>(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 16(a)/(b)/(c): See contents of Results, Table 1, Figure 1, Figure 2, Supplementary Table 1, Supplementary Table 2 and Supplementary Figure 1 | | |
| Other analyses | 17 | Report other analyses done—<br>e.g., analyses of subgroups and interactions, and sensitivity analyses | 17: See contents of Results - Pages 8-13 | | |

| Discussion | | | | | |
|---|---|---|---|---|---|
| Key results | 18 | Summarise key results with reference to study objectives | 18: "We identified significant inequities on cardiovascular risk factors by income level across 31 european countries (…)" - page 14 | | |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 19: See contents of Discussion - Pages 14-17 | RECORD 19.1: Discuss the implications of using data that were not created or collected to answer the specific research question(s). Include discussion of misclassification bias, unmeasured confounding, missing data, and changing eligibility over time, as they pertain to the study being reported. | 19.1: "(…)study in which causality cannot be inferred (…)" "(…)based upon self-reported diagnoses or measures can lead up to information bias." - page 16 |

| | | | | | |
|---|---|---|---|---|---|
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 20: See contents of Discussion - Pages 14-17 | | |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 21: See contents of Discussion - Pages 14-17 | | |
| Other Information | | | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 22: "The authors declare no conflict of interest. No funding was perceived throughout the analysis and drafting of the manuscript of this study." - Page 17 | | |
| Accessibility of protocol, raw data, and programming code | | .. | | RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code. | 22.1: See contents of Methods - Pages 5-7 |

*Reference: Benchimol EI, Smeeth L, Guttmann A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, the RECORD Working Committee. The REporting of studies Conducted using Observational Routinely-collected health Data (RECORD) Statement. *PLoS Medicine* 2015; in press.

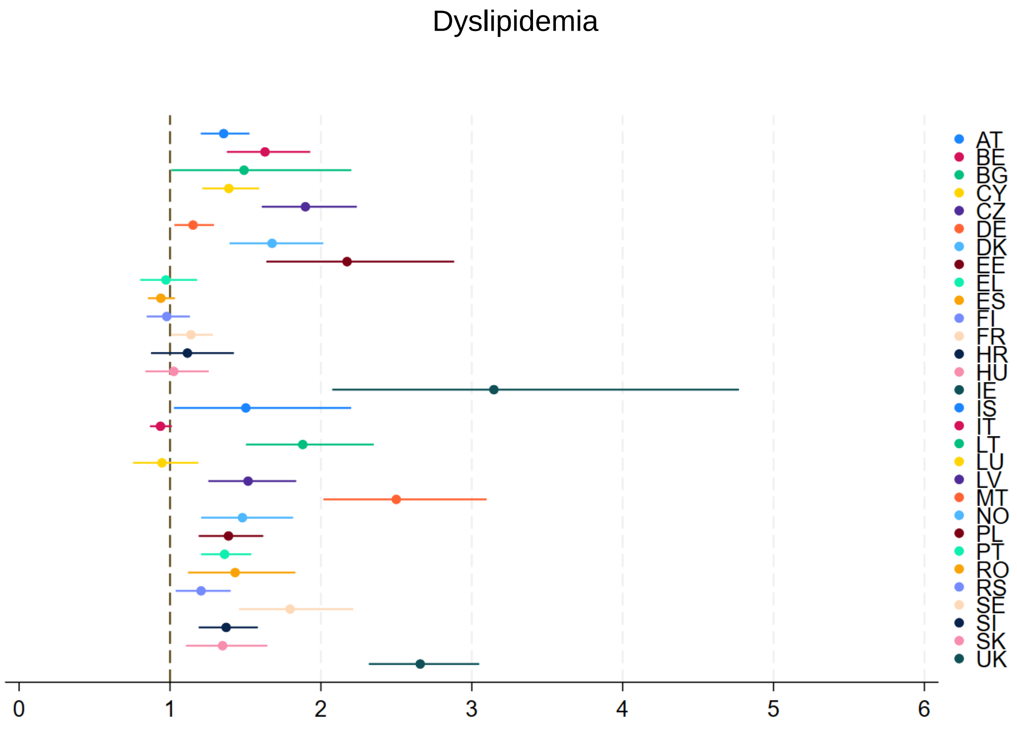
| | Dyslipidemia | | Diabetes | | High blood pressure | | Obesity | | Smoking | | Sedentary lifestyle | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n (%) | 95% CI | n (%) | 95% CI | n (%) | 95% CI | n (%) | 95% CI | n (%) | 95% CI | n (%) | 95% CI |
| Overall | 239,788 (19.3) | 19.1-19.6 | 246,255 (10.6) | 10.4-10.8 | 246,563 (31.1) | 30.8-31.4 | 248,42 (20.5) | 20.2-20.7 | 242,729 (20.8) | 20.5-21.0 | 248,42 (56.5) | 56.2-56.8 |
| Austria | 10,59 (26.2) | 25.2-27.3 | 10,59 (9.0) | 8.3-9.7 | 10,59 (32.0) | 31.0-33.1 | 10,59 (20.2) | 19.2-21.1 | 10,59 (22.1) | 21.1-23.1 | 10,59 (44.0) | 42.8-45.1 |
| Belgium | 6,476 (26.5) | 25.0-28.0 | 6,494 (8.3) | 7.5-9.2 | 6,492 (25.9) | 24.5-27.3 | 6,496 (20.4) | 19.1-21.8 | 5,417 (18.0) | 16.6-19.4 | 6,496 (60.8) | 59.2-62.5 |
| Bulgaria | 5,547 (4.0) | 3.5-4.5 | 5,652 (10.3) | 9.5-11.1 | 5,656 (44.1) | 42.7-45.4 | 5,661 (17.0) | 16.0-18.0 | 5,476 (35.0) | 33.6-36.3 | 5,661 (91.0) | 90.2-91.9 |
| Cyprus | 4,048 (31.6) | 30.0-33.1 | 4,048 (12.5) | 11.4-13.5 | 4,048 (33.9) | 32.3-35.4 | 4,048 (20.1) | 18.8-21.5 | 4,048 (22.6) | 21.1-24.0 | 4,048 (64.3) | 62.7-66.0 |
| Czech Republic | 6,002 20.1 | 19.0-21.2 | 6,005 (13.0) | 12.1-13.9 | 6,004 (38.2) | 36.8-39.6 | 6,005 (24.2) | 23.0-25.4 | 6,004 (24.9) | 23.6-26.1 | 6,005 (72.1) | 70.7-73.4 |
| Germany | 17,771 (24.7) | 23.7-25.7 | 18,16 (12.3) | 11.6-13.1 | 18,125 (37.0) | 35.9-38.0 | 18,191 (23.4) | 22.5-24.4 | 18,182 (25.0) | 24.0-26.1 | 18,191 (37.5) | 36.4-38.7 |

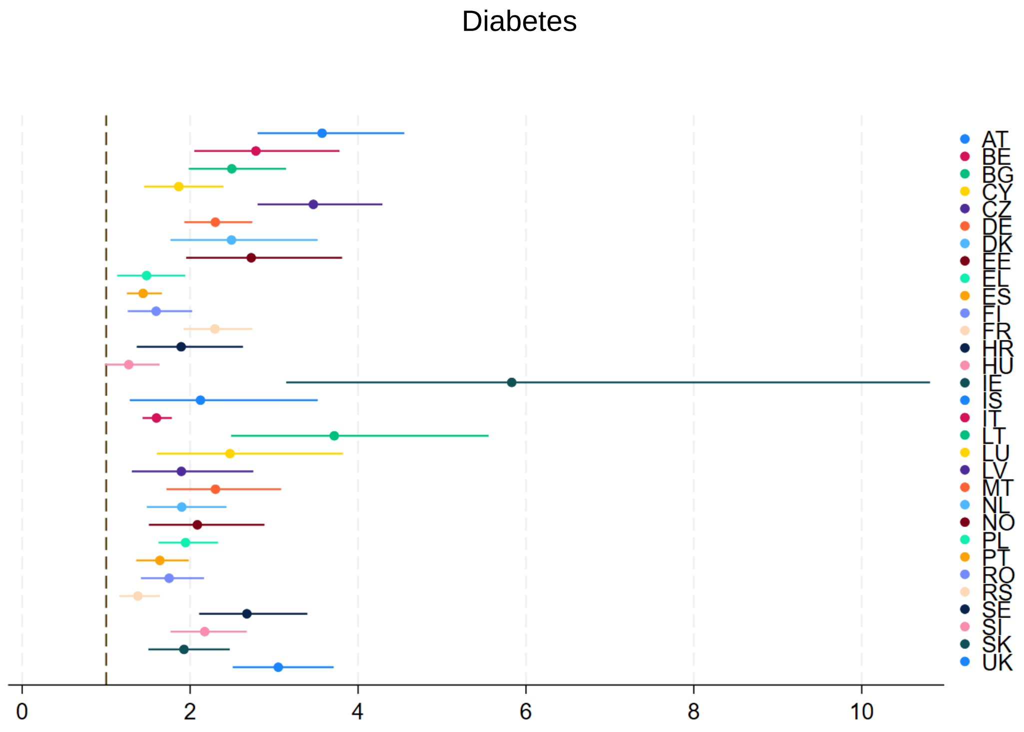
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Denmark | 4,811 (19.6) | 18.4-20.7 | 4,808 (7.4) | 6.7-8.2 | 4,816 (27.4) | 26.1-28.7 | 4,957 (22.2) | 21.0-23.4 | 4,761 (17.4) | 16.3-18.6 | 4,957 (24.4) | 23.2-25.7 |
| Estonia | 3,41 (10.9) | 9.9-12.0 | 3,411 (9.1) | 8.1-10.0 | 3,408 (35.2) | 33.5-36.9 | 3,411 (28.3) | 26.7-30.0 | 3,411 (23.0) | 21.5-24.6 | 3,411 (64.0) | 62.3-65.7 |
| Greece | 6,318 (21.8) | 20.6-23.0 | 6,326 (11.5) | 10.6-12.3 | 6,323 (28.3) | 27.1-29.5 | 6,334 (20.1) | 18.9-21.3 | 6,334 (29.2) | 27.9-30.6 | 6,334 (80.6) | 79.4-81.8 |
| Spain | 17,067 (21.6) | 20.9-22.3 | 17,094 (10.8) | 10.2-11.3 | 17,074 (27.7) | 26.9-28.5 | 17,097 (21.3) | 20.6-22.1 | 17,068 (20.7) | 19.9-21.5 | 17,097 (52.2) | 51.2-53.1 |
| Finland | 4,141 (31.6) | 30.1-33.1 | 4,056 (13.6) | 12.6-14.7 | 4,288 (39.8) | 38.2-41.3 | 4,755 (25.1) | 23.8-26.5 | 4,665 (15.4) | 14.2-16.6 | . (.) | . |
| France | 9,391 (19.9) | 19.1-20.8 | 9,391 (10.7) | 10.0-11.3 | 9,391 (24.7) | 23.8-25.7 | 9,391 (17.3) | 16.5-18.1 | 9,391 (19.9) | 19.0-20.7 | 9,391 (62.0) | 61.0-63.1 |
| Croatia | 4,053 (25.8) | 24.0-27.5 | 4,1 (15.4) | 14.1-16.8 | 4,103 (48.5) | 46.5-50.5 | 4,108 (26.5) | 24.8-28.2 | 4,098 (23.7) | 22.1-25.4 | 4,108 (74.2) | 72.4-76.1 |
| Hungary | 3,84 (18.8) | 17.5-20.1 | 3,892 (12.7) | 11.6-13.8 | 3,917 (45.7) | 44.1-47.4 | 3,948 (30.0) | 28.3-31.4 | 3,897 (24.0) | 22.6-25.4 | 3,948 (64.0) | 62.4-65.6 |
| Ireland | 5,227 (9.3) | 8.4-10.1 | 5,227 (5.3) | 4.7-6.0 | 5,227 (18.9) | 17.7-20.2 | 5,227 (68.2) | 66.7-69.8 | 5,199 (16.1) | 14.8-17.3 | 5,227 (57.4) | 55.7-59.0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Iceland | 2,465 (14.2) | 12.3-16.1 | 2,524 (7.8) | 6.3-9.3 | 2,517 (33.5) | 31.0-36.0 | 2,531 (26.6) | 24.3-28.8 | 2,519 (12.8) | 11.1-14.5 | 2,531 (30.7) | 28.3-33.1 |
| Italy | 33,083 (17.1) | 16.6-17.6 | 33,083 (9.0) | 8.7-9.4 | 33,083 (28.6) | 28.0-29.1 | 33,569 (14.4) | 14.0-14.9 | 32,728 (20.7) | 20.1-21.1 | 33,569 (78.7) | 78.1-79.2 |
| Lithuania | 3,499 (20.0) | 19.1-21.8 | 3,499 (7.8) | 6.8-8.6 | 3,499 (44.2) | 42.6-46.0 | 3,499 (23.9) | 25.3 | 3,499 (22.6) | 21.2-24.1 | 3,499 (76.5) | 75.0-78.0 |
| Luxembourg | 2,82 (23.1) | 21.5-24.6 | 2,793 (7.4) | 6.4-8,4 | 2,827 (22.8) | 21.2-24.4 | 2,914 (24.7) | 23.1-26.3 | 2,784 (15.5) | 14.1-16.9 | 2,914 (34.1) | 32.3-35.8 |
| Latvia | 3,719 (22.5) | 21.0-23.9 | 3,865 (8.3) | 7.4-9.3 | 3,854 (44.4) | 42.7-46.1 | 3,87 (29.7) | 28.2-31.3 | 3,866 (24.8) | 23.2-26.3 | 3,87 (69.0) | 67.4-70.6 |
| Malta | 2,968 (21.6) | 20.1-23.1 | 2,968 (12.5) | 11.3-13.7 | 2,968 (30.3) | 28.6-32 | 2,968 (40.1) | 38.3-41.9 | 2,962 (23.2) | 21.6-24.8 | 2,968 (80.4) | 78.9-81.9 |
| Netherlands | - - | - | 5,436 (8.7) | 7.9-9.5 | 5,424 (23.7) | 22.5-24.9 | 5,437 (18.0) | 16.9-19.0 | 5,437 (18.6) | 17.5-19.7 | 5,437 (52.7) | 51.3-54.1 |
| Norway | 5,109 (15.5) | 14.4-16.6 | 5,109 (6.7) | 6.0-7.5 | 5,109 (22.8) | 21.5-24.1 | 5,11 (18.3) | 17.1-19.5 | 5,092 (18.3) | 17.1-19.5 | 5,11 (15.1) | 14.0-16.3 |
| Poland | 13,986 (14.6) | 13.8-15.3 | 14,116 (12.6) | 11.9-13.2 | 14,098 (40.6) | 39.6-41.7 | 14,149 (21.1) | 20.2-21.9 | 14,094 (23.4) | 22.5-24.3 | 14,149 (70.7) | 69.7-71.7 |

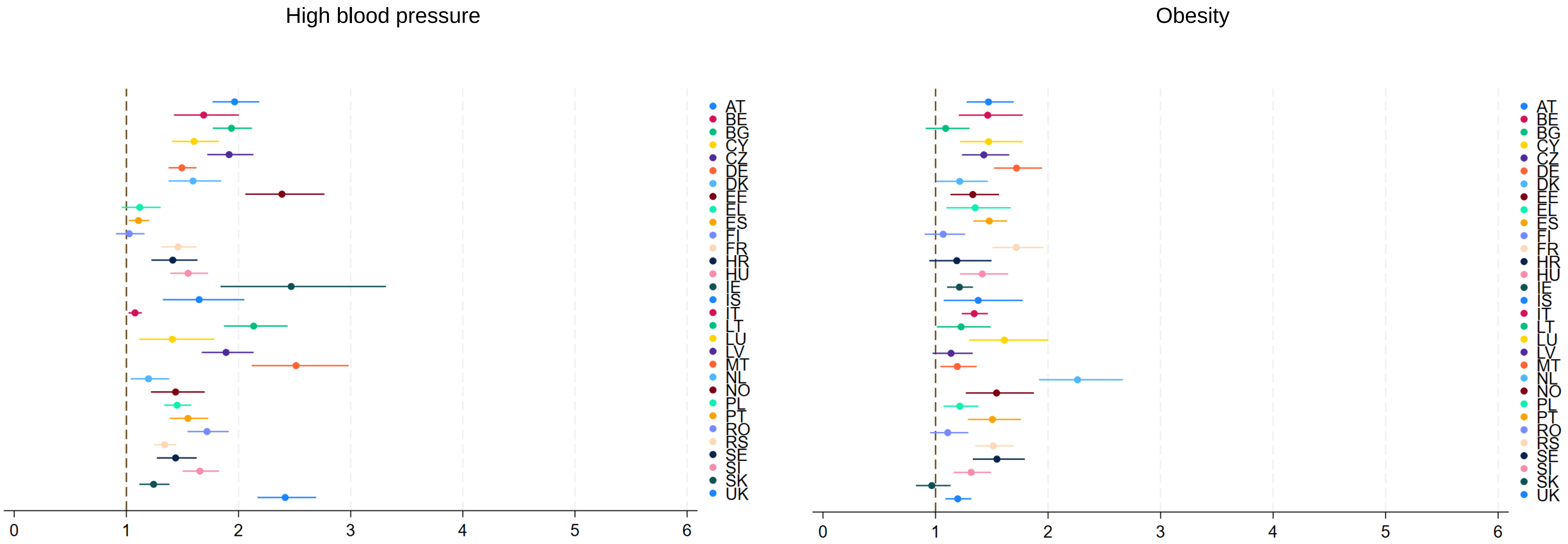
| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Portugal | 11,431 (33.0) | 31.6-34.3 | 11,535 (14.4) | 13.4-15.4 | 11,523 (37.8) | 36.4-39.2 | 11,617 (23.6) | 22.3-24.9 | 11,571 (14.6) | 13.5-15.6 | 11,617 (72.6) | 71.3-74.0 |
| Romania | 11,69 (5.4) | 4.9-5.9 | 11,692 (7.7) | 7.2-8.3 | 11,691 (24.3) | 23.4-25.2 | 11,692 (14.3) | 13.6-15.1 | 11,691 (24.8) | 23.8-25.8 | 11,692 (97.1) | 96.7-97.5 |
| Serbia | 9,043 (15.7) | 14.9-16.6 | 9,094 (11.5) | 10.8-122.5 | 9,084 (43.7) | 42.6-44.9 | 9,106 (26.1) | 25.1-27.2 | 6,395 (32.4) | 31.2-33.7 | 9,106 (89.2) | 88.5-89.9 |
| Sweden | 6,303 (10.8) | 9.9-11.6 | 6,303 (9.3) | 8.5-10.1 | 6,303 (27.1) | 25.9-28.2 | 6,303 (20.7) | 19.6-21.8 | 6,21 (11.3) | 10.5-12.2 | 6,303 (26.0) | 24.8-27.1 |
| Slovenia | 6,531 (21.5) | 20.5-22.6 | 6,446 (11.6) | 10.8-12.4 | 6,6 (36.6) | 35.4-37.8 | 6,873 (25.5) | 24.4-26.6 | 6,848 (20.6) | 19.6-21.7 | 6,873 (52.3) | 51.0-53.5 |
| Slovakia | 4,008 (17.1) | 15.9-18.3 | 4,008 (11.7) | 10.7-12.8 | 4,008 (44.1) | 42.4-45.7 | 4,01 (26.4) | 25.0-27.9 | 3,997 (25.0) | 23.6-26.5 | 4,01 (76.0) | 74.5-77.4 |
| United Kingdom | 14,441 (16.8) | 16.0-17.6 | 14,53 (9.8) | 9.2-10.4 | 14,513 (25.3) | 24.3-26.2 | 14,553 (32.3) | 31.2-33.4 | 14,495 (12.1) | 11.3-12.9 | 14,553 (33.7) | 32.5-34.8 |

Supplementary Table (1): Adjusted prevalence of cardiovascular risk factors and regular physical activity among European citizens in 2020 (EHIS 3). Microdata for dyslipidemia in the Netherlands and regular physical activity in Finland was not available.

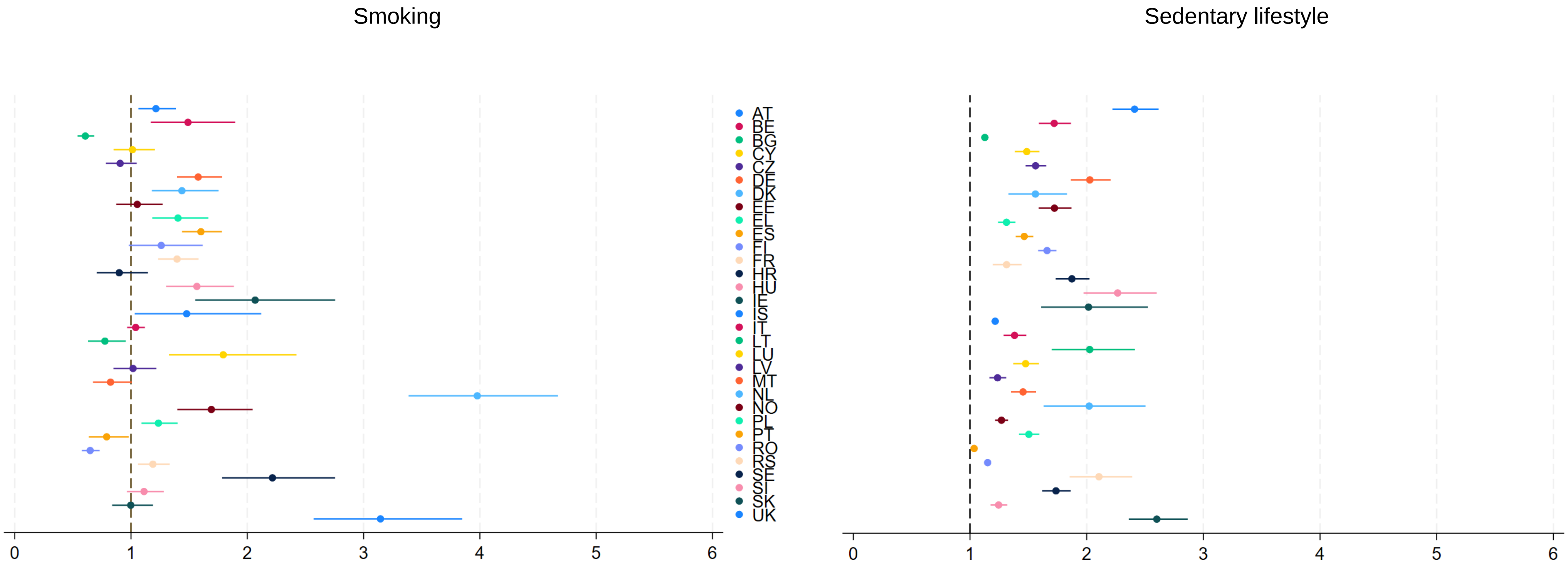



Suppmentary Figure 1 part 1/3: Relative Index of Inequity (RII) by country. Associations between income level (increasing social class) and cardiovascular risk factors prevalence. AT: Austria; BE: Belgium; BG: Bulgaria; CY: Cyprus; CZ: Czech Republic; DE: Germany; DK: Denmark; EE: Estonia; EL: Greece; ES: Spain; FI: Finland; FR: France; HR: Croatia; HU: Hungary; IE: Ireland; IS: Iceland; IT: Italy; LT: Lithuania; LU: Luxembourg; LV: Latvia; MT: Malta; NL: Netherlands; NO: Norway; PL: Poland; PT: Portugal; RO: Romania; RS: Serbia; SE: Sweden; SI: Slovenia; SK: Slovakia; UK: United Kingdom.




Suppmentary Figure 1 part 2/3: Relative Index of Inequity (RII) by country. Associations between income level (increasing social class) and cardiovascular risk factors prevalence. AT: Austria; BE: Belgium; BG: Bulgaria; CY: Cyprus; CZ: Czech Republic; DE: Germany; DK: Denmark; EE: Estonia; EL: Greece; ES: Spain; FI: Finland; FR: France; HR: Croatia; HU: Hungary; IE: Ireland; IS: Iceland; IT: Italy; LT: Lithuania; LU: Luxembourg; LV: Latvia; MT: Malta; NL: Netherlands; NO: Norway; PL: Poland; PT: Portugal; RO: Romania; RS: Serbia; SE: Sweden; SI: Slovenia; SK: Slovakia; UK: United Kingdom




Suppmentary Figure 1 part 3/3: Relative Index of Inequity (RII) by country. Associations between income level (increasing social class) and cardiovascular risk factors prevalence. AT: Austria; BE: Belgium; BG: Bulgaria; CY: Cyprus; CZ: Czech Republic; DE: Germany; DK: Denmark; EE: Estonia; EL: Greece; ES: Spain; FI: Finland; FR: France; HR: Croatia; HU: Hungary; IE: Ireland; IS: Iceland; IT: Italy; LT: Lithuania; LU: Luxembourg; LV: Latvia; MT: Malta; NL: Netherlands; NO: Norway; PL: Poland; PT: Portugal; RO: Romania; RS: Serbia; SE: Sweden; SI: Slovenia; SK: Slovakia; UK: United Kingdom