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# Burden of cardiovascular diseases and depression attributable to psychosocial work exposures in 28 European countries

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**Background:** This study aimed to estimate the annual burden of cardiovascular diseases and depression attributable to five psychosocial work exposures in 28 European Union countries (EU28) in 2015. **Methods:** Based on available attributable fraction estimates, the study covered five exposures, job strain, effort–reward imbalance, job insecurity, long working hours and workplace bullying; and five outcomes, coronary/ischemic heart diseases (CHD), stroke, atrial fibrillation, peripheral artery disease and depression. We estimated the burden attributable to each exposure separately and all exposures together. We calculated Disability-Adjusted Life Years (DALY) rate per 100 000 workers in each country for each outcome attributable to each exposure and tested the differences between countries and between genders using the Wald test. **Results:** The overall burden of CHD attributable to the five studied psychosocial work exposures together was estimated at 173 629 DALYs for men and 39 238 for women, 5092 deaths for men and 1098 for women in EU28 in 2015. The overall burden of depression was estimated at 528 549 DALYs for men and 344 151 for women (respectively 7862 and 1823 deaths). The three highest burdens in DALYs in EU28 in 2015 were found for depression attributable to job strain (546 502 DALYs), job insecurity (294 680 DALYs) and workplace bullying (276 337 DALYs). Significant differences between countries were observed for DALY rates per 100 000 workers. **Conclusions:** Such results are necessary as decision tools for decision-makers (governments, employers and trade unions) when defining public health priorities and work stress preventive strategies in Europe.

## Introduction

Psychosocial work factors are a major occupational hazard in European countries. They may be highly prevalent in these countries and are associated with cardiovascular diseases (CVD) and mental disorders, especially depression, with a high level of evidence in the literature.<sup>1</sup> These health outcomes represent a high and increasing burden in terms of morbidity and mortality. Prevalent cases of CVD have raised by 26% between 1990 and 2019 in 28 European Union member countries (EU28) (from 47.6 to 59.9 million), the increase being higher for men (36%) than for women (18%). Prevalent cases of depressive disorders increased by 11% between 1990 and 2019 in EU28 (13% for men and 10% for women).<sup>2</sup>

Yet, evaluations of the burden of diseases attributable to occupational exposures are seldom in the literature and these are even scarcer for psychosocial work exposures. In Europe, only a few studies provided estimates of the burden of these exposures in Denmark and Sweden,<sup>3</sup> and in France,<sup>4</sup> and they were limited to job strain exposure only. Other studies were conducted in the USA,<sup>5</sup> Australia<sup>6</sup> and South Korea.<sup>7</sup> There is no study available on the burden of psychosocial work factors encompassing all European Union (EU) countries and covering several concepts of psychosocial work factors. However, such results are necessary as decision tools for decision-makers and policymakers (governments, employers and trade unions) in order to identify preventive priorities in occupational health.

Indeed, such estimates are difficult to produce since data on the number of cases of occupational diseases available in work

compensation statistical systems are heavily underestimated. Several estimates of under-reporting and under-coverage were produced for work-related diseases,<sup>8–10</sup> and this phenomenon is all the more present for diseases due to psychosocial work factors since they are often not recognized as work-related diseases by public health insurance systems in EU countries.<sup>11</sup>

The objectives of this study were to estimate the annual burden of CVD and depression attributable to psychosocial work exposures in EU28 in 2015. This study was based on up-to-date estimates of fractions of CVD and depression attributable to five psychosocial work exposures in Europe<sup>12</sup> and on a new formula for the estimation of the overall fraction of diseases attributable to multiple dependent risk factors.<sup>13</sup> This is the first study focusing on the morbidity and mortality burden of diseases attributable to five different psychosocial work exposures, encompassing several health outcomes and covering 28 EU member states (Austria, Belgium, Bulgaria, Croatia, Republic of Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and UK).

## Methods

### Attributable fractions

Fractions of CVD and depression attributable to psychosocial work exposures in Europe were provided in one of our previous publications<sup>12</sup> and covered job strain, effort–reward imbalance (ERI), job

insecurity, long working hours and workplace bullying. Attributable fraction (AF) estimates were based on the prevalences of exposure to these factors obtained from the 2015 European Working Conditions survey data of the European Foundation for the improvement of living and working conditions (EUROFOUND). Relative risk (RR) estimates were obtained from the literature.<sup>1,12</sup>

We used the same AFs to estimate the number of morbidity and mortality cases attributable to each psychosocial work exposure. RRs used to compute AFs derived from meta-analyses based on prospective studies. However, meta-analyses were missing for mortality. Comparison between the rare available studies on cardiovascular mortality<sup>14,15</sup> and meta-analyses on cardiovascular morbidity<sup>16</sup> suggested RRs of similar magnitude. In the same way, a comparison between the very seldom studies on suicide ideation<sup>17</sup> and meta-analyses on depression<sup>18</sup> showed a strong similarity of RRs.

We retained all significant AFs (i.e. those with a 95% confidence interval above 0) (table 1), which allowed us to include the following diseases: coronary/ischemic heart disease (CHD), peripheral artery disease, atrial fibrillation and stroke for CVD and depression. Given the lack of available data on the prevalence of venous thromboembolism in EU28, this disease was not included.

We also provided the overall burden of a given disease attributable to the five studied psychosocial work exposures together.<sup>12</sup> Given that these exposures may be partially dependent (i.e. workers may be exposed to more than one factor), we used an approximation of the overall fractions of diseases for EU28 based on Niedhammer and Chastang's formula.<sup>13</sup> We used the overall fraction of CHD attributable to the four among five studied psychosocial work exposures together (7.88%) since RR and consequently AF were not available for the pair bullying-CHD. We also used the overall fraction of depression attributable to the five studied exposures together in EU28 in 2015 (25.95%).<sup>12,13</sup>

### Burden of diseases

In line with the Global Burden of Diseases study,<sup>19</sup> we used as health outcome indicators prevalent cases, deaths, Years of Life Lost (YLL), Years of Life Lost due to Disability (YLD) and Disability-Adjusted Life Years (DALY). These indicators were extracted from the Global Health Data Exchange (GHDx) database for the year 2015. The GHDx database provided data for all 28 EU countries, for the working-age population (15–64 years), for men and women together and for men and women separately and for CVD and depression.<sup>20,21</sup>

In the GHDx database, YLLs were computed using standard life expectancy at each age, which is based on the lowest observed death rates for each 5-year age group in populations larger than 5 million.<sup>20,21</sup> The same standard life expectancy was used for all EU countries. This method avoids ethical issues related to gaps in average life expectancy between European countries, which would attribute a greater burden to deaths occurring in countries where the life expectancy is longer. YLDs were provided by the GHDx database with the 2013 calculation of disability weights.<sup>21,22</sup>

All data were available for CVD in the GHDx database. For depression, data were not available for deaths, YLLs and consequently DALYs. As suggested in the literature, 53.7% of suicide cases were

found to be related to depression.<sup>23</sup> Thus, we extracted data related to suicide and multiplied these indicators by 53.7%, which provided an estimate of mortality related to depression. This estimation method for mortality related to depression was used previously.<sup>4</sup>

To estimate the burden of disease attributable to each exposure and all studied exposures, the health outcome indicators were multiplied by the previously mentioned AFs.

In order to provide results for the working population, we multiplied each health outcome indicator by the employment rate in each country in 2015 according to Eurostat (Labour Force Survey 2015).

### Burden per 100 000 workers

To take into account differences in population sizes between countries, we calculated the prevalence rate  $R_P$ , the mortality rate  $R_M$  and the DALY rate  $R_D$  for each health outcome attributable to each exposure per 100 000 workers as follows:

$$R_P = \frac{\text{Attributable prevalent cases} * 100\,000}{\text{Employed population (15 - 64 years)}} \quad (1)$$

$$R_M = \frac{\text{Attributable death cases} * 100\,000}{\text{Employed population (15 - 64 years)}} \quad (2)$$

$$R_D = \frac{\text{Attributable DALYs} * 100\,000}{\text{Employed population (15 - 64 years)}} \quad (3)$$

Data for the employed population were extracted from the Eurostat database (Labour Force Survey 2015). We tested the differences between countries and between genders using the Wald test.<sup>24</sup>

All results were provided for each country and the whole 28 EU, and for men and women together and separately. Statistical analyses were performed using SAS software and maps were designed using Microsoft Excel.

## Results

### Burden in prevalent cases, deaths, YLLs, YLDs and DALYs

The overall burden of CHD attributable to the four studied psychosocial work exposures together was estimated at 173 629 DALYs for men and 39 238 for women, 5092 deaths for men and 1098 for women in EU28 in 2015. The overall burden of depression attributable to the five studied exposures was estimated at 528 549 DALYs for men and 344 151 for women, 7862 deaths for men and 1823 for women (table 2).

When analyzing each psychosocial work factor separately, the three highest burdens in DALYs in EU28 in 2015 were found for depression attributable to job strain (546 502 DALYs), job insecurity (294 680 DALYs) and workplace bullying (276 337 DALYs) (table 3). The highest burdens for CHD were attributable to job insecurity (129 280 DALYs) and job strain (112 995 DALYs) (table 3). Detailed results for men, women and both genders are presented in Supplementary file S1.

**Table 1** Available and significant fractions of cardiovascular diseases and depression attributable to psychosocial work exposures for EU28 in 2015<sup>12</sup>

	Coronary/ischemic heart disease	Peripheral artery disease	Atrial fibrillation	Overall stroke	Depression
Job strain	✓	✓	NA	NS	✓
ERI	✓	NA	NA	NA	✓
Job insecurity	✓	NA	NA	NA	✓
Long working hours	✓	NA	✓	✓	✓
Workplace bullying	NA	NA	NA	NA	✓

ERI, effort–reward imbalance; NA, RR estimates were not available in the literature; NS, RR estimates were not significant in the literature.

### Burden per 100 000 workers

Differences between men and women in DALY rates per 100 000 workers in EU 28 were significant for several exposure–outcome pairs: CHD attributable to job strain and to job insecurity, peripheral artery disease attributable to job strain, and all exposure–outcome pairs related to long working hours, with a higher burden for men (Supplementary file S2, Table S2-1).

Differences between countries in prevalence, deaths and DALY rates were significant for all exposure–outcome pairs, except for the prevalence of peripheral artery disease attributable to job strain and the prevalence of CHD attributable to ERI (Supplementary file S2, Table S2-2).

At the country level, the three highest DALY rates were found for depression attributable to job strain in Lithuania and Hungary (respectively 680 and 418 DALY rate), and depression attributable to workplace bullying in France (370 DALY rate). The highest DALY rates for CHD were attributable to job insecurity in Latvia (194 DALY rate), and to job strain in Romania (157 DALY rate). Our study showed discrepancies between EU countries in the burden borne by workers. For instance, the burden in DALY rates of depression attributable to job strain was six times higher in Lithuania compared to Malta. The burden in DALY rate of depression attributable to ERI was four times higher in Slovenia than in Bulgaria. The burden of CHD attributable to job insecurity was nine times higher in Latvia compared to Denmark. The burden of stroke attributable to

long working hours was 26 times higher in Bulgaria than in Italy (Supplementary file S3).

Maps highlighted an East–West gradient for some exposure–outcome pairs: the burdens of CHD attributable to job strain, ERI, job insecurity and long working hours showed a higher burden in DALY rates in the Eastern part of the EU than in the Western part. The burden of stroke attributable to long working hours also showed an East–West gradient with a higher burden in the Eastern part of the EU (figure 1).

We stratified by country and gender the analysis of DALY rates per 100 000 workers for the two health outcomes with the highest prevalence in the employed population (CHD and depression), and for the three psychosocial work exposures with the highest prevalence of exposure (job strain, ERI and job insecurity). At the country level, gender differences in DALY rates were found in all countries for two exposure–outcome pairs (CHD attributable to job strain and to job insecurity) with a higher burden for men. There was almost no gender difference for CHD attributable to ERI whatever the country. Differences in the burden in DALY rates were observed between men and women mostly in Eastern Europe and Baltic countries for depression attributable to job strain, ERI and job insecurity, with a higher burden for men (Supplementary file S4).

## Discussion

### Main results

Our study showed a high burden of CHD and depression attributable to the five studied psychosocial work exposures in EU28 in 2015, with a higher burden for depression. Our study showed discrepancies between EU countries in the burden borne by workers, with an East–West gradient for some exposure–outcome pairs related to CHD and stroke. At the country level, differences in DALY rates per 100 000 workers between men and women were observed in all countries for CHD attributable to job strain and job insecurity and mainly in Eastern Europe and Baltic countries for depression attributable to job strain, ERI and job insecurity, with a higher burden for men.

### Differences between countries

Given the calculation method, burden differences between countries for a given exposure–outcome pair resulted from differences in two parameters:

**Table 2** Overall burden of CHD and depression attributable to all studied psychosocial work exposures in EU28 in 2015

	Prevalent cases	Deaths	YLL	YLD	DALY
CHD					
Men	203 745	5 092	166 331	7 298	173 629
Women	95 715	1 098	35 028	4 210	39 238
All	299 460	6 190	201 359	11 508	212 867
Depression					
Men	1 107 449	7 862	345 769	182 780	528 549
Women	1 631 247	1 823	77 609	266 542	344 151
All	2 738 696	9 685	423 379	449 322	872 701

CHD, coronary/ischemic heart disease.

Overall fraction for CHD: 7.88%; Overall fraction for depression: 25.95%.<sup>13</sup>

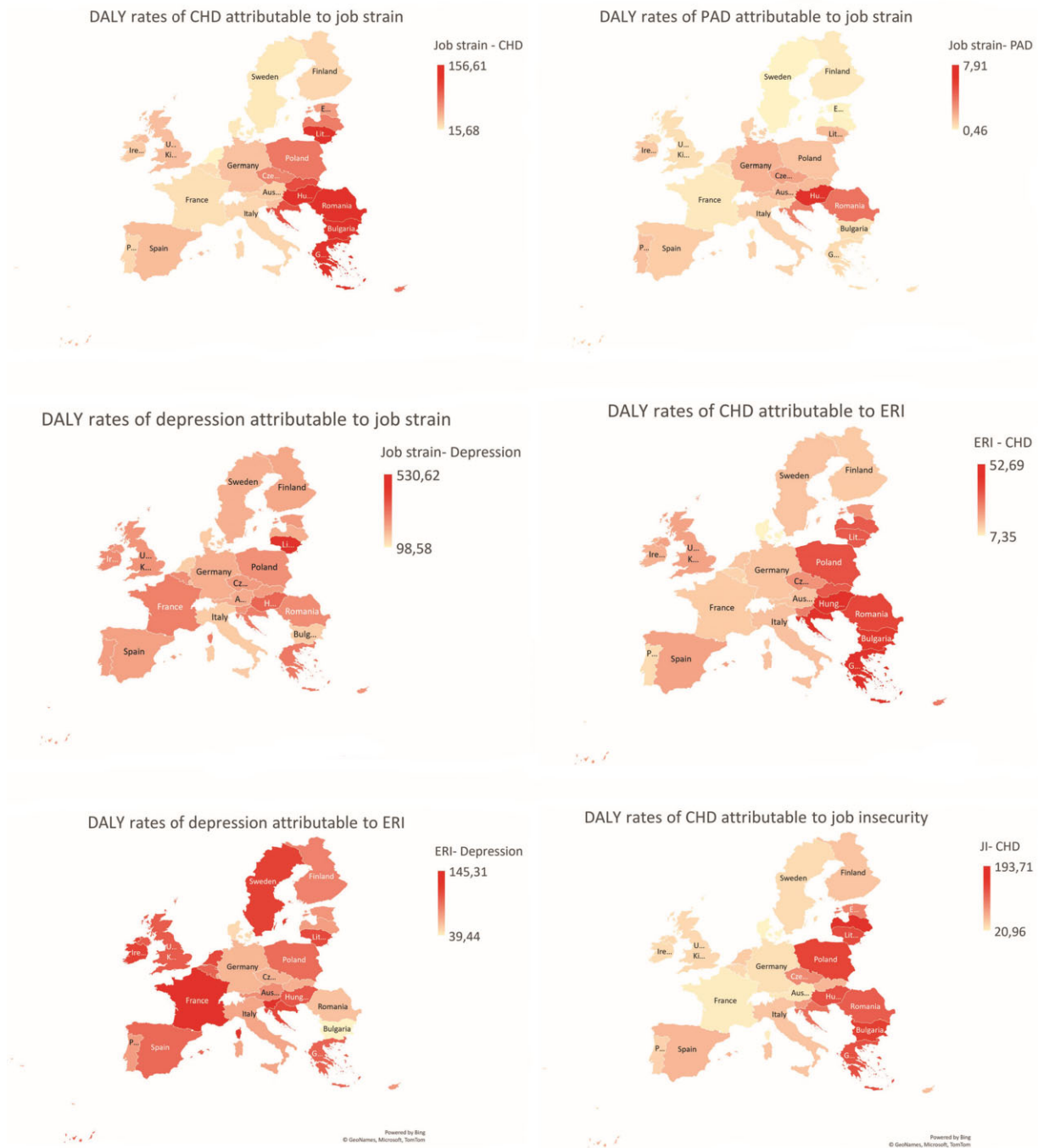
**Table 3** Burden in DALYs for the five psychosocial work factors in EU28 in 2015

	DALYs men		DALYs women		DALYs total <sup>a</sup>	
	N	95% CI	N	95% CI	N	95% CI
Job strain						
CHD	92 714	26 026–159 403	20 702	5 806–35 598	112 995	31 775–194 216
PAD	2 698	998–4 399	1 008	372–1 643	3 697	1 368–6 026
Depression	332 698	213 498–451 898	214 315	137 395–291 235	546 502	351 039–741 966
ERI						
CHD	46 795	7 699–85 891	8 378	1 347–15 410	51 502	8 474–94 531
Depression	140 200	81 054–199 347	73 054	41 728–104 381	208 844	120 682–297 006
Job insecurity						
CHD	106 036	27 076–184 996	23 710	6 045–41 375	129 280	33 121–225 438
Depression	179 422	84 322–274 523	115 643	54 286–177 000	294 680	138 791–450 568
Long working hours						
CHD	15 064	1 617–28 511	1 306	121–2 491	12 800	1 384–24 215
Stroke	14 623	4 710–24 536	3 159	950–5 368	15 859	5 097–26 621
AT	1 697	401–2 993	254	54–454	1 639	384–2 894
Depression	14 006	2 594–25 418	3 497	594–6 401	16 027	2 985–29 068
Work bullying						
Depression	167 363	106 737–227 989	125 771	81 411–170 131	276 337	176 236–376 438

CHD, coronary/ischemic heart disease; PAD, peripheral artery disease; ERI, effort–reward imbalance; AT, atrial fibrillation.

a: Sums of the two columns for men and women are more reliable than the column for total DALYs, the differences being explained by the use of a mean AF for the total population and differences in the number of DALYs for men and women.





**Figure 1** DALY rates per 100 000 workers in EU28 in 2015.

- i. Differences in AF estimates between countries. Since the same RR estimates were used for all countries, differences in AF estimates resulted from differences in the prevalence of exposure between countries.<sup>12</sup>
- ii. Differences in the public health situation between countries i.e. in the prevalence of CVD and depression in the employed population. For instance, the East–West gradient observed for the DALY rates per 100 000 workers of CHD attributable to job strain, ERI, job insecurity and long working hours, as well as stroke attributable to long working hours may be explained by the East–West gradient for cardiovascular mortality.<sup>25,26</sup>

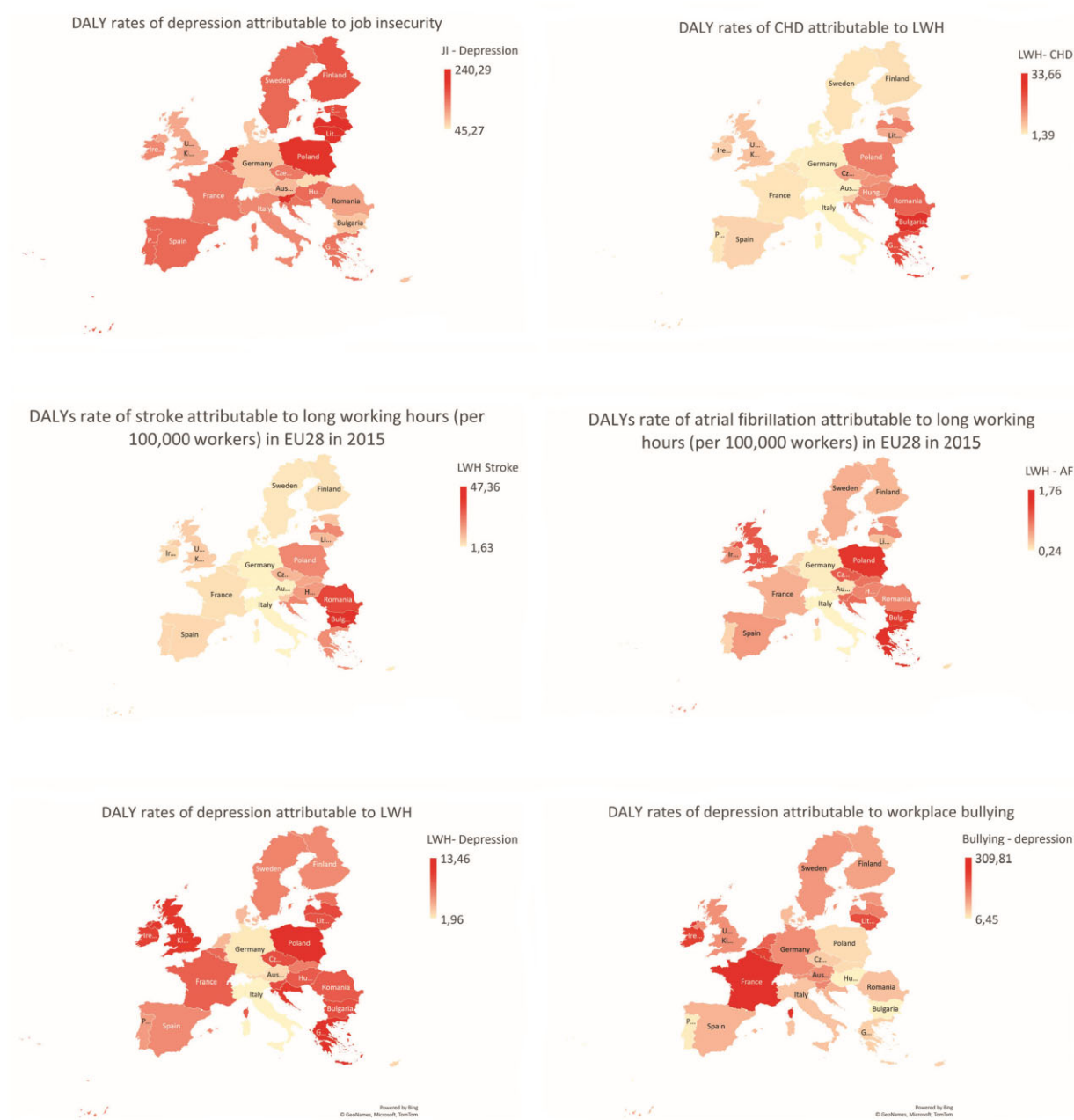
Consequently, these results provide relevant information on the burden attributable to psychosocial work factors borne by workers in each country, taking into account the size of the employed population. From an intervention perspective, these results underline the discrepancies

between countries and may have a contribution to decision-making and priorities orientation for policy makers at the European level.

**Gender differences**

Burden differences between genders resulted from differences in the same two parameters:

- i. Differences in AF estimates between men and women were only observed for stroke, atrial fibrillation and depression attributable to long working hours, with a higher burden for men. Indeed, AFs were based on RR estimates from a literature review<sup>1</sup> in which studies either did not test gender differences (for most of them), or reported no differences between men and women, although the study of sub-groups may have suffered from a lack of statistical power.<sup>12</sup> Therefore, gender differences in AFs could only derive from gender



CHD: Coronary/ischemic heart disease; PAD: Peripheral Artery Disease; ERI: Effort-reward imbalance; AT: Atrial fibrillation; JI: Job insecurity; LWH: Long working hours.

**Figure 1** (Continued).

differences in the prevalence of exposure, which were either non-significant or small, except for long working hours.<sup>12</sup> Gender comparisons should be interpreted with caution. Indeed, the studied exposures were based on general concepts to correspond to those used in the RR literature. However, a more refined analysis of specific exposures might show a higher prevalence of exposure to repetitive work<sup>27</sup> or low job control<sup>28–30</sup> (subdimensions of job strain), to sexual harassment<sup>31</sup> (a specific form of violence and bullying at work), and to temporary contracts, undesired changes in working conditions or enforced part-time work<sup>32,33</sup> (specific exposures related to job insecurity) among women than among men.

ii. Gender differences in the burden of disease attributable to psychosocial work factors also resulted from gender differences in disease prevalence. The number of DALYs lost related to CVD was higher for men than women in EU28. It was also the case for the number of DALYs lost because of depression, which included

a higher number of years of life lost because of suicide among men than women. These gender differences in the prevalence of diseases may explain gender differences in the burden of these diseases attributable to the studied psychosocial work factors.

### Comparison with the literature

Comparing our results with the literature may be difficult as studies on this topic are lacking. A comparison can be made with our previous publication about the burden of CVD and mental disorders attributable to job strain in France in 2003.<sup>4</sup> In the present study, the estimated numbers of CHD and depression cases attributable to job strain were more conservative than those in our previous publication. For CHD, this was explained by the use of a lower but more robust RR estimate. For depression, this was explained by a more precise and restrictive definition of the outcome. The study by Pega et al.<sup>34</sup>

estimated the burden of CHD and stroke attributable to long working hours in Europe. Although we used the same AF formula and very similar estimates for RR (1.17 compared to 1.13 in our study for CHD and 1.35 in both studies for stroke) and for the prevalence of exposure (3.5%), AF estimates in Pega's study were 1.4% and 2.3% for CHD/IHD and 2.5% and 3.8% for stroke, which appear overestimated. The low burden attributable to long working hours may be explained by a low prevalence of exposure to 55 hours or more per week in Europe (leading to low AFs<sup>12</sup>) due to the European working time directive passed in 2003, which sets a maximum of 48 h/week.

### Limitations and strengths

This study had several strengths. Results were reported for the whole employed population, as well as for men and women separately following the best practices regarding gender issue.<sup>35</sup> Gender stratification made our results more reliable as the results for both genders together did not take account of the differences in the number of cases between genders when applying the mean AF for both genders (see footnote, table 3).

Results were based on up-to-date AF estimates comparable across Europe. Five different psychosocial work exposures were included and we covered a wide range of health outcomes related to CVD and depression. We also estimated the overall burden of CHD and depression attributable to the studied psychosocial work factors together, based on a recent and useful approximation method, as substantial dependence was found between the studied exposures. The burden per 100 000 workers was also provided for each exposure–outcome pair, which allowed comparisons between 28 EU countries of the burden borne by workers, taking into account the size of the employed population. Therefore, this study provided detailed estimates on the burden due to psychosocial work factors, something which is very rare on this topic.

This study has also several limitations.

Although we used the most recent available data (2015), we were unable to provide information that may be relevant for the burden of diseases during the coronavirus disease 2019 pandemic. There were differences in the definition of the outcomes between RR estimates used to compute AF estimates and health outcomes data from GHDx. For instance, GHDx database provided data on the prevalence of atrial fibrillation and flutter, whereas RR estimates were available for atrial fibrillation only, which may have overestimated our results on the burden of this health outcome. In addition, the RR estimates were from reviews/meta-analyses that were themselves based on a number of primary studies that may have been heterogeneous in the measurement of the outcome. Furthermore, for a given outcome, the definition may have been different from a review/meta-analysis to another.<sup>1,12</sup> The results for the five health outcomes included in the study should not be added together since there may be comorbidities. We used health outcome data for each disease, multiplied by the employment rate among the population aged 15–64 in each country to provide relevant estimates for the working population. This method was based on the hypothesis that cases are equally distributed in the working and non-working population, which may not be the case. Because the healthy worker effect leads to select healthier people at the workplace, there may be a bias towards overestimation. On the other hand, as the healthy worker effect leads to remove from the workplace people, who may be sick because of exposures, this is likely to underestimate the results. All in all, the impact of these two biases is likely to be offset. Since we applied AFs to the number of cases/deaths in the working population only, our estimates did not take into account potential delayed health effects due to psychosocial work factors that may occur after retirement, which may have underestimated the results. However, studies exploring delayed effects or effect reversibility after the end of exposure are still missing. We studied health outcomes related to CVD and depression for which a high level of evidence has been provided by the literature. Other outcomes might be of interest, such as

diabetes, musculoskeletal disorders or occupational injuries for example, but the level of evidence remains lower to date.<sup>1</sup> The definition and calculation of the different exposures may make the strict comparison of the burden difficult between exposures. Indeed, job strain and ERI were defined by arbitrary thresholds (median and ratio over 1 respectively) contrary to the other exposures, which may have an impact on the differences in exposure prevalence between factors. Exposure prevalence was based on estimates using the European Working Conditions Survey data,<sup>12</sup> but the assessment of exposure of job strain and ERI was not based on validated questionnaires, leading to potential imprecision and misclassification. Finally, some psychosocial work factors including specific exposures may be lacking, for instance, organizational injustice or violence at work. Other occupational exposures not related to psychosocial work factors were not studied, such as for example shift or night work. Our results thus provide conservative estimates of the burden of diseases attributable to psychosocial work factors, as we studied a limited set of exposures and outcomes.

### Conclusion

This study provided an unparalleled contribution to the analysis of the loss of health related to psychosocial work exposures. Our study showed an overall picture across EU countries. This may provide information for decision-making and health policy action. It also underlined the areas where epidemiological data on the etiological role of psychosocial work factors are still missing. Indeed, information about exposure–outcome associations are lacking for a number of psychosocial work factors, health outcomes and for men and women separately.

### Supplementary data

Supplementary data are available at *EURPUB* online.

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### Disclaimer

The sole responsibility for the content of this article lies with the authors. The European Commission or European Trade-Union Institute (ETUI) are not responsible for any use that may be made of the information contained therein.

*Conflicts of interest:* None declared.

### Key points

- This is the first study focusing on the morbidity and mortality burden of cardiovascular diseases (coronary/ischemic heart disease (CHD), peripheral artery disease, atrial fibrillation and stroke) and depression attributable to five different psychosocial work exposures and covering 28 European Union member states.
- Our study showed a high burden of CHD and depression attributable to the five studied psychosocial work exposures, with a higher burden for depression.
- There were discrepancies between EU countries in the burden borne by workers, with an East–West gradient for some exposure–outcome pairs related to CHD and stroke.
- From an intervention perspective, these results may have a contribution to decision-making and priorities orientation related to psychosocial work factors for policy makers at the European level.

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