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Risk factors and their contribution to population health in the European Union (EU-28) countries in 2007 and 2017

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Background: The Global Burden of Disease (GBD) study has generated a wealth of data on death and disability outcomes in Europe. It is important to identify the disease burden that is attributable to risk factors and, therefore, amenable to interventions. This paper reports the burden attributable to risk factors, in deaths and disability-adjusted life years (DALYs), in the 28 European Union (EU) countries, comparing exposure to risks between them, from 2007 to 2017. **Methods:** Retrospective descriptive study, using secondary data from the GBD 2017 Results Tool. For the EU-28 and each country, attributable (all-cause) age-standardized death and DALY rates, and summary exposure values are reported. **Results:** In 2017, behavioural and metabolic risk factors showed a higher attributable burden compared with environmental risks, with tobacco, dietary risks and high systolic blood pressure standing out. While tobacco and air quality improved significantly between 2007 and 2017 in both exposure and attributable burden, others such as childhood maltreatment, drug use or alcohol use did not. Despite significant heterogeneity between EU countries, the EU-28 burden attributable to risk factors decreased in this period. **Conclusion:** Accompanying the improvement of population health in the EU-28, a comparable trend is visible for attributable burden due to risk factors. Besides opportunities for mutual learning across countries with different disease/risk factors patterns, good practices (i.e. tobacco control in Sweden, air pollution mitigation in Finland) might be followed. On the opposite side, some concerning cases must be highlighted (i.e. tobacco in Bulgaria, Latvia and Estonia or drug use in Czech Republic).

Introduction

The Global Burden of Disease (GBD) study is considered a powerful tool that allows the synthetization of large sets of data into comprehensive, comparable and internally consistent estimates of global population health. The GBD 2017 study provides population health measures [e.g. mortality, incidence, prevalence, years lived with disability, years of life lost due to premature death, disability-adjusted life years (DALY)] for 354 diseases and injuries in 195 countries and territories.[1] Global results showed important increases in the burden of non-communicable diseases (NCDs) between 2007 and 2017.[2,3] In the European Union (EU-28), a general decrease of the burden of disease was observed, with NCDs representing the leading causes of death and DALYs.[4]

Understanding which injuries and diseases drive the burden of disease is essential to identify potential areas for health improvements. However, to implement public health measures, it is important to pin down which shares of burden can be attributed to risk factors and are, therefore, amenable to public health interventions.[1] For instance, tackling dietary risks, high blood pressure and tobacco consumption can help to reduce health loss due to cardiovascular diseases.[5] In the GBD 2017 study, 84 behavioural, environmental and occupational, and metabolic risk factors were included using the comparative risk assessment (CRA) framework with exposures as input, allowing to calculate the population attributable fractions (PAF) and attributable burden of risk factors by age, sex and geographic locations.[1] This analysis provides insights into the trends of risk exposure and the association between risk factors and health outcomes. Globally, in 2017, 61% of deaths and 48% of DALYs were attributable to risk factors.[1]

While the GBD study provides global, regional, national and subnational portraits of population health, many burden of disease studies carried out in Europe focus on a limited number of countries or a subset of diseases/risk factors.[6] There are published reports on risk factors related burden in the EU-28, such as 'Health at a Glance', by the Organization for Economic Cooperation and

Development and the European Commission.[7] However, they lack a comprehensive and systematic approach for all risk factors, focusing only on specific risk factors and age groups.[7] Thus, using GBD 2017 to study the EU and its countries allows a harmonized and comparable approach, which can highlight EU-specific results. Moreover, this allows for benchmarking of EU countries and identification of risk factors' patterns, which may lead to opportunities for mutual learning and collaborations between countries, especially regarding successful national policies in managing risk factors with a substantial impact on population health.

The aims of this paper were to assess the disease burden, estimated in deaths and DALYs, attributable to risk factors in the 28 EU countries and compare exposure to risks between these countries and over time, from 2007 to 2017.

Methods

We used estimates from the GBD 2017 study, which combined data from multiple sources, including mortality, morbidity and risk exposure.[1–3,8,9] Estimates of age-standardized death and DALY rates attributable to risk factors were extracted for the years 2007 and 2017 from the GBD 2017 Results Tool. The corresponding 95% uncertainty intervals (UIs), calculated in the GBD study using a Bayesian approach taking 1000 draws from relevant distributions for each metric, were also extracted. Summary exposure values (SEVs) for risk factors and their relations with the attributable burden in death and DALY rates were analyzed for the EU-28 countries for 2007 and 2017.

Country-specific estimates and UIs, also obtained from the GBD 2017 study, were compared with those estimated for the EU-28, as the sum of all 28 countries. The change between 2007 and 2017 was expressed as the percentage difference between both years. More information on data sources used by the Institute for Health Metrics and Evaluation can be found in the GBD 2017 study-related papers.[1–3,8,9]

Risk factors

Estimates on attributable deaths and DALYs for 84 behavioural, environmental and occupational, and metabolic risks for the EU-28 countries were obtained from the GBD 2017 study, organized into five hierarchical levels. At level 0, all risk factors are combined. Level 1 includes three categories: (i) environmental and occupational, (ii) metabolic and (iii) behavioural risk factors. Levels 2–4 include 19, 39 and 22 risk factors or risk factor groups, respectively, with each subsequent level considering risk factors that are more detailed, nested in the broader category above.

The CRA framework, following the establishment of a causal web of hierarchically organized risks that contribute to health outcomes (i.e. mortality and disability), is used in the GBD study to provide estimates on levels and trends in exposure, attributable deaths and DALYs by age, sex and geographic location for each one of the 84 risk factors.[1,10] First, each risk factor is associated with one or more health outcomes, forming a set of 476 risk–outcome pairs, and relative risks are estimated as a function of exposure, on the basis of evidence rules including meta-regressions of previous studies.[1,11] Levels of exposure for each age–sex–geography–year are estimated with the Bayesian meta-regression software, DisMod-MR 2.0, or spatial–temporal Gaussian process regression.[1,11] Afterwards, and relying on existing evidence, the level of exposure associated with minimum risk (i.e. theoretical minimum risk exposure level) is assessed.[1] Finally, PAF are estimated and multiplied by the overall burden estimates such as number of deaths or DALYs for each age–sex–geography–year, also providing the attributable burden while taking into account the combination and mediation of different risk factors.[1]

Summary exposure values

This metric refers to the risk-weighted prevalence of an exposure for each risk factor. SEVs are an easily comparable summary measure, ranging from 0% (no risk exposure in a given population) to 100% (maximum possible risk exposure). GBD considers the following equation to compute SEV:

$$SEV = \frac{\sum_{i=min}^{max} Prev_i * RR_i - 1}{RR_{max} - 1} (1)$$

where $Prev_i$ and RR_i are the prevalence and relative risk of the risk category i, and RR_{max} is the maximum observed relative risk between categories. A more detailed methodological overview on SEV is available in the GBD 2015 study.[11]

Attributable burden due to more than one risk factor was only described for the level 1 risk factors: (i) behavioural; (ii) environmental and occupational; and (iii) metabolic. For deaths and DALY estimates, 19 level 2 risk factors are presented. For SEV estimates, level 2 risk factors were not available and, therefore, the top level 3 risk factors with higher EU attributable DALY burden were presented. Exceptions due to data availability include: (i) metabolic risks only available for level 2 risk factors estimates; and (ii) only level 4 branches of 'particulate matter pollution' and 'low birth weight and short gestation' were available and considered, except for 'household air pollution from solid fuels' which was not considered due to its low value.

Results

In 2017, 58.6% [95%UI: 56.0–61.3%; $N = 3\,049\,342$ (95%UI: 2 911 090–3 193 283)] of all deaths and 44.4% [95%UI: 41.9–47.3%; $N = 66\,210\,208$ (95%UI: 60 638 141–72 234 034)] of all DALYs in the EU-28 were attributed to risk factors (table 1). Including non-attributable deaths and DALYs (Supplementary figure 1), behavioural risk factors accounted for 38.7% of all deaths, followed by metabolic (36.8%) and environmental and occupational risks (7.9%), while for DALYs, metabolic risks represented the highest share in 2017 (36.8%), followed by behavioural (31.1%) and environmental and occupational risk factors (7.9%).

Whilst age-standardized death rates for all risk factors but drug use decreased between 2007 and 2017, the only risk factor for which the age-standardized DALY-rate estimate increased was childhood maltreatment (figure 1). Nevertheless, the exposure (SEV) to several risk factors increased in the EU, namely high fasting plasma glucose (18.1%), high body mass index (6.8%), short gestation for birth weight (3.3%), drug use (2.2%), diet high in sodium (1.7%), low birth weight for gestation (1.5%) and diet low in vegetables (0.7%). Besides these, other risk factors showed a significant increase, such as diet high in sugar-sweetened beverages (14.1%), occupational exposure to benzene (6.9%), diet high in processed meat (6.6%) or bullying victimization (4.1%)—table 1. On the other hand, some risk factors showed quite significant decreases such as unsafe sanitation (–33.8%), unsafe water source (–25.2%), ambient particulate matter pollution (–12.2%), diet high in trans fatty acids (–22.6%), smoking (–11.5%), iron deficiency (–10.2%)—figure 1C and table 1.

In a 10-year span, however, the EU-28 experienced a considerable decrease in age-standardized death and DALY rates attributed to risk factors (table 1). The highest all-cause attributable age-standardized death and DALY rates were observed for tobacco, high systolic blood pressure and dietary risks among level 2 risk factors (figure 2). When considering the ranking of the most detailed risk factors, besides tobacco, dietary risks, alcohol use and low physical activity (behavioural risks) and air pollution (environmental risk), there is a clear predominance of metabolic risks in both 2007 and 2017, with some even experiencing an improvement in the ranking, mainly for DALYs (Supplementary figure 2).

Table 1 All-cause all-ages risk-attributable shares of deaths and DALYs , age-standardized death and DALY rates, as well as summary exposure values in 2017, and their percentage change between 2007 and 2017 for all risk factors and all levels, in EU-28

Risk (level)	Deaths attributable to risk factors (%), in 2017 (95% UI)	Age-standardized death rate (deaths per 100 000 inhabitants), in 2017 (95% UI)	Change of age-standardized death rate (%), 2007–17 (95% UI)	DALYs attributable to risk factors (%), in 2017 (95% UI)	Age-standardized DALY rate (DALYs per 100 000 inhabitants), in 2017 (95% UI)	Change of age-standardized DALY rate (%), 2007–17 (95% UI)	Summary exposure value (%), in 2017 (95% UI)	Change of summary exposure value (%), 2007–17 (95% UI)
All risk factors (0)	**58.6 (56.0–61.3)**	**263.8 (252.6–275.2)**	**–16.8 (–18.4 to –15.2)**	**44.4 (41.9–47.3)**	**7768.6 (7055.8–8586.8)**	**–13.8 (–15.6 to –12.1)**	**NA**	**NA**
Environmental/occupational risks (1)	**7.9 (7.0–8.9)**	**35.9 (31.8–40.3)**	**–20.7 (–23.7 to –18.0)**	**7.0 (6.3–7.7)**	**1243.2 (1062.4–1442.8)**	**–14.5 (–17.4 to –11.9)**	**NA**	**NA**
Unsafe water, sanitation and handwashing (2)	0.0 (0.0–0.1)	0.2 (0.1–03)	–14.8 (–20.7 to –8.9)	0.0 (0.0–0.1)	14.7 (8.0–23.9)	–21.5 (–29.2 to –14.9)	NA	NA
Unsafe water source (3)	0.0 (0.0–0.0)	0.1 (0.0–0.1)	–11.5 (–23.7 to –0.5)	0.0 (0.0–0.1)	8.9 (2.1–18.2)	–21.0 (–33.1 to –12.5)	1.3 (1.1–1.5)	–25.2 (–34.9 to –14.5)
Unsafe sanitation (3)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–25.1 (–37.5 to –10.8)	0.0 (0.0–0.0)	3.7 (2.4–5.3)	–34.4 (–43.4 to –24.8)	2.0 (1.6–2.6)	–33.8 (–43.1 to –23.4)
No access; handwashing facility (3)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	–15.5 (–20.9 to –9.3)	0.0 (0.0–0.0)	3.5 (2.0–5.5)	–20.0 (–27.2 to –13.1)	3.2 (3.0–3.4)	–5.5 (–10.3 to 0.2)
Air pollution (2)	4.6 (3.8–5.4)	20.4 (17.0–24.1)	–25.5 (–30.0 to –21.1)	3.2 (2.6–3.8)	492.3 (395.8–590.7)	–23.0 (–29.0 to –18.0)	NA	NA
Particulate matter pollution (3)	4.2 (3.4–5.0)	18.7 (15.2–22.2)	–26.9 (–32.3 to –22.1)	3.0 (2.4–3.7)	469.0 (371.2–567.9)	–23.6 (–29.9 to –18.4)	NA	NA
Ambient particulate matter pollution (4)	3.9 (3.1–4.7)	17.5 (14.1–21.0)	–25.6 (–31.4 to –20.5)	2.8 (2.2–3.5)	438.1 (341.0–537.2)	–22.0 (–28.9 to –16.1)	29.7 (21.6–42.2)	–12.2 (–21.6 to –3.8)
Household air pollution from solid fuels (4)	0.2 (0.2–0.3)	1.1 (0.5–1.5)	–42.3 (–54.0 to –27.9)	0.2 (0.1–0.3)	30.9 (22.2–42.2)	–41.4 (–53.6 to –26.0)	1.7 (1.0–4.2)	–29.8 (–45.6 to –12.3)
Ambient ozone pollution (3)	0.5 (0.2–0.8)	2.0 (0.7–3.4)	–7.5 (–10.4 to –4.2)	0.2 (0.1–0.3)	28.0 (10.2–46.5)	–8.2 (–11.2 to –4.9)	41.5 (15.6–53.4)	2.0 (0.6–3.7)
Other environmental risks (2)	1.3 (0.7–1.9)	5.4 (3.0–8.3)	–22.5 (–25.7 to –19.5)	0.7 (0.4–1.1)	104.7 (59.3–157.4)	–26.6 (–30.2 to –23.4)	NA	NA
Residential radon (3)	0.3 (0.2–0.5)	1.6 (0.8–2.6)	–9.1 (–13.2 to –5.0)	0.2 (0.1–0.4)	35.9 (17.5–59.4)	–11.8 (–16.2 to –7.4)	26.7 (14.9–40.4)	–0.8 (–1.8 to 0.1)
Lead exposure (3)	0.9 (0.4–1.6)	3.8 (1.7–6.3)	–27.0 (–31.4 to –24.0)	0.5 (0.2–0.8)	68.8 (32.7–114.2)	–32.5 (–37.6 to –29.1)	3.3 (1.2–6.3)	–27.7 (–36.4 to –20.1)
Occupational risks (2)	2.4 (2.0–2.8)	11.7 (9.9–13.5)	–10.1 (–13.2 to –6.9)	3.3 (3.0–3.6)	668.2 (554.5–804.8)	–4.8 (–6.9 to –2.7)	NA	NA
Occupational carcinogens (3)	1.9 (1.5–2.2)	8.8 (7.1–10.5)	–7.0 (–11.0 to –2.8)	1.1 (0.9–1.4)	116.7 (134.4–201.1)	–10.1 (–14.0 to –5.9)	NA	NA
Occupational exposure; asbestos (4)	1.7 (1.3–2.0)	7.7 (6.0–9.3)	–6.2 (–10.6 to –1.3)	1.0 (0.7–1.2)	137.1 (105.9–168.7)	–9.2 (–13.6 to –4.2)	3.8 (3.7–4.0)	0.4 (–3.7 to 5.2)
Occupational exposure; arsenic (4)	0.0 (0.0–0.1)	0.1 (0.0–0.3)	NA	0.0 (0.0–0.0)	3.8 (0.0–8.3)	NA	0.3 (0.0–0.7)	NA
Occupational exposure; benzene (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–13.6 (–17.4 to –9.2)	0.0 (0.0–0.0)	0.8 (0.2–1.5)	–15.9 (–20.1 to –11.2)	0.7 (0.0–2.1)	6.9 (5.8–8.4)
Occupational exposure; beryllium (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–3.2 (–7.5 to –1.1)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–6.5 (–10.8 to –2.0)	0.0 (0.0–0.0)	3.7 (3.1–4.2)
Occupational exposure; cadmium (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–6.7 (–10.8 to –2.4)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	–9.9 (–14.1 to –5.5)	0.0 (0.0–0.0)	0.2 (–1.2 to 1.6)
Occupational exposure; chromium (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–5.5 (–9.3 to –1.4)	0.0 (0.0–0.0)	0.2 (0.2–0.2)	–8.7 (–12.4 to –4.7)	0.1 (0.1–0.1)	1.3 (0.2–2.5)
Occupational exposure; diesel engine exhaust (4)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	–3.6 (–7.1 to 0.6)	0.0 (0.0–0.0)	2.6 (2.3–3.0)	–6.9 (–10.5 to –2.9)	0.5 (0.4–0.5)	4.6 (3.5–5.9)
Occupational exposure; formaldehyde (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–18.2 (–22.2 to –14.2)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	–20.5 (–24.6 to –16.2)	0.2 (0.2– 0.2)	0.3 (–1.1 to 1.7)
Occupational exposure; nickel (4)	0.0 (0.0–0.1)	0.1 (0.0–0.4)	NA	0.0 (0.0–0.1)	3.2 (0.0–11.5)	NA	0.3 (0.0–1.2)	NA
Occupational exposure; polycyclic aromatic hydrocarbons (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–5.0 (–9.0 to –0.6)	0.0 (0.0–0.0)	0.7 (0.6–0.8)	–8.2 (–12.2 to –3.7)	0.2 (0.2–0.2)	1.8 (0.8–2.9)
Occupational exposure; silica (4)	0.2 (0.1–0.3)	0.9 (0.3–1.4)	–13.3 (–21.0 to –9.6)	0.1 (0.0–0.2)	22.3 (6.7–36.9)	–14.7 (–21.0 to –11.3)	2.9 (0.4–9.4)	–0.3 (–1.8 to 1.4)
Occupational exposure; sulphuric acid (4)	0.0 (0.0–0.0)	0.0 (0.0–0.1)	–20.2 (–23.5 to –16.8)	0.0 (0.0–0.0)	0.9 (0.2–2.0)	–22.9 (–26.2 to –19.5)	0.4 (0.1–1.3)	–2.2 (–3.5 to –0.7)

(continued)

Table 1 Continued

Risk (level)	Deaths attributable to risk factors (%), in 2017 (95% UI)	Age-standardized death rate (deaths per 100 000 inhabitants), in 2017 (95% UI)	Change of age-standardized death rate (%), 2007–17 (95% UI)	DALYs attributable to risk factors (%), in 2017 (95% UI)	Age-standardized DALY rate (DALYs per 100 000 inhabitants), in 2017 (95% UI)	Change of age-standardized DALY rate (%), 2007–17 (95% UI)	Summary exposure value (%), in 2017 (95% UI)	Change of summary exposure value (%), 2007–17 (95% UI)
Occupational exposure; trichloroethylene (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	1.8 (–2.6 to 6.4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–1.0 (–5.2 to –3.8)	0.1 (0.1–0.1)	2.5 (1.6–3.5)
Occupational asthmagens (3)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–34.9 (–38.3 to –31.2)	0.1 (0.1–0.1)	18.6 (12.6–26.2)	–8.1 (–12.9 to –3.5)	11.3 (10.1–12.7)	–0.9 (–2.7 to 1.0)
Occupational particulate matter, gases and fumes (3)	0.4 (0.3–0.5)	1.6 (1.2–2.0)	–13.8 (–16.9 to –10.6)	0.3 (0.2–0.4)	45.7 (37.5–54.2)	–11.2 (–14.8 to –7.6)	4.2 (3.3–5.7)	–6.4 (–7.5 to –5.2)
Occupational noise (3)	NA (NA–NA)	0.0 (0.0–0.0)	0.00 (0.00–0.00)	0.2 (0.1–0.2)	34.3 (23.3–48.8)	–2.2 (–3.2 to –1.2)	4.4 (4.2–4.8)	–1.8 (–2.1 to –1.5)
Occupational injuries (3)	0.1 (0.1–0.1)	1.3 (1.2–1.3)	–22.8 (–26.6 to –18.5)	0.6 (0.5–0.7)	154.4 (125.7–190.9)	–4.4 (–10.4 to 1.7)	NA	NA
Occupational ergonomic factors (3)	NA (NA–NA)	0.0 (0.0–0.0)	0.00 (0.00–0.00)	1.0 (0.8–1.2)	248.3 (176.5–342.5)	0.2 (–1.6 to 2.1)	6.8 (5.9–7.9)	–1.9 (–3.6 to –0.3)
Behavioural risks (1)	**38.7 (37.1–40.3)**	**183.5 (176.6–190.9)**	**–19.3 (–21.0 to –17.6)**	**31.1 (28.9–33.4)**	**5702.2 (5232.5–6201.0)**	**–16.2 (–18.0 to –14.3)**	**NA**	**NA**
Child and maternal malnutrition (2)	0.2 (0.2–0.3)	4.0 (3.7–4.2)	–23.9 (–28.6 to –19.4)	1.2 (1.1–1.4)	563.0 (494.2–647.3)	–17.4 (–22.4 to –12.2)	NA	NA
Suboptimal breastfeeding (3)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	–42.9 (–48.5 to –36.6)	0.0 (0.0–0.0)	8.5 (6.7–10.4)	–34.6 (–41.4 to –27.8)	NA	NA
Non-exclusive breastfeeding (4)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	–43.5 (–49.0 to –37.1)	0.0 (0.0–0.0)	7.3 (5.7–8.8)	–37.6 (–43.8 to –31.2)	0.5 (0.4–0.6)	–1.1 (–3.5 to 1.6)
Discontinued breastfeeding (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–30.6 (–39.4 to –19.2)	0.0 (0.0–0.0)	1.5 (0.5–2.7)	–10.2 (–17.5 to –2.8)	2.1 (2.1–2.2)	0.8 (–0.7 to 2.1)
Child growth failure (3)	0.1 (0.1–0.1)	0.5 (0.4–0.6)	–27.0 (–33.1 to –21.2)	0.1 (0.1–0.1)	30.8 (22.6–38.7)	–35.5 (–41.3 to –29.0)	NA	NA
Child underweight (4)	0.1 (0.1–0.1)	0.3 (0.2–0.4)	–4.3 (–11.7 to –3.0)	0.0 (0.0–0.0)	5.1 (3.9–6.0)	–19.0 (–27.4 to –12.1)	0.1 (0.1–0.1)	–5.7 (–7.7 to –3.9)
Child wasting (4)	0.1 (0.1–0.1)	0.5 (0.4–0.6)	–26.1 (–32.5 to –18.8)	0.1 (0.0–0.1)	29.0 (19.4–37.8)	–35.0 (–41.2 to –27.5)	0.1 (0.1–0.1)	–4.5 (–7.8 to –1.4)
Child stunting (4)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–52.7 (–61.1 to –42.2)	0.0 (0.0–0.0)	2.4 (0.6–6.5)	–47.1 (–56.0 to –25.0)	0.3 (0.2–0.4)	–6.2 (–12.5 to –0.3)
Low-birth-weight and short gestation (3)	0.2 (0.1–0.2)	3.4 (3.1–3.6)	–23.2 (–28.5 to –18.1)	0.8 (0.7–1.0)	421.5 (378.4–472.8)	–16.8 (–22.7 to –10.0)	NA	NA
Low-birth-weight for gestation (4)	0.1 (0.1–0.1)	2.7 (2.5–2.8)	–22.7 (–28.1 to –17.4)	0.7 (0.6–0.9)	357.6 (316.9–407.5)	–15.2 (–21.8 to –7.3)	0.0 (0.0–0.0)	1.5 (–2.8 to 10.5)
Short gestation for birth weight (4)	0.1 (0.1–0.1)	2.7 (2.5–2.9)	–23.2 (–28.5 to –18.3)	0.7 (0.6–0.9)	364.2 (321.8–414.3)	–15.8 (–22.1 to –8.3)	0.0 (0.0–0.0)	3.3 (–1.6 to 8.3)
Iron deficiency (3)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–29.4 (–34.4 to –24.6)	0.3 (0.2–0.4)	89.3 (56.7–138.6)	–9.8 (–18.4 to –0.4)	2.7 (1.9–3.6)	–10.2 (–15.4 to –5.1)
Vitamin A deficiency (3)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–49.4 (–54.8 to –42.2)	0.0 (0.0–0.1)	20.3 (13.1–30.2)	–27.0 (–36.0 to –15.2)	1.2 (1.0–1.5)	–6.6 (–9.5 to –3.8)
Zinc deficiency (3)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–28.9 (–40.8 to –4.1)	0.0 (0.0–0.0)	1.2 (0.4–2.7)	–9.4 (–28.0 to 28.8)	0.5 (0.2–1.0)	5.0 (–7.8 to 21.3)
Tobacco (2)	16.5 (15.8–17.2)	79.4 (76.2–82.8)	–20.2 (–22.0 to –18.4)	13.9 (12.7–15.1)	2269.4 (2093.6–2463.8)	–18.3 (–20.0 to –16.5)	NA	NA
Smoking (3)	15.7 (15.0–16.4)	75.4 (72.2–78.8)	–20.0 (–21.9 to –18.1)	13.3 (12.1–14.3)	2152.2 (1981.0–2337.5)	–18.2 (–19.9 to –16.4)	7.4 (6.5–8.4)	–11.5 (–13.0 to –10.0)
Chewing tobacco (3)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	–16.8 (–22.4 to –10.1)	0.0 (0.0–0.0)	0.4 (0.3–0.5)	–20.0 (–25.5 to –13.6)	0.1 (0.1–0.1)	–6.9 (–12.3 to –0.6)
Second-hand smoke (3)	1.3 (1.0–1.6)	6.2 (4.9–7.6)	–26.1 (–28.3 to –24.0)	1.1 (0.8–1.3)	183.4 (143.1–228.5)	–23.8 (–27.0 to –20.5)	35.4 (34.6–36.1)	–7.7 (–8.8 to –6.6)
Alcohol use (2)	6.0 (4.6–7.7)	20.4 (17.0–24.1)	–20.7 (–28.4 to –13.0)	6.7 (5.7–7.8)	1333.5 (1157.0–7768.6)	–18.8 (–24.2 to –13.7)	22.4 (15.1–31.0)	0.0 (–8.8 to –9.1)
Drug use (2)	0.8 (0.7–0.8)	5.1 (4.6–5.6)	1.9 (–1.6 to 5.2)	1.5 (1.3–1.6)	378.2 (319.8–436.7)	–1.6 (–4.7 to 1.4)	0.6 (0.4–0.9)	2.2 (–2.6 to 7.8)
Dietary risks (2)	18.3 (16.7–19.9)	79.2 (72.4–86.3)	–22.3 (–24.0 to –20.6)	10.8 (9.6–12.0)	1635.3 (1491.0–1805.7)	–20.5 (–22.6 to –18.4)	NA	NA
Diet low in fruits (3)	3.3 (1.8–5.1)	15.2 (8.6–23.2)	–23.7 (–26.6 to –21.0)	2.3 (1.3–3.4)	371.1 (221.8–549.6)	–22.0 (–25.6 to –18.1)	28.7 (22.8–33.0)	–2.0 (–3.9 to –0.5)
Diet low in vegetables (3)	2.3 (1.0–3.9)	9.7 (4.3–16.5)	–26.2 (–28.7 to –23.9)	1.2 (0.5–2.0)	175.8 (82.0–298.9)	–27.5 (–29.8 to –25.0)	24.2 (18.9–29.0)	0.6 (–1.4 to 2.8)
Diet low in legumes (3)	1.6 (0.7–2.7)	6.9 (2.9–11.5)	–23.3 (–25.1 to –21.3)	0.8 (0.3–1.4)	127.3 (53.5–209.8)	–26.11 (–28.1 to –24.2)	38.6 (35.9–41.0)	0.9 (0.3–1.7)
Diet low in whole grains (3)	5.0 (3.3–6.8)	22.1 (14.9–29.8)	–24.5 (–26.2 to –22.7)	3.4 (2.4–4.5)	539.2 (385.8–713.7)	–20.5 (–23.5 to –17.1)	43.9 (42.2–45.4)	0.1 (–0.3 to 0.4)
Diet low in nuts and seeds (3)	3.6 (2.2–5.1)	15.4 (9.5–22.0)	–25.1 (–27.2 to –23.2)	2.0 (1.3–2.9)	314.5 (206.8–435.1)	–23.9 (–27.2 to –20.1)	41.7 (38.9–43.9)	–2.8 (–4.1 to –1.8)
Diet low in milk (3)	0.3 (0.1–0.6)	1.6 (0.5–3.0)	–11.5 (–14.5 to –8.4)	0.2 (0.1–0.4)	32.2 (10.4–60.8)	–12.6 (–15.6 to –9.4)	28.0 (22.7–32.4)	–1.0 (–2.4 to 0.0)
Diet high in red meat (3)	0.1 (0.0–0.2)	0.6 (0.2–1.0)	–5.9 (–11.8 to 1.0)	0.2 (0.1–0.3)	30.4 (12.6–51.3)	6.6 (–3.8 to 15.8)	26.3 (23.9–28.8)	3.6 (–0.1 to 7.8)
Diet high in processed meat (3)	0.5 (0.1–1.0)	2.4 (0.5–4.6)	–15.3 (–19.4 to –7.8)	0.4 (0.2–0.7)	71.2 (27.5–121.1)	–8.4 (–14.9 to 8.1)	10.6 (8.2–12.9)	6.6 (3.2–11.1)
Diet high in sugar-sweetened beverages (3)	0.4 (0.0–0.8)	1.9 (0.2–3.8)	–10.6 (–16.7 to 0.2)	0.4 (0.1–0.6)	63.5 (20.6–110.9)	–2.6 (–11.3 to 28.0)	11.3 (5.8–12.6)	14.1 (7.9–21.4)
Diet low in fibre (3)	1.9 (1.1–2.8)	8.1 (4.8–12.2)	–21.0 (–23.2 to –18.6)	1.0 (0.6–1.5)	148.6 (87.3–225.7)	–23.2 (–25.5 to –20.6)	32.5 (27.8–36.2)	0.8 (–0.1 to 2.0)
Diet low in calcium (3)	0.5 (0.3–0.8)	2.4 (1.3–3.7)	–13.2 (–16.5 to –10.5)	0.3 (0.2–0.5)	45.6 (23.7–71.3)	–14.4 (–17.8 to –11.4)	20.9 (14.7–26.1)	–2.5 (–4.1 to –1.5)

(continued)

Table 1 Continued

Risk (level)	Deaths attributable to risk factors (%), in 2017 (95% UI)	Age-standardized death rate (deaths per 100 000 inhabitants), in 2017 (95% UI)	Change of age-standardized death rate (%), 2007–17 (95% UI)	DALYs attributable to risk factors (%), in 2017 (95% UI)	Age-standardized DALY rate (DALYs per 100 000 inhabitants), in 2017 (95% UI)	Change of age-standardized DALY rate (%), 2007–17 (95% UI)	Summary exposure value (%), in 2017 (95% UI)	Change of summary exposure value (%), 2007–17 (95% UI)
Diet low in seafood omega-3 fatty acids (3)	2.4 (1.0–4.0)	10.4 (4.6–17.7)	−25.7 (−27.7 to −23.7)	1.2 (0.5–2.1)	183.6 (82.2–308.6)	−28.6 (−30.7 to −26.6)	36.5 (33.2–39.7)	−2.3 (−3.0 to −1.7)
Diet low in polyunsaturated fatty acids (3)	1.3 (0.6–2.3)	5.8 (2.4–9.8)	−25.3 (−31.0 to −21.7)	0.7 (0.3–1.2)	100.0 (41.1–169.6)	−27.9 (−31.9 to −24.8)	28.0 (23.3–32.0)	−2.6 (−4.3 to −1.3)
Diet high in trans fatty acids (3)	0.3 (0.1–0.8)	1.4 (0.2–3.7)	−40.1 (−56.7 to −33.6)	0.2 (0.0–0.5)	26.0 (4.0–69.0)	−42.4 (−59.1 to −35.7)	1.7 (0.3–4.1)	−22.6 (−45.0 to −13.7)
Diet high in sodium (3)	3.7 (0.5–8.2)	15.8 (2.3–34.4)	−20.7 (−28.5 to −16.1)	2.0 (0.3–4.4)	287.6 (47.8–622.5)	−21.1 (−27.2 to −15.2)	6.2 (0.9–12.6)	1.7 (−4.2 to 14.7)
Intimate partner violence (2)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	−23.9 (−27.1 to −20.5)	0.1 (0.1–0.2)	35.7 (25.7–48.1)	−4.3 (−7.2 to −1.4)	1.1 (0.9–1.3)	−4.4 (−5.8 to −3.0)
Childhood maltreatment (2)	0.0 (0.0–0.0)	0.1 (0.1–0.2)	−7.8 (−14.0 to −1.6)	0.2 (0.2–0.3)	75.9 (54.0–103.3)	2.6 (0.4–5.1)	NA	NA
Childhood sexual abuse (3)	0.0 (0.0–0.0)	0.1 (0.1–0.2)	−7.8 (−14.0 to −1.6)	0.1 (0.1–0.2)	34.9 (24.7–47.5)	−1.4 (−3.6 to −0.8)	6.5 (5.6–7.5)	0.4 (−0.7 to 1.6)
Bullying victimization (3)	NA (NA–NA)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.1 (0.1–0.1)	41.8 (27.1–61.3)	6.1 (2.6–10.9)	6.1 (3.0–11.6)	4.1 (1.5–8.2)
Unsafe sex (2)	0.4 (0.4–0.4)	2.4 (2.3–2.5)	−23.0 (−25.3 to −20.6)	0.5 (0.4–0.5)	98.5 (87.9–113.8)	−20.3 (−23.2 to −17.3)	NA	NA
Low physical activity (2)	2.9 (1.6–4.6)	11.9 (6.6–18.7)	−21.7 (−23.5 to −19.6)	1.4 (0.8–2.2)	194.4 (106.2–302.8)	−20.1 (−22.5 to −17.3)	0.5 (0.2–0.9)	0.6 (0.1–1.0)
Metabolic risks (1)	**36.8 (32.5–41.0)**	**153.3 (136.0–170.3)**	**−17.4 (−19.4 to −15.3)**	**22.7 (20.3–25.4)**	**3351.5 (2890.8–3819.4)**	**−14.3 (−16.8 to −12.0)**	**NA**	**NA**
High fasting plasma glucose (2)	14.9 (10.3–20.9)	60.4 (42.4–83.3)	−12.0 (−17.5 to −6.2)	9.2 (7.3–11.7)	1337.3 (1051.0–1657.4)	−5.7 (−11.7 to −0.7)	2.7 (2.0–3.7)	18.1 (6.9–33.6)
High LDL cholesterol (2)	9.3 (6.5–12.3)	39.5 (29.3–51.0)	−24.0 (−26.1 to −22.0)	4.8 (3.7–5.9)	714.9 (589.9–851.8)	−25.5 (−27.5 to −23.6)	14.3 (12.7–15.9)	−0.2 (−0.8 to 0.5)
High systolic blood pressure (2)	20.4 (17.6–23.1)	85.3 (74.8–95.3)	−21.5 (−23.0 to −20.1)	10.7 (9.4–12.2)	1524.9 (1371.6–1672.1)	−22.6 (−24.2 to −21.1)	7.8 (7.2–8.5)	−3.7 (−4.9 to −2.5)
High body mass index (2)	10.9 (6.8–15.5)	48.7 (31.0–68.5)	−14.2 (−16.8 to −11.3)	9.0 (6.0–12.1)	1460.2 (975.9–1985.4)	−9.7 (−12.5 to −6.5)	15.4 (12.5–19.3)	6.8 (4.7–9.2)
Low bone mineral density (2)	0.7 (0.7–0.7)	2.7 (2.6–2.9)	−6.8 (−10.0 to −3.6)	1.0 (0.8–1.1)	131.7 (111.4–166.3)	−3.3 (−5.0 to −1.8)	4.8 (4.1–5.6)	−0.9 (−4.8 to 3.0)
Impaired kidney function (2)	4.6 (4.1–5.2)	18.1 (16.2–20.3)	−14.9 (−18.0 to −11.8)	2.2 (2.0–2.5)	307.1 (275.8–339.5)	−16.3 (−18.9 to −13.6)	2.0 (0.9–5.3)	−0.4 (−2.7 to 2.2)

Figure 1 Relationship between summary exposure values and risk-attributable (all-cause) age-standardized death and DALY rates by level 2 risk factor with their percent changes between 2007 and 2017, in the EU-28. Each dot represents the EU-28 estimate and crossed lines the 95% uncertainty intervals.

The comparison of age-standardized DALY rates revealed large differences between the EU-28 countries when considering level 2 risk factors—figure 2. Bulgaria (13 839 DALYs per 100 000 inhabitants), Romania (13 729), Latvia (13 445) and Lithuania (13 397) had the highest risk factors attributable burden, whereas Italy (5879.0), Spain (6281.1) and France (6170.7) had the lowest. In fact, most level 2 risk factors showed a particular heterogeneity throughout the EU-28, especially tobacco, dietary risks, high systolic blood pressure, high LDL cholesterol, impaired kidney function or unsafe sex (figure 2).

Regarding both age-standardized DALY and death rates, Bulgaria had the highest estimates for tobacco, dietary risks and high systolic

	All risk factors	Tobacco	Dietary risks	High systolic blood pressure	High body-mass index	High fasting plasma glucose	Alcohol use	High LDL cholesterol	Occupational risks	Child and maternal malnutrition	Air pollution	Drug use	Impaired kidney function	Low physical activity	Low bone mineral density	Other environmental risks	Unsafe sex	Childhood maltreatment	Intimate partner violence	Unsafe water, sanitation, and handwashing
EU 28	**7769**	2269	1635	1525	1460	1337	1333	715	668	563	492	378	307	194	132	105	99	76	36	15
Austria	**7073**	1961	1321	1361	1250	1315	1254	650	632	468	414	398	330	177	121	82	73	75	24	8
Belgium	**7243**	2444	1262	1141	1183	1273	1223	488	642	474	474	308	255	168	144	142	75	93	45	7
Bulgaria	**13839**	4631	4707	5056	3385	2276	1778	2348	582	915	1268	323	785	449	187	216	168	61	18	50
Croatia	**9924**	3184	2706	2523	2203	2142	1599	1157	681	565	803	286	462	272	234	116	80	56	32	36
Cyprus	**7003**	2358	1698	1515	1368	1713	635	815	654	512	590	190	382	208	109	85	51	60	29	7
Czech Republic	**9753**	2956	2614	2289	2093	2127	1794	1183	764	424	727	310	411	281	259	116	98	44	43	33
Denmark	**7740**	2399	1248	1136	1254	1689	1276	466	758	523	456	423	274	161	107	83	75	61	36	7
Estonia	**11122**	2634	2534	3026	2414	1887	2899	1248	520	407	405	904	540	231	156	94	185	107	34	46
Finland	**7273**	1389	1614	1527	1410	1470	1503	716	537	343	217	554	246	209	151	56	39	73	59	4
France	**6281**	1769	977	864	919	811	1293	384	826	410	286	354	190	122	123	99	85	81	42	4
Germany	**7664**	2240	1559	1444	1357	1284	1300	720	686	509	457	337	343	194	112	64	79	101	35	8
Greece	**7756**	3017	1768	1558	1503	1380	881	926	561	576	624	250	402	221	97	151	63	76	34	4
Hungary	**12036**	4008	3417	3379	2681	2246	2409	1514	659	679	996	223	518	324	246	184	108	49	23	64
Ireland	**6980**	1993	1323	1278	1280	1460	1249	573	561	446	351	444	273	194	96	94	68	87	22	5
Italy	**5879**	1625	1096	1012	1055	1208	667	424	587	498	395	384	232	145	99	113	90	62	47	4
Latvia	**13446**	3457	3986	3906	2903	2263	3197	1967	616	515	851	663	744	449	174	113	241	97	50	56
Lithuania	**13398**	3238	3877	4004	2613	1892	3855	2074	613	464	793	634	688	484	197	94	153	126	42	63
Luxembourg	**7154**	1998	1208	1283	1413	1510	1515	489	566	362	405	406	273	160	127	75	61	81	39	5
Malta	**7672**	2121	1856	1633	1689	2126	354	876	648	763	583	344	395	295	116	189	57	50	27	4
Netherlands	**6767**	2357	1158	1069	1170	1362	731	451	727	504	443	243	243	137	112	55	62	86	39	3
Poland	**10466**	3307	2687	2292	2215	1970	2046	1166	729	622	857	301	380	295	240	119	119	59	10	32
Portugal	**7403**	1777	1407	1161	1433	1830	1584	478	643	527	380	264	341	187	85	127	292	76	48	10
Romania	**13730**	3749	3623	4154	2873	1726	3296	1691	818	1320	1032	388	595	387	205	234	223	59	28	102
Slovakia	**10886**	2960	3293	3061	2411	1729	1854	1564	553	717	809	295	540	357	237	132	111	49	29	37
Slovenia	**7735**	2339	1590	1537	1611	1209	946	620	756	433	498	386	255	166	305	89	66	58	25	26
Spain	**6171**	1989	1028	1019	1134	1034	1119	428	503	492	325	319	234	137	94	137	109	55	33	4
Sweden	**6254**	1545	1368	1197	1169	1301	825	578	541	382	220	384	248	182	126	50	57	86	48	6
United Kingdom	**7365**	1870	1387	1131	1377	1121	932	606	659	702	418	611	228	180	102	68	78	85	39	6

Figure 2 Risk-attributable age-standardized DALY rates (DALYs per 100 000 inhabitants) by level 2 risk factors and by country, for the European Union (EU-28) in 2017. Green cells: estimate range that is below the EU-28 average range; red cells: estimate range above the average range; yellow cells: estimate range crossing the EU-28 average range

blood pressure, the most burdensome level 2 risks, with lower percentage decreases when compared with the EU-28-average. Germany presented the lowest decrease in deaths attributed to tobacco, dietary risks and high systolic blood pressure and also displayed the lowest decreases in DALYs attributed to tobacco and high systolic blood pressure. On the other hand, Denmark showed the largest reduction in deaths and DALYs attributable to tobacco, despite presenting an age-standardized death rate that remained considerably higher than the EU-28-average. In terms of tobacco burden and exposure, Finland and Sweden showed the lowest estimates in 2017, while Latvia and Estonia were the only countries with an exposure increase despite not showing the same trend for disease burden (figure 3).

In terms of deaths and DALYs attributed to drug use, Estonia accounted for the largest burden by far, with little to no change in comparison to the EU-28-average. Portugal, Hungary and Greece presented the lowest rates but achieved the largest reduction in deaths and DALYs attributed to drug use, considerably better than the EU-28-average, whereas Czech Republic, Sweden and Netherlands stood out in the opposite direction. There was also an increase of the SEV for drug use in the EU-28, with Czech Republic showing by far the largest increase. However, the UK presented the highest SEV estimates for drug use in 2017, also reporting an increase in the exposure that was similar to that observed for the EU-28-average. Other relevant examples are Finland, as the best performer on air pollution, and Lithuania, as the worst in DALY rates due to childhood maltreatment. Additional country-specific age-standardized death and DALY rates for 19 level 2 risk factors, and SEV estimates for 18 level 3 risk factors with the highest attributable DALY-rates, including their percentage change between 2007 and 2017, are displayed in Supplementary figures 2, 3 and 4, respectively.

Discussion

Between 2007 and 2017, the EU experienced a considerable decrease in risk-attributable age-standardized death and DALY rates. However, an important share of the burden of disease in 2017 can still be attributed to selected risk factors in the EU-28 countries. In general, behavioural and metabolic risks remained the most important ones for all ages and both sexes. Tobacco, dietary risks and high systolic blood pressure were in the top three for both death and DALY rates, while metabolic risk factors closely followed.

Despite this improvement, there is heterogeneity in burden of disease attributable to risk factors across countries. Eastern and Central European countries generally had higher death and DALY rates attributable to risk factors when compared with the EU-28 average. Bulgaria in particular had the highest attributable DALY-rates.

Tobacco-attributable burden generally improved throughout the EU-28. Scandinavian countries were among the best performers in health outcomes and exposure: Finland had the lowest death and DALY rates on tobacco and the lowest exposure to smoking, followed by Sweden. Denmark led the decreasing trend of exposure and DALYs attributable to tobacco. Both Sweden and Finland have a long history of tobacco control, being among the first countries to sign the World Health Organization (WHO) Framework Convention on Tobacco Control and adopting measures that include offering alternatives to cigarettes (i.e. snus tobacco).[12] In addition, there have been efforts at the EU-level, including actions on excise duties for tobacco products (2011) and targeting the manufacturing, trade and taxation of tobacco products.[13,14] Raising taxes on tobacco was widely adopted in the EU in 2012, when 22 countries complied with the minimum tax level recommended by the WHO.[15] Despite a clear progress in Europe in recent years,[16] Bulgaria still showed an important burden attributable to tobacco, having the highest death and DALY rate and the highest exposure to smoking in the EU. In addition, Latvia and Estonia were the only European countries with increases in exposure since 2007. The same trend is not found for burden as there is a high time lag between exposure and the reflection on its burden. For Bulgaria, some reasons may explain our findings: (i) difficulties in implementing smoking regulatory policies; and (ii) an economy highly dependent on the tobacco industry, an important source of income, with extremely effective lobbying.[2] Considering that Bulgaria has one of the lowest

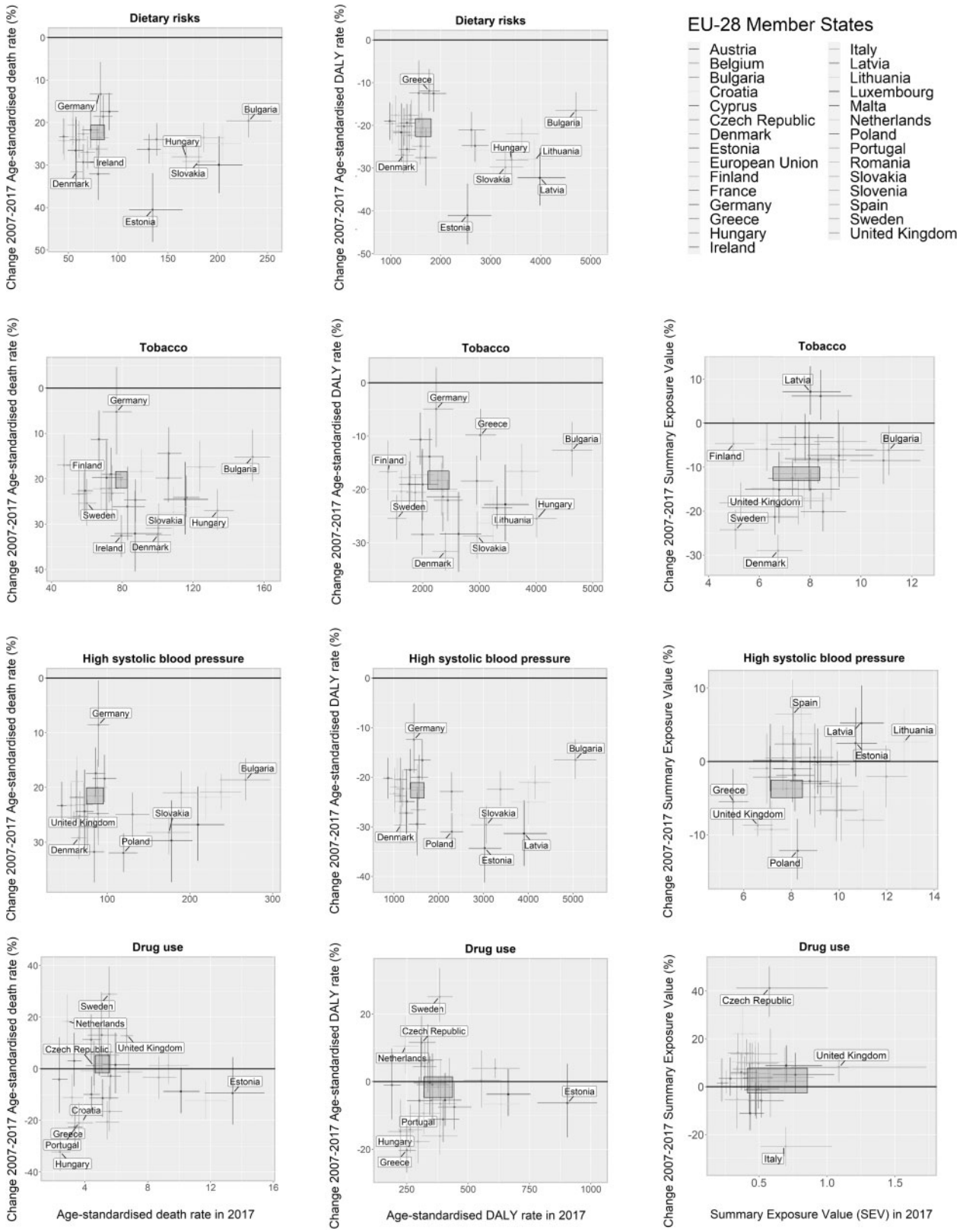

Figure 3 Relationship between SEV and risk-attributable (all-cause) age-standardized death and DALY rates for selected risk factors and their percent changes between 2007 and 2017, in EU-28. Each dot represents one EU-28 country and crossed lines the 95% uncertainty intervals. The green boxes represent the EU-28 estimate and its uncertainty interval

health expenditures in the EU-28 and underdeveloped preventive actions, the EU has a key role to play in coordinating guidelines and best practice exchange, monitoring health systems/programmes and producing legislation/regulations that, for example, in the case of the tobacco and food industries, lead to effective industry self-regulation.[17]

Metabolic risk factors also represent an important threat. In particular, Bulgaria again showed a much higher burden attributable to high systolic blood pressure, the levels of which were also alarming in Germany with the smallest burden reduction in the EU. Highly connected to this risk factor are dietary risks.[18] In fact, the countries with the best estimates (and changes from 2007) in high systolic

blood pressure also showed the best results for dietary risks (e.g. Estonia). These two risk factors show great changes in burden, but remain a persistent problem in the EU-28. Many EU countries took actions acknowledging that metabolic risk factors and unhealthy diets contribute to overweight/obesity.[19] Interventions vary from product reformulation, taxes or new labelling schemes to marketing, awareness-raising campaigns and promotion of active modes of transport.[20,21] Many initiatives are currently active at the EU-level, including the Physical Activity Strategy and Nutrition Action Plan, while individual countries carry their own national strategies/programmes.[19] For example, France and Italy have adopted several policies/programmes over the years to tackle obesity and show the lowest level of burden attributable to dietary risks and high systolic blood pressure.[19]

Drug use was the only level 2 risk factor that showed an increased death rate, with great heterogeneity between countries. Estonia had the highest death rate and Cyprus the lowest; while Sweden, the Netherlands and Czech Republic showed the highest increases in deaths. Illicit drug policy remains a debated topic. In the EU, different approaches are taken by national governments, despite several EU Action Plans and Drug Strategies. Even though consensus exists on the approach towards drug trafficking, the coexistence of opposing paradigms when it comes to drug use(rs) makes the adoption of a common policy difficult (e.g.: the liberal Dutch policy focusing on reducing harm for drug users vs. Sweden's 'zero tolerance' to eradicate drug use from society).[22,23] These examples show that it will be difficult to achieve a 'one-size-fits-all' drug policy in the EU, who should continue to play a guiding role both on legislation and platforms for best practices sharing, promoting a whole-of-society approach, fundamental for effective drug policies.[24]

Globally, alcohol-attributable burden, measured in total DALYs, was the highest for Eastern and Central Europe.[25] Alcohol use in the EU in 2017 seemed to be similar to that of 2007. However, alcohol-attributable death and DALY rates declined. Even though some progress was made, there is still need for a stronger EU alcohol strategy focusing on (i) harmonizing EU legislation in the prevention of alcohol harm; (ii) specific laws for alcoholic beverages and (iii) a truly comprehensive and regulatory alcohol policy.[26] The WHO recently recommended (2020) more generalized taxation on alcoholic beverages related to their alcohol content,[27] complemented by regulatory measures, e.g. regulating physical availability or drink-driving counter-measures.[28] However, EU directives governing alcohol duties pose significant challenges. Recently, both Scotland and Wales were the first among the EU-28 to implement minimum unit pricing on alcohol purchases, a policy proven to be effective in reducing alcohol consumption.[29]

When it comes to EU DALY rates and childhood maltreatment, this was the only level 2 risk factor that showed an increase, mainly due to increased bullying, despite international efforts. The Council of Europe's Strategy for the Rights of the Child 2016–21 prioritizes the eradication of violence against children, including all forms of bullying (school bullying and cyber-bullying[30,31]). Progress has been achieved, with implementation of national legislation and activities (media campaigns, conferences and lectures/publications), as well as best practice sharing amongst member states.[32] However, countries like Lithuania, with the highest attributable DALY rate in 2017 and some of the EU's highest levels of school bullying since 1994,[33] have only recently started to improve its implementation, through stronger legislation, greater engagement with schools and educational communities and targeted media campaigns.[32,34]

Intimate partner violence showed a decrease in both attributable burden and exposure in the EU. In fact, the EU has established several resolutions towards the strengthening of the rights and protections of victims, calling on Member States to improve national laws and policies to combat violence against women.[35] However, with recent insights from the COVID-19 pandemic impact, this positive trend might change.

Regarding air pollution, attributable deaths and DALY rates decreased for the EU, as well as the exposure to ambient particulate matter pollution, with Finland maintaining the lowest estimates and still showing a decreasing trend. In fact, emissions of many air pollutants have decreased substantially in Europe over the past decades, with further recent initiatives by the EU Commission such as the Clean Air Policy Package and Programme for Europe.[36] Finland's air quality is one of the best globally due to strong environmental regulations, such as the National Air Pollution Control Programme 2030, which aims to bring down emissions and concentrations of pollutants to levels even lower than those required in EU legislation.[37]

The EU already does much for health when it comes to environmental, labour and consumer protection policies, with visible and positive effects, but the legal space for EU action in other domains remains immense.[17] However, the fact that, ultimately, health policy is still a responsibility of each country poses a limitation to the extent that the EU can act. The big steps in EU public health policy seem to follow crises—what political scientists call 'focusing events'.[17] In the wake of COVID-19, its impact on healthcare and evidence that the direct costs of NCDs in the EU will continue to grow in the future,[38] it is clear that much remains to be done and the focus should be on strengthening EU health policy. Initiatives such as 'State of Health in the EU' and the EU 'Health Programme' stand out as important tools for the improvement of European Health.[17]

Limitations

This study presents several limitations, and many of them are intrinsic to the relying data and methods used in the GBD, namely the availability and quality of primary data (in particular for exposure and morbidity), the use of the same disability weights and severity distribution, PAF estimation and other techniques implemented within the CRA framework.[9,11] Despite the GBD 2017 study aiming to update the GBD CRA framework with improved methods, new risks and risk–outcome pairs, as well as presenting new data regarding risk exposure levels and risk–outcome associations at a global level, there are still specific limitations related to CRA estimates.[2] Additionally, the use of a world standard population may lead to important differences when compared with the EU age structure.[39]

Conclusion

Although an overall improvement was observed from 2007 to 2017, the risk factor attributable burden of disease in the EU-28 remains high. The significant burden of disease attributable to risk factors in the EU-28 underlines the room for acting in order to reduce the part of burden of disease that is avoidable by tackling risk factors like tobacco and dietary risks, by means of public health interventions. There are many opportunities for mutual learning among countries with different patterns of disease and risk factors, be it through sharing good practices and policies, or highlighting concerning cases. This paper can be a first step for more detailed analyses, further decomposition of these results (e.g. age groups, sex, subnational estimates) and future mutual learning between Member States. There is clearly much to be done, with risk factors prevention serving as a strategic future direction for upcoming times in the EU.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Ethics approval

The study was not appraised by an Ethical Committee as it is only the reuse of publicly available secondary data, despite complying with the Declaration of Helsinki.

Key points

- Despite a general improvement, risk factor attributable burden of disease in the EU-28 remains high, with behavioural and metabolic risk factors standing out.
- Important heterogeneity between countries was observed, and good practices with possible public health implications were identified.
- This paper can be a first step for more detailed analyses and future mutual learning between Member States, as there is clearly much to be done regarding risk factors prevention in the EU.

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Factors associated with emergency-related diagnosis, time to treatment and type of treatment in 5713 lung cancer patients

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Background: International and national differences exist in survival among lung cancer patients. Possible explanations include varying proportions of emergency presentations (EPs), unwanted differences in waiting time to treatment and unequal access to treatment. **Methods:** Case-mix-adjusted multivariable logistic regressions the odds of EP and access to surgery, radiotherapy and systemic anticancer treatment (SACT). Multivariable quantile regression analyzed time from diagnosis to first treatment. **Results:** Of 5713 lung cancer patients diagnosed in Norway in 2015–16, 37.9% ($n = 2164$) had an EP before diagnosis. Higher age, more advanced stage and more comorbidities were associated with increasing odds of having an EP ($P < 0.001$) and a lower odds of receiving any treatment ($P < 0.001$). After adjusting for case-mix, waiting times to curative radiotherapy and SACT were 12.1 days longer [95% confidence interval (CI): 10.2, 14.0] and 5.6 days shorter (95% CI: −7.3, −3.9), respectively, compared with waiting time to surgery. Patients with regional disease experienced a 4.7-day shorter (Coeff: −4.7, 95% CI:−9.4, 0.0) waiting time to curative radiotherapy when compared with patients with localized disease. Patients with a high income had a 22% reduced odds [odds ratio (OR) = 0.78, 95% CI: 0.63, 0.97] of having an EP, and a 63% (OR = 1.63, 95% CI: 1.20, 2.21) and a 40% (OR = 1.40, 95% CI: 1.12, 1.76) increased odds of receiving surgery and SACT, respectively. **Conclusion:** Patients who were older, had advanced disease or increased comorbidities were more likely to have an EP and less likely to receive treatment. While income did not affect the waiting time for lung cancer treatment in Norway, it did affect the likelihood of receiving surgery and SACT.

Introduction

Although lung cancer survival is modest, it has improved significantly over the last decade, and substantial variation exists both internationally and nationally.[1–3] In patients diagnosed in 2015–19, the 5-year survival was estimated to be 22.7% in men and 29.2% in women in Norway.[4] The proportion of patients diagnosed through an emergency presentation (EP), waiting times from diagnosis to treatment, as well as access to treatment may explain some of the observed variations in survival.

There are different explanations for why patients may have an emergency visit. Patients may experience a disease that rapidly manifests symptoms, or they may have delayed health-seeking behaviour which could result in a worsened condition (patient-delay). It is also possible that an emergency visit may be associated with a prolonged diagnostic interval by the general practitioner or hospital (system-delay). During their emergency visit, patients may be diagnosed with lung cancer due to lung-specific symptoms, or incidentally diagnosed when examined for an unrelated condition. Internationally, the proportion of lung cancer patients who are diagnosed during an emergency visit varies.[5,6]

The timeliness of and access to treatment are of great importance to the prognosis. In order to ensure a timely treatment, not only does there need to be sufficient capacity in terms of medical staff and equipment but there should also be a well-organized and structured healthcare system where unnecessary delays to treatment are kept at a minimum. In Norway from 2007 to 2016 waiting time from diagnosis to lung cancer treatment (surgery and radiotherapy)