Gender-specific associations between coronary heart disease and other chronic diseases: cross-sectional evaluation of national survey data from adult residents of Germany

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Abstract

Background Combinations of coronary heart disease (CHD) and other chronic conditions complicate clinical management and increase healthcare costs. The aim of this study was to evaluate gender-specific relationships between CHD and other comorbidities. Methods We analyzed data from the German Health Interview and Examination Survey (DEGS1), a national survey of 8152 adults aged 18–79 years. Female and male participants with self-reported CHD were compared for 23 chronic medical conditions. Regression models were applied to determine potential associations between CHD and these 23 conditions. Results The prevalence of CHD was 9% (547 participants): 34% (185) were female CHD participants and 66% (362) male. In women, CHD was associated with hypertension (OR = 3.28 (1.81–5.9)), lipid disorders (OR = 2.40 (1.50–3.83)), diabetes mellitus (OR = 2.08 (1.24–3.50)), kidney disease (OR = 2.66 (1.10–6.99)), thyroid disease (OR = 1.81 (1.18–2.79)), gout/high uric acid levels (OR = 2.08 (1.22–3.56)) and osteoporosis (OR = 1.69 (1.01–2.84)). In men, CHD patients were more likely to have hypertension (OR = 2.80 (1.94–4.04)), diabetes mellitus (OR = 1.87 (1.29–2.71)), lipid disorder (OR = 1.82 (1.34–2.47)), and chronic kidney disease (OR = 3.28 (1.81–5.9)). Conclusion Our analysis revealed two sets of chronic conditions associated with CHD. The first set occurred in both women and men, and comprised known risk factors: hypertension, lipid disorders, kidney disease, and diabetes mellitus. The second set appeared unique to women: thyroid disease, osteoporosis, and gout/high uric acid. Identification of shared and unique gender-related associations between CHD and other conditions provides potential to tailor screening, preventive, and therapeutic options.

J Geriatr Cardiol 2019; 16: 663–670. doi:10.11909/j.issn.1671-5411.2019.09.004

Keywords: Chronic diseases; Comorbidities; Gender; Heart disease; Risk factors; Survey data

1 Introduction

There is growing awareness of the increased prevalence of chronic health conditions and the impact of these conditions on healthcare utilization.[1] One such chronic condition is coronary heart disease (CHD). CHD represents the single largest cause of death worldwide and its management is complicated by frequent associations with other multiple chronic conditions.[2] Furthermore, CHD exhibits gender differences; although the traditional risk factors do not differ between genders and men, and comprised known risk factors: hypertension, lipid disorders, kidney disease, and diabetes mellitus. The second set appeared unique to women: thyroid disease, osteoporosis, and gout/high uric acid. Identification of shared and unique gender-related associations between CHD and other conditions provides potential to tailor screening, preventive, and therapeutic options.

7 to 10 years later than in men and remains the major cause of death. Estrogen exposure is assumed to account for the delayed CHD development.[5] However, women presenting with CHD often exhibit a wider array of different concomitant chronic diseases.[5,6] In addition, risk levels exhibit gender-related differences. For example, women with diabetes have a significantly greater risk of developing CHD versus diabetic men.[5] Also, mean low-density lipoprotein (LDL) in postmenopausal women is significantly higher than in men.[6] Furthermore, management of CHD presents more challenges and outcomes appear generally worse in women.[5] Such differences may be explained because women receive fewer screening tests and fewer medications for primary and secondary prevention of cardiovascular risk factors and CHD.[7]

The aim of our study was to assess the relationships between CHD and common chronic diseases using data from a national survey of adult residents of Germany. Identification of gender-related similarities and differences in the spec-
trum of chronic diseases associated with CHD could improve screening approaches and enhance healthcare delivery.

2 Methods

2.1 Data

This study used data from the German Health Interview and Examination Survey for Adults (DEGS1), a national survey carried out by the Robert-Koch Institute. The sample included 8152 adult permanent residents of Germany aged 18–79 years. Of these, 4193 persons were newly enlisted for the DEGS1 survey and 3959 had participated in the National Health Interview and Examination Survey (BGS98). Sampling was performed using a two-stage stratified cluster design. In the first stage, sample points were selected from a list of German communities and in the second stage, men and women were randomly selected from local population registries for each community. Information on health status, medical history, health-related behavior, socio-demographics, and anthropometry were collected from interviews, self-administered questionnaires, physical examinations, and from blood and urine samples. Description of the sampling strategy and the evaluation protocol have been published.

2.2 Study population and study variables

Our study focused on participants with a self-reported history of CHD, with or without a history of myocardial infarction, coronary artery bypass grafting, or percutaneous coronary intervention. A list of the questions asked and the answer options for each parameter in the survey is provided in supplementary Table S1. We identified 547 cases of self-reported CHD; all above 40 years of age. Consequently, we limited our analyses to people aged 40–79 years (5782 adults (3037 women and 2745 men)). The prevalence of the 23 common chronic conditions assessed in the survey was calculated for both women and men with and without CHD.

2.3 Statistical analysis

Descriptive statistics were used to examine characteristics of the study population. The multivariable logistic regression models used DEGS1 sample weights. These weights were adjusted for sampling and loss to follow-up, as well as deviations between the design-weighted net sample and German population statistics with respect to age, gender, region, nationality, municipality, and education, to represent the German population. In accordance with previous studies, we also adjusted for age, social status, educational level, employment status, smoking status, and body mass index (BMI). Results are presented as odds ratios (OR) with 95% confidence intervals (CI) and P values. To examine the robustness of our models, regression analyses were performed with and without sample weights, as well as with and without adjustment (Supplementary data, Table S2.1–S2.8). Analysis was performed using Stata (v.14.1; Stata-Corp, College Station, TX, USA).

3 Results

3.1 Population characteristics

In the DEGS1 survey, participation rate was 42% for first-time participants and 62% for participants who had taken part in the BGS98 survey. Of the 5782 participants, 9% self-reported CHD; 185 women and 362 men (66% vs. 34%; P < 0.001; Table 1). Social status and employment status were lower in women than men (low social status, 26% vs. 19%, low education status, 32% vs. 9%; both P < 0.001).

3.2 Prevalence of chronic diseases

Table 2 shows the prevalence of the chronic conditions in women and men with and without CHD. In the CHD population, hypertension was the most common chronic disease in both genders, affecting 81% of men and 80% of women. More than one-third of patients with CHD had a BMI ≥ 30 kg/m² in both genders. The prevalence of thyroid disease, depression, osteoporosis, anxiety disorders and migraine were higher in women with CHD than in men with CHD (all P < 0.001).

3.3 Associations between CHD and other chronic diseases

After controlling for possible confounders in multivariable analyses, CHD was significantly associated with seven of the examined chronic diseases in women and with four in men (Table 3, Model 3). All chronic diseases and their association with CHD in both genders are given in the supplementary data with and without DEGS1 population weights (supplementary Table S2.1–S2.6). In women, CHD showed the strongest association with hypertension (OR = 3.28, 95% CI: 1.81–5.94, P < 0.001). In addition, female CHD patients were more likely to have lipid disorders (OR = 2.4; 95% CI: 1.50–3.83, P < 0.001), diabetes mellitus (OR = 2.08; 95% CI: 1.24–3.50, P = 0.006), chronic kidney disease (OR= 2.66; 95% CI: 1.01–6.99, P = 0.047), thyroid disease...
chronic kidney disease (CKD) (OR = 3.16; 95% CI: 1.94–4.04, \( P < 0.001 \)), diabetes (OR = 1.87; 95% CI: 1.29–2.71, \( P = 0.001 \)), lipid disorder (OR = 1.82; 95% CI: 1.34–2.43, \( P < 0.001 \)).

Overall, no significant differences were found between analyses with and without DEGS1 weights, supporting the robustness of the identified associations (Table 3 and Table S2.1–S2.6). Adjustment for baseline covariates and for sample weights changed the results only for chronic kidney disease in women with CHD. Without adjustment and sample weights, CHD was not associated with chronic kidney disease in women.

### 4 Discussion

In this analysis of national health survey date, we found that about 10% of participants suffered from CHD above 40 years of age. We identified several chronic conditions, all with important healthcare relevance, associated with CHD; some were unspecific to gender, while others appeared unique to women.

In general, traditional risk factors for CHD are considered to be similar in women and men. Nevertheless, there are gender differences in the prevalence of risk factors and chronic diseases. In our study, hypertension was overall the most common chronic disease in both genders, affecting 80% of women and 81% of men. This result is consistent with previous studies showing that hypertension is the most prevalent chronic disease in Germany, nearly equally represented in women and men. \[13,14\] Other chronic diseases such as thyroid disease, depression, osteoporosis, anxiety disorders, and migraine were significantly more frequent in women than in men.

We found that CHD was significantly associated with four chronic conditions in both genders, after adjustment for potential confounders. Three of these conditions, hypertension, diabetes and lipid disorders are well-known risk factors for CHD, described in detail in previous studies.\[15,16\] Our study supports prior research, but with added weight because the data were obtained from a national survey. Moreover, we found CHD was particularly associated with hypertension, with an odds ratio of more than threefold in female and more than twofold in male participants.

In addition to these chronic diseases, women and men with CHD seemed to be more likely to also have chronic kidney diseases. The association between CKD and CHD has been the subject of numerous studies; however, most trials assessed patients with CKD and evaluated the likelihood of also having CHD.\[17,18\] For example, Chonchol, \textit{et al.}\[18\] demonstrated that patients with CKD had a high

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**Table 1. Main characteristics of the study population (CHD population = 547 participants)**

|                          | Female \((n = 185)\) | Male \((n = 362)\) | \(P\)-value |
|--------------------------|----------------------|-------------------|------------|
| CHD                      | 6.1%                 | 13.3%             | <0.001     |
| Within gender of study population | 33.8%               | 66.2%             | <0.001     |
| Age groups               |                      |                   |            |
| 40–49 yrs                | 9 (4.9%)             | 16 (4.4%)         |            |
| 50–59 yrs                | 14 (7.6%)            | 46 (12.7%)        | 0.408      |
| 60–69 yrs                | 74 (40%)             | 135 (37.3%)       |            |
| 70–79 yrs                | 88 (47.6%)           | 165 (45.6%)       |            |
| BMI status               |                      |                   |            |
| < 18.5 kg/m\(^2\)       | 1 (0.5%)             | 0                 |            |
| 18.5–25 kg/m\(^2\)      | 50 (27.5%)           | 79 (21.9%)        |            |
| 25 < 30 kg/m\(^2\)      | 68 (37.4%)           | 164 (45.6%)       | 0.61       |
| ≥ 30 kg/m\(^2\)         | 63 (34.6%)           | 117 (32.5%)       |            |
| Physical activity (> 2.5 h/w) |                      |                   |            |
| No                      | 143 (84.1%)          | 280 (80.5%)       | 0.299      |
| Yes                     | 27 (15.9%)           | 68 (19.5%)        |            |
| Smoking status          |                      |                   |            |
| Smoker                  | 85 (15.7%)           | 52 (14.4%)        |            |
| Ex-smoker               | 37 (20.6%)           | 223 (61.8%)       | <0.001     |
| Never smoker            | 110 (61.1%)          | 86 (23.8%)        |            |
| Social status*          |                      |                   |            |
| Low                     | 47 (26.1%)           | 67 (18.7%)        |            |
| Middle                  | 112 (62.2%)          | 202 (56.3%)       | <0.001     |
| High                    | 21 (11.6%)           | 90 (25.0%)        |            |
| Educational status*     |                      |                   |            |
| Low                     | 57 (31.7%)           | 33 (9.2%)         |            |
| Middle                  | 97 (36.9%)           | 166 (46.2%)       | <0.001     |
| High                    | 26 (14.4%)           | 160 (44.6%)       |            |
| Employment status       |                      |                   |            |
| Never                   | 8 (4.6%)             | 4 (1.2%)          |            |
| Previous                | 135 (78%)            | 259 (74.6%)       | 0.017      |
| Current                 | 30 (17.3%)           | 84 (24.2%)        |            |

Data are presented as \(n\) (%) unless otherwise indicated. The prevalence rates are adjusted with weights to reflect the German population. \(^\dagger\)Social status was defined according to a previously published index by Lampert, \textit{et al.}\[19\]

\(^\circ\)Educational status was defined according to the International Standard Classification of Education (ISCED) 1997, low: (ISCED 0, 1 or 2), middle (ISCED 3 or 4), high (ISCED 5 or 6). BMI: body mass index; CHD: coronary heart disease.

(OR = 1.81; 95% CI: 1.18–2.79, \( P = 0.007 \)), gout/high uric acid levels (OR = 2.08; 95% CI: 1.22–3.56, \( P = 0.008 \)) and osteoporosis (OR = 1.69; 95% CI: 1.01–2.84, \( P = 0.047 \)).

In men, the strongest association was between CHD and chronic kidney disease (CKD) (OR = 3.16; 95% CI: 1.49–6.73, \( P = 0.003 \)). Male participants with CHD were also more likely to have hypertension (OR = 2.78; 95% CI: 1.94–4.04, \( P < 0.001 \)), diabetes (OR = 1.87; 95% CI: 1.29–2.71, \( P = 0.001 \)), lipid disorder (OR = 1.82; 95% CI: 1.34–2.43, \( P < 0.001 \)).
Table 2.  Distribution of chronic diseases in women and men with and without CHD.

| Health condition                  | Participants with CHD |          |          | Participants without CHD |          |          |
|-----------------------------------|-----------------------|----------|----------|---------------------------|----------|----------|
|                                   | Female (n = 185)     | Male (n = 362) | P-value  | Female (n = 2852)         | Male (n = 2383) |          |
|                                   | %        | %        |          | %        | %        |          |
| Hypertension                      | 80.2     | 81.3     | 0.789    | 43.6     | 46.7     |          |
| Joint pain in the last 12 months  | 79.8     | 67.2     | 0.003    | 67.6     | 58.6     |          |
| Dyslipidemia                      | 68.9     | 64.0     | 0.261    | 34.6     | 37.2     |          |
| Osteoarthritis                    | 51.1     | 37.8     | 0.004    | 33.1     | 23.9     |          |
| Obesity (BMI ≥ 30 kg/m²)          | 34.6     | 32.5     | 0.621    | 26.8     | 25.8     |          |
| Gout or high uric acid            | 25       | 31.8     | 0.109    | 7.6      | 17.2     |          |
| Diabetes mellitus                 | 28       | 28.5     | 0.886    | 7.7      | 9.7      |          |
| Thyroid disease                   | 59.7     | 20.1     | < 0.001  | 42.5     | 13.0     |          |
| Stomach ulcers disease            | 14.8     | 16.2     | 0.68     | 8.1      | 9.7      |          |
| Cancer                            | 14       | 13.5     | 0.83     | 10.3     | 7.9      |          |
| Depression                        | 25.1     | 10.5     | < 0.001  | 16.7     | 8.5      |          |
| Stroke                            | 9.4      | 9.5      | 0.961    | 2.0      | 3.2      |          |
| Hepatitis                         | 12       | 9.5      | 0.362    | 7.8      | 6.9      |          |
| Chronic kidney disease            | 9.2      | 7.5      | 0.482    | 1.7      | 1.6      |          |
| Asthma                            | 12.7     | 6.9      | 0.026    | 8.5      | 6.0      |          |
| Osteoporosis                      | 28.7     | 5.9      | < 0.001  | 11.6     | 3.0      |          |
| Anxiety disorder                  | 14.6     | 5.0      | < 0.001  | 7.1      | 3.0      |          |
| Migraine                          | 25.7     | 4.4      | < 0.001  | 18.6     | 5.0      |          |
| Rheumatic arthritis               | 6.8      | 4.2      | 0.195    | 4.0      | 2.3      |          |
| Burnout syndrome                  | 5.4      | 2.8      | 0.127    | 5.7      | 4.2      |          |
| Chronic inflammatory bowel disease| 2.2      | 1.7      | 0.658    | 1.7      | 1.2      |          |
| Epilepsy                          | 1.6      | 1.1      | 0.609    | 1.2      | 1.7      |          |
| Liver cirrhosis                   | 0        | 0.8      | 0.261    | 0.2      | 0.8      |          |

The prevalence rates are adjusted with weights to reflect the German population. BMI: body mass index; CHD: coronary heart disease.

Table 3.  Association between CHD and chronic diseases in female and male.

| Gender | Health condition                  | Model 1 OR (95% CI) | Model 2 OR (95% CI) | Model 3 OR (95% CI) |
|--------|-----------------------------------|---------------------|---------------------|---------------------|
| Female | Hypertension                       | 3.45 (2.00–5.93)    | 2.83 (1.63–4.92)    | 3.28 (1.81–5.94)    |
|        | Lipid disorders                    | 2.42 (1.56–3.76)    | 2.15 (1.38–3.35)    | 2.40 (1.50–3.83)    |
|        | Diabetes                           | 2.51 (1.54–4.10)    | 2.24 (1.36–3.69)    | 2.08 (1.24–3.50)    |
|        | Chronic kidney disease             | 2.43 (0.99–5.95)    | 2.37 (0.92–6.13)    | 2.66 (1.01–6.99)    |
|        | High uric acid or gout             | 2.06 (1.24–3.42)    | 2.07 (1.23–3.47)    | 2.08 (1.22–3.56)    |
|        | Thyroid disease                    | 1.62 (1.08–2.44)    | 1.67 (1.10–2.53)    | 1.81 (1.18–2.79)    |
|        | Osteoporosis                       | 2.33 (1.43–3.80)    | 1.82 (1.11–2.99)    | 1.69 (1.01–2.84)    |
| Male   | Hypertension                       | 3.09 (2.19–4.34)    | 2.67 (1.87–3.78)    | 2.78 (1.94–4.04)    |
|        | Lipid disorders                    | 1.85 (1.39–2.48)    | 1.89 (1.39–2.55)    | 1.82 (1.34–2.43)    |
|        | Diabetes                           | 2.22 (1.57–3.13)    | 1.85 (1.29–2.65)    | 1.87 (1.29–2.71)    |
|        | Chronic kidney disease             | 3.58 (1.78–7.22)    | 3.56 (1.74–7.31)    | 3.16 (1.49–6.73)    |
|        | High uric acid or gout             | 1.05 (0.76–1.46)    | 1.06 (0.75–1.48)    | 1.09 (0.77–1.55)    |
|        | Thyroid disease                    | 1.40 (0.98–2.00)    | 1.22 (0.84–1.76)    | 1.13 (0.77–1.67)    |
|        | Osteoporosis                       | 1.82 (0.91–3.65)    | 1.86 (0.92–3.77)    | 1.40 (0.65–3.03)    |

Odds ratio (OR) and 95% confidence interval (CI) obtained from multivariable logistic regression analysis; *Significant association. Model 1: Crude OR; Model 2: OR adjusted for age group, social status, education and employment status, smoking status, and body mass index; Model 3: OR adjusted for age group, social status, education and employment status, smoking status, and body mass index and with sample weights. CHD: coronary heart disease.
prevalence of CHD. The likelihood of CHD increased monotonically as glomerular filtration rate decreased not only is the frequent association between the two diseases important, but also the cumulative risk when both conditions are present in the same person.[39] It is well-known that the population with CHD and CKD has higher mortality regardless of the treatment used for coronary disease.[38] For example, among patients with acute coronary syndrome (ACS) who also have CKD, mortality is increased twofold versus patients with ACS and normal kidney function.[21] As far as we are aware, only one other study, by Sabe, et al.,[22] compared patients with and without CHD in regards to kidney function. They reported that patients with CHD were more likely to progress to end-stage renal disease.

The main pathophysiological mechanism involved in the CHD-CKD relationship appears to be endothelial dysfunction, which leads to the progression of atherosclerotic lesions.[23] Nonetheless, other mechanisms including inflammation, systemic arterial hypertension, and vascular calcification play important roles in the development of both chronic conditions.[24–26]

In women, CHD was also significantly associated with thyroid disease, gout or high uric acid levels, and osteoporosis. There is evidence to suggest an association between abnormal thyroid function and CHD.[27,28] For instance, Mayer, et al.[28] examined patients after acute myocardial infarction and demonstrated hypothyroidism was more prevalent in patients with clinical CHD. Similar to our study, thyroid dysfunction was more prevalent in female than in male CHD patients (23% vs. 7%, respectively). Consequently, thyroid function screening seems warranted, especially in female coronary patients. This is important because CHD, with concomitant thyroid dysfunction, is associated with a more severe clinical condition and with poorer clinical outcomes.[23,29] For example, Friberg, et al.[29] reported about 20% of patients experienced a decrease of free triiodo-thyronine (FT3) levels after myocardial infarction. FT3 was the most important predictor of subsequent cardiac events.[23] In another study of patients with CHD, thyroid dysfunction including subclinical hypothyroidism, subclinical hyperthyroidism and low T3 syndrome were associated with higher incidence of major cardiac events.[30] Furthermore, thyroid concentration alterations have been associated with worse prognosis in patients with ischemic left ventricular dysfunction in chronic stable heart failure.[31] Potential mechanisms that link coronary artery disease with thyroid dysfunction are endothelial dysfunction, dyslipidemia, myocardial systolic and diastolic dysfunction, and changes in blood pressure.[32–34] Several studies have demonstrated that thyroid hormones regulate endothelial nitric oxide production and vascular tone and that patients with hypothyroidism exhibit impaired endothelial function.[35] Also, hypothyroidism is associated with hypercholesterolemia and a marked increases in low-density lipoproteins and apolipoprotein B, which promotes atherogenesis.[34] In contrast, hyperthyroidism causes a hyperdynamic circulation with increased blood pressure, cardiac output, and contractility.[33]

CHD was also associated with gout or high uric acid levels in women. Gout and cardiovascular disease frequently coexist in the general population.[36] Our results confirmed this relationship and suggest that female CHD patients are more likely to also have gout than female patients without CHD. This is important because the co-occurrence of both chronic conditions may worsen outcomes. A recent study assessed the long-term association between gout and CHD in men and women.[37] The data suggest gout is associated with worse long-term cardiovascular clinical outcomes and all-cause mortality in patients with CHD. Another study focused on male patients with gout and known CHD. In this Canadian survey, the presence of gout was associated with a 26% increase in the risk of cardiovascular death.[38] Possible mechanisms that may provide a link between gout and CHD are oxidative stress and inflammation.[39] Oxidative stress is generated by xanthine oxidase, an enzyme that catalyzes the formation of uric acid.[40] Allopurinol, a xanthine oxidase inhibitor, has been shown to reduce oxidative stress and mitigate endothelial dysfunction in patients with stable CHD.[41] Furthermore, low-grade inflammation has an important role in the pathogenesis of CHD and gout.[42] Previous work has failed to establish if uric acid plays a definite role in CHD or is simply highly correlated with known risk factors such as hypertension and lipid disorders.[43] However, the association in women, but not in men, gives support to the former interpretation.

In women, CHD was also associated with osteoporosis. Research demonstrates that CHD and osteoporosis often present together. For example, women with osteoporosis showed a 3.9-fold increased risk for cardiovascular events.[44] Another study, by Markovitz, et al.,[45] demonstrated that osteoporosis was associated with angiographically-determined CHD in women (OR = 5.6; 95% CI: 2.6–12.0). Both chronic conditions share common risk factors, such as smoking, low physical activity, and elevated BMI.[46] In addition, potential pathophysiological mechanisms that may link osteoporosis and CHD have been suggested. These include low bone mineral density, oestrogen deficiency, inflammatory process, oxidized lipids, vitamin K deficiency, and vitamin D metabolism.[47]
Our results demonstrate that the association between CHD and other chronic diseases differ in women and men. Identifying gender-specific needs is essential to develop new strategies to improve patients’ outcomes and manage resource allocation. Future research should aim to clarify if special programs for CHD patients addressing these gender-specific comorbidity associations in advance reduce inpatient care and decrease healthcare costs.

4.1 Limitations

The diagnosis for CHD was obtained by a self-administered questionnaire. Misclassification of CHD cannot be excluded, because, especially in women, CHD is often under-diagnosed due to public and professional under-appreciation of women’s coronary risk. Nevertheless, a Norwegian survey found a very high positive predictive value (93%) for CHD. Similarly, our study used self-reported measures of behavioral factors, such as smoking status, and chronic diseases and so their prevalence may be underestimated. Although the survey’s overall participation rate (about 50%) was similar to other European national health surveys, we cannot rule out selection bias. Reasons for non-participation were lack of time, health-related issues and language problems. The main limitation of cross-sectional studies is that cause and effect cannot be determined. Therefore, we do not know if CHD was present before the other comorbidities, occurred afterwards, or developed simultaneously. These distinctions will be relevant for screening, but, not in terms of treatment once they are present. Lastly, we cannot rule out the presence of residual confounding.

4.2 Conclusion

Our analysis of national survey data revealed that CHD was associated with two sets of chronic condition, one shared by both genders and the second found only in women. The shared set comprised three well-known risk factors for CHD (hypertension, lipid disorders, and diabetes mellitus) and chronic kidney disease. The second set found in women consisting of thyroid disease, osteoporosis and gout/high uric acid may be of greater interest in terms of both optimizing screening and treatment strategies.

Acknowledgments

All authors have no conflicts of interest related to the subject of the article. No competing financial interests exist.

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### Supplementary Data

Table S1. DEGS1 survey and list of variables.

| Variable                  | Variable code | Questions and answer categories                                                                 |
|---------------------------|---------------|---------------------------------------------------------------------------------------------------|
| Gender                    | Sex           | What is your gender? 1 Male 2 Female                                                               |
| Age                       | Age10B        | When were you born? Day/months/year                                                                  |
| BMI                       | USBMI_st      | How much do you weight without clothes? How tall are you without shoes?                            |
| Physical activity         | KAempf_k2     | Do you exercise 2.5 hours per week or more? 1 Yes 2 No                                             |
| Smoking                   | RCstat_k      | Do you currently smoke-even if it’s only occasionally? 1 Yes, daily 2 Yes, occasionally 3 No, not anymore 4 Have never smoked |
| Social status*            | SDses         | Socioeconomic status: 1 low 2 medium 3 high                                                          |
|                           |               | Education level: 0 Pre-primary 1 Primary 2 lower secondary 3 Upper secondary 4 Post-secondary        |
|                           |               | non-tertiary 5 First stage tertiary 6 Second stage of tertiary education                            |
| Education status          | SDisced97eu   | Low (ISCED 0,1 or 2)                                                                                 |
|                           |               | Middle (ISCED 3 or 4)                                                                                |
|                           |               | High (ISCED 5 or 6)                                                                                 |
| Employment status         | SDerwtB       | Are you currently employed? This means any paid activity or activity associated with income,        |
|                           |               | regardless of the timescale? Note: occasional workers, who are not presently in work, are also regarded as employed. 1 Yes 2 No |
| Chronic diseases          |               | Has a doctor ever told you that you have circulatory disorders in the heart or a narrowing of the coronary arteries? Note: coronary heart disease or angina pectoris is also referred to here. 1 Yes 2 No Or Has a doctor ever diagnosed you with a heart attack? 1 Yes 2 No |
| CHD                       | KHlkhkmyo     | Has a doctor ever told you that you have high blood pressure or hypertonia in you?                  |
| Hypertension              | KHiyp         | Has a doctor ever told you that you have a disease of the thyroid? 1 Yes 2 No                      |
|                           |               | Note: this only means medical diagnoses! 1 Yes 2 No                                                |
| Joint pain                | SZglk12       | Have you had joint pain in the last 12 months?                                                     |
| Dyslipidemia              | KHflipB       | Has a doctor ever detected elevated blood lipids or high cholesterol levels in you? 1 Yes 2 No     |
| Obesity                   | USadipos      | Measured weight                                                                                     |
| Osteoarthritis            | KHidge        | Has a doctor ever told you that you have arthritis or degenerative joint disease?                  |
|                           |               | Note: arthritis = osteoarthrosis. 1 Yes 2 No                                                        |
| Thyroid disease           | KHiSD         | Has a doctor ever told you that you have a disease of the thyroid? 1 Yes 2 No                      |
| Gout/high uric acid level | KHihs         | Has a doctor ever told you that you have a high uric acid level or gout? 1 Yes 2 No                |
| Diabetes mellitus         | KHiDiab       | Has a doctor ever told you that you have a sugar related illness or diabetes? 1 Yes 2 No          |
| Depression                | PKdepB        | Are you currently treated for depression? 1 Yes 2 No                                               |
| Cancer                    | KHiKarz       | Has a doctor ever told you that you have cancer or a malignant tumor? 1 Yes 2 No                   |
| Stroke                    | KHiSt         | Has a doctor ever told you that you have a stroke? 1 Yes 2 No                                     |
| Ulcer disease             | KHule         | Has a doctor ever told you that you have an ulcer disease? 1 Yes 2 No                              |
| Chronic kidney disease    | KHiN          | Has a doctor ever told you that you have chronic kidney disease? 1 Yes 2 No                       |
| Asthma                    | KHiAb         | Has a doctor ever told you that you have asthma? 1 Yes 2 No                                       |
| Migraine                  | KHiMig        | Has a doctor ever told you that you have migraine? 1 Yes 2 No                                     |
| Burn out syndrome         | KHiBos        | Has a doctor ever told you that you have burn out syndrome? 1 Yes 2 No                             |
| Chronic inflammatory      | KHiCed        | Has a doctor ever told you that you have chronic inflammatory bowel disease? 1 Yes 2 No           |
| bowel disease             |               |                                                                                                    |
| Epilepsy                  | KHelep        | Has a doctor ever told you that you have epilepsy? 1 Yes 2 No                                     |
| Liver cirrhosis           | KHiuz         | Has a doctor ever told you that you have liver cirrhosis? 1 Yes 2 No                              |
| Anxiety Disorder          | PKangst       | Has a doctor ever told you that you have anxiety disorder? 1 Yes 2 No                             |
| Osteoporosis              | KHiOs         | Has a doctor ever told you that you have osteoporosis? 1 Yes 2 No                                 |
| Rheumatic arthritis       | KHiRac        | Has a doctor ever told you that you have rheumatic arthritis? 1 Yes 2 No                         |
| Hepatitis                 | KHihep        | Has a doctor ever told you that you have hepatitis? 1 Yes 2 No                                    |

*The social status was calculated with a previously published index by Lampert et al. (2013). [5]*
Table S2.1.  Model 1- Association between CHD and chronic diseases analyzed in women without weights and without adjustment.

| Chronic disease                        | OR   | 95% CI       | p-value |
|----------------------------------------|------|--------------|---------|
| Hypertension                           | 3.45 | 2.00 to 5.93 | 0.000   |
| Stroke                                 | 1.67 | 0.74 to 3.78 | 0.221   |
| Diabetes mellitus                      | 2.51 | 1.54 to 4.10 | 0.000   |
| Thyroid disease                        | 1.62 | 1.08 to 2.44 | 0.020   |
| Adiposity (BMI ≥ 30)                   | 1.05 | 0.67 to 1.65 | 0.832   |
| Dyslipidemia                           | 2.42 | 1.56 to 3.76 | 0.000   |
| Chronic kidney disease                 | 2.43 | 0.99 to 5.95 | 0.051   |
| Cancer                                 | 1.26 | 0.72 to 2.18 | 0.420   |
| Gastric ulcer                          | 0.95 | 0.51 to 1.78 | 0.879   |
| Chronic inflammatory bowel syndrome    | 0.94 | 0.23 to 3.94 | 0.934   |
| Liver cirrhosis                        | 0.00 | 0.00         | 0.999   |
| Osteoarthrosis                         | 1.09 | 0.70 to 1.70 | 0.696   |
| Rheumatic arthritis                    | 0.79 | 0.31 to 2.04 | 0.632   |
| Osteoporosis                           | 2.33 | 1.43 to 3.80 | 0.001   |
| Gout or high uric acid                 | 2.06 | 1.24 to 3.42 | 0.005   |
| Migraine                               | 1.19 | 0.73 to 1.94 | 0.490   |
| Epilepsy                               | 0.47 | 0.05 to 4.33 | 0.507   |
| Depression                             | 0.87 | 0.49 to 1.56 | 0.648   |
| Anxiety disorder                       | 1.80 | 0.88 to 3.68 | 0.105   |
| Burn out syndrome                      | 0.43 | 0.14 to 1.37 | 0.154   |
| Asthma                                 | 1.28 | 0.68 to 2.43 | 0.447   |
| Joint pain in the last 12 months       | 0.94 | 0.55 to 1.59 | 0.807   |
| Hepatitis                              | 1.02 | 0.52 to 1.98 | 0.961   |

Table S2.2.  Model 1- Association between CHD and chronic diseases analyzed in men without weights and without adjustment.

| Chronic disease                        | OR   | 95% CI       | p-value |
|----------------------------------------|------|--------------|---------|
| Hypertension                           | 3.09 | 2.19 to 4.34 | 0.0001  |
| Stroke                                 | 1.29 | 0.73 to 2.31 | 0.380   |
| Diabetes mellitus                      | 2.22 | 1.57 to 3.13 | 0.0001  |
| Thyroid disease                        | 1.40 | 0.98 to 2.00 | 0.063   |
| Adiposity (BMI ≥ 30)                   | 1.06 | 0.77 to 1.46 | 0.709   |
| Dyslipidemia                           | 1.85 | 1.39 to 2.48 | 0.0001  |
| Chronic kidney disease                 | 3.58 | 1.78 to 7.22 | 0.0001  |
| Cancer                                 | 1.32 | 0.87 to 2.01 | 0.194   |
| Gastric ulcer                          | 1.13 | 0.74 to 1.71 | 0.576   |
| Chronic inflammatory bowel syndrome    | 0.96 | 0.26 to 3.53 | 0.956   |
| Liver cirrhosis                        | 0.77 | 0.18 to 3.22 | 0.715   |
| Osteoarthrosis                         | 1.16 | 0.84 to 1.59 | 0.375   |
| Rheumatic arthritis                    | 1.36 | 0.63 to 2.96 | 0.436   |
| Osteoporosis                           | 1.82 | 0.91 to 3.65 | 0.093   |
| Gout or high uric acid                 | 1.05 | 0.76 to 1.46 | 0.756   |
| Migraine                               | 0.79 | 0.382 to 1.64| 0.525   |
| Epilepsy                               | 0.65 | 0.16 to 2.59 | 0.541   |
| Depression                             | 1.05 | 0.60 to 1.82 | 0.873   |
| Anxiety disorder                       | 1.95 | 0.90 to 4.20 | 0.089   |
| Burn out syndrome                      | 0.38 | 0.13 to 1.14 | 0.083   |
| Asthma                                 | 0.91 | 0.49 to 1.71 | 0.775   |
| Joint pain in the last 12 months       | 1.12 | 0.82 to 1.54 | 0.475   |
| Hepatitis                              | 1.63 | 0.98 to 2.59 | 0.036   |
Table S2.3. Model 2- Association between CHD and chronic diseases analyzed in women without weights and adjusted for age group, social status, education and employment status, smoking status, and body mass index.

| Chronic disease                                      | OR   | 95% CI        | p-value |
|------------------------------------------------------|------|---------------|---------|
| Hypertension                                         | 2.83 | 1.63 to 4.92  | 0.0001  |
| Stroke                                               | 1.36 | 0.59 to 3.07  | 0.466   |
| Diabetes mellitus                                     | 2.24 | 1.36 to 3.69  | 0.002   |
| Thyroid disease                                       | 1.67 | 1.10 to 2.53  | 0.016   |
| Adiposity (BMI ≥ 30)                                  | 1.05 | 0.66 to 1.67  | 0.827   |
| Dyslipidemia                                          | 2.15 | 1.38 to 3.35  | 0.001   |
| Chronic kidney disease                                | 2.37 | 0.92 to 6.13  | 0.074   |
| Cancer                                               | 1.13 | 0.65 to 1.98  | 0.667   |
| Gastric ulcer                                         | 0.86 | 0.46 to 1.62  | 0.647   |
| Chronic inflammatory bowel syndrome                   | 1.15 | 0.27 to 4.78  | 0.845   |
| Liver cirrhosis                                       | 0.00 | 0.00          | 0.999   |
| Osteoarthritis                                        | 0.94 | 0.59 to 1.47  | 0.779   |
| Rheumatic arthritis                                   | 1.08 | 0.32 to 1.22  | 0.678   |
| Osteoporosis                                          | 1.24 | 0.75 to 2.05  | 0.411   |
| Gout or high uric acid                                | 2.07 | 1.23 to 3.47  | 0.006   |
| Migraine                                             | 1.24 | 0.75 to 2.05  | 0.411   |
| Epilepsy                                             | 0.66 | 0.08 to 5.51  | 0.701   |
| Depression                                            | 0.93 | 0.51 to 1.68  | 0.801   |
| Anxiety disorder                                      | 1.71 | 0.83 to 3.50  | 0.145   |
| Burn out syndrome                                     | 0.62 | 0.19 to 2.03  | 0.426   |
| Asthma                                               | 1.20 | 0.62 to 2.32  | 0.599   |
| Joint pain in the last 12 months                     | 1.01 | 0.59 to 1.72  | 0.974   |
| Hepatitis                                            | 0.98 | 0.49 to 1.98  | 0.961   |

Table S2.4. Model 2- Association between CHD and chronic diseases analyzed in men without weights and adjusted for age group, social status, education and employment status, smoking status, and body mass index.

| Chronic disease                                      | OR   | 95% CI        | p-value |
|------------------------------------------------------|------|---------------|---------|
| Hypertension                                         | 2.67 | 1.87 to 3.78  | 0.000   |
| Stroke                                               | 0.91 | 0.50 to 1.67  | 0.769   |
| Diabetes mellitus                                     | 1.85 | 1.29 to 2.65  | 0.001   |
| Thyroid disease                                       | 1.22 | 0.84 to 1.76  | 0.304   |
| Adiposity (BMI ≥ 30)                                  | 1.19 | 0.85 to 1.67  | 0.310   |
| Dyslipidemia                                          | 1.89 | 1.39 to 2.55  | 0.000   |
| Chronic kidney disease                                | 3.56 | 1.74 to 7.31  | 0.001   |
| Cancer                                               | 0.99 | 0.64 to 1.54  | 0.979   |
| Gastric ulcer                                         | 0.99 | 0.64 to 1.54  | 0.988   |
| Chronic inflammatory bowel syndrome                   | 0.84 | 0.22 to 3.14  | 0.791   |
| Liver cirrhosis                                       | 0.60 | 0.13 to 2.73  | 0.513   |
| Osteoarthritis                                        | 1.05 | 0.76 to 1.48  | 0.747   |
| Rheumatic arthritis                                   | 1.09 | 0.49 to 2.44  | 0.823   |
| Osteoporosis                                          | 1.86 | 0.92 to 3.77  | 0.085   |
| Gout or high uric acid                                | 1.06 | 0.75 to 1.48  | 0.757   |
| Migraine                                             | 0.92 | 0.44 to 1.95  | 0.835   |
| Epilepsy                                             | 0.74 | 0.19 to 2.91  | 0.667   |
| Depression                                            | 1.18 | 0.68 to 2.07  | 0.555   |
| Anxiety disorder                                      | 1.86 | 0.85 to 4.09  | 0.121   |
| Burn out syndrome                                     | 0.53 | 0.17 to 1.63  | 0.268   |
| Asthma                                               | 0.89 | 0.47 to 1.70  | 0.728   |
| Joint pain in the last 12 months                     | 1.18 | 0.85 to 1.65  | 0.322   |
| Hepatitis                                            | 1.60 | 0.99 to 2.58  | 0.053   |
Table S2.5. Model 3- Association between CHD and chronic diseases analyzed in women with weights and adjusted for age group, social status, education and employment status, smoking status, and body mass index.

| Chronic disease                         | OR  | 95% CI          | p-value |
|----------------------------------------|-----|----------------|---------|
| Hypertension                           | 3.28| 1.81 to 5.94    | 0.0001  |
| Stroke                                 | 1.46| 0.63 to 3.39    | 0.374   |
| Diabetes mellitus                      | 2.08| 1.24 to 3.50    | 0.006   |
| Thyroid disease                        | 1.81| 1.18 to 2.79    | 0.007   |
| Adiposity (BMI ≥ 30)                   | 1.02| 0.63 to 1.64    | 0.934   |
| Dyslipidemia                           | 2.40| 1.50 to 3.83    | 0.0001  |
| Chronic kidney disease                 | 2.66| 1.01 to 6.99    | 0.047   |
| Cancer                                 | 1.01| 0.56 to 1.83    | 0.972   |
| Gastric ulcer                          | 0.694| 0.35 to 1.37   | 0.291   |
| Chronic inflammatory bowel syndrome    | 1.21| 0.27 to 5.38    | 0.799   |
| Liver cirrhosis                        | 0.000| 0.000          | 0.999   |
| Osteoarthrosis                         | 0.98| 0.61 to 1.56    | 0.923   |
| Rheumatic arthritis                    | 0.89| 0.34 to 2.35    | 0.818   |
| Osteoporosis                           | 1.69| 1.01 to 2.84    | 0.055   |
| Gout or high uric acid                 | 2.08| 1.22 to 3.56    | 0.008   |
| Migraine                               | 1.31| 0.08 to 2.21    | 0.308   |
| Epilepsy                               | 0.64| 0.07 to 5.71    | 0.690   |
| Depression                             | 1.03| 0.56 to 1.88    | 0.926   |
| Anxiety disorder                       | 1.56| 0.74 to 3.30    | 0.243   |
| Burn out syndrome                      | 0.63| 0.19 to 2.10    | 0.449   |
| Asthma                                 | 1.32| 0.67 to 2.59    | 0.418   |
| Joint pain in the last 12 months       | 1.02| 0.59 to 1.8     | 0.945   |
| Hepatitis                              | 1.18| 0.59 to 2.40    | 0.636   |

Table S2.6. Model 3- Association between CHD and chronic diseases analyzed in men with weights and adjusted for age group, social status, education and employment status, smoking status, and body mass index.

| Chronic disease                         | OR  | 95% CI          | p-value |
|----------------------------------------|-----|----------------|---------|
| Hypertension                           | 2.80| 1.94 to 4.04    | 0.0001  |
| Stroke                                 | 0.94| 0.51 to 1.74    | 0.837   |
| Diabetes mellitus                      | 1.87| 1.29 to 2.71    | 0.001   |
| Thyroid disease                        | 1.13| 0.77 to 1.67    | 0.527   |
| Adiposity (BMI ≥ 30)                   | 1.10| 0.78 to 1.56    | 0.578   |
| Dyslipidemia                           | 1.82| 1.34 to 2.47    | 0.0001  |
| Chronic kidney disease                 | 3.16| 1.49 to 6.73    | 0.003   |
| Cancer                                 | 1.05| 0.67 to 1.65    | 0.822   |
| Gastric ulcer                          | 1.05| 0.67 to 1.63    | 0.840   |
| Chronic inflammatory bowel syndrome    | 0.89| 0.23 to 3.41    | 0.862   |
| Liver cirrhosis                        | 0.74| 0.16 to 3.47    | 0.698   |
| Osteoarthrosis                         | 0.99| 0.71 to 1.41    | 0.982   |
| Rheumatic arthritis                    | 1.17| 0.53 to 2.61    | 0.695   |
| Osteoporosis                           | 1.40| 0.65 to 3.03    | 0.388   |
| Gout or high uric acid                 | 1.09| 0.77 to 1.55    | 0.608   |
| Migraine                               | 0.95| 0.45 to 2.01    | 0.896   |
| Epilepsy                               | 0.52| 0.11 to 2.53    | 0.418   |
| Depression                             | 1.16| 0.66 to 2.06    | 0.604   |
| Anxiety disorder                       | 1.56| 0.662 to 3.68   | 0.308   |
| Burn out syndrome                      | 0.57| 0.19 to 1.75    | 0.324   |
| Asthma                                 | 0.89| 0.46 to 1.73    | 0.733   |
| Joint pain in the last 12 months       | 1.28| 0.91 to 1.80    | 0.153   |
| Hepatitis                              | 1.52| 0.92 to 2.50    | 0.100   |