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# Burden of non-communicable diseases among adolescents aged 10-24 years in the EU, 1990-2019: a systematic analysis of the Global Burden of Diseases Study 2019 

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#### Abstract

Summary Background Disability and mortality burden of non-communicable diseases (NCDs) have risen worldwide; however, the NCD burden among adolescents remains poorly described in the EU.

Methods Estimates were retrieved from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019. Causes of NCDs were analysed at three different levels of the GBD 2019 hierarchy, for which mortality, years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life-years (DALYs) were extracted. Estimates, with the $95 \%$ uncertainty intervals (UI), were retrieved for EU Member States from 1990 to 2019, three age subgroups ( $10-14$ years, $15-19$ years, and 20-24 years), and by sex. Spearman's correlation was conducted between DALY rates for NCDs and the Socio-demographic Index (SDI) of each EU Member State.


Findings In 2019, NCDs accounted for $86 \cdot 4 \%$ ( $95 \%$ uncertainty interval $83 \cdot 5-88 \cdot 8$ ) of all YLDs and $38 \cdot 8 \%(37 \cdot 4-39 \cdot 8)$ of total deaths in adolescents aged $10-24$ years. For NCDs in this age group, neoplasms were the leading causes of both mortality ( 4.01 [ $95 \%$ uncertainty interval $3 \cdot 62-4 \cdot 25$ ] per 100000 population) and YLLs ( 281.78 [254.25-298.92] per 100000 population), whereas mental disorders were the leading cause for YLDs (2039.36 [1432.56-2773.47] per 100000 population) and DALYs (2040.59 [1433.96-2774.62] per 100000 population) in all EU Member States, and in all studied age groups. In 2019, among adolescents aged 10-24 years, males had a higher mortality rate per 100000 population due to NCDs than females ( 11.66 [11.04-12.28] vs 7.89 [7.53-8.23]), whereas females presented a higher DALY rate per 100000 population due to NCDs ( $8003 \cdot 25$ [5812•78-10701.59] vs $6083 \cdot 91$ [4576.63-7857.92]). From 1990 to 2019, mortality rate due to NCDs in adolescents aged $10-24$ years substantially decreased $(-40 \cdot 41 \%$ [ $-43 \cdot 00$ to $-37 \cdot 61$ ), and also the YLL rate considerably decreased ( $-40 \cdot 56 \%$ [ $-43 \cdot 16$ to $-37 \cdot 74]$ ), except for mental disorders (which increased by $32.18 \%$ [ 1.67 to 66.49$]$ ), whereas the YLD rate increased slightly ( $1.44 \%$ [ 0.09 to 2.79$]$ ). Positive correlations were observed between DALY rates and SDIs for substance use disorders ( $r_{s}=0.58, \mathrm{p}=0.0012$ ) and skin and subcutaneous diseases ( $r_{s}=0.45, \mathrm{p}=0 \cdot 017$ ), whereas negative correlations were found between DALY rates and SDIs for cardiovascular diseases ( $r_{s}=-0.46, \mathrm{p}=0.015$ ), neoplasms ( $r_{s}=-0.57, \mathrm{p}=0.0015$ ), and sense organ diseases ( $r_{s}=-0.61, \mathrm{p}=0.0005$ ).

Interpretation NCD-related mortality has substantially declined among adolescents in the EU between 1990 and 2019, but the rising trend of YLL attributed to mental disorders and their YLD burden are concerning. Differences by sex, age group, and across EU Member States highlight the importance of preventive interventions and scaling up adolescent-responsive health-care systems, which should prioritise specific needs by sex, age, and location.

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## Introduction

Adolescence is a period of major physical growth, psychological development, and shifting social relationships, with major repercussions for health. ${ }^{1}$ The inclusion of adolescents within the Global Strategy for Women's, Children's, and Adolescents' Health ${ }^{2}$ and the Countdown to $2030,{ }^{3}$ has reinforced the importance of tracking adolescent health. However, so far, global progress has been slow, ${ }^{4}$ and adolescents remain a neglected age group in the quest for universal health coverage. ${ }^{5}$ In this context, the scarcity of adolescent-specific country data, disaggregated by sex and age, is a major barrier. ${ }^{5}$ The non-communicable
disease (NCD) agenda has so far predominantly focused on adults, ${ }^{6.7}$ reflecting historical assumptions of adolescents as largely healthy. However, globally among adolescents, the burden of disability and mortality from NCDs has risen substantially, ${ }^{8}$ with the leading causes being mental disorders, substance use disorders, and chronic physical illness. ${ }^{\text {' }}$
EU Member States, although committed to addressing certain issues in adolescent health, particularly mental health and wellbeing, ${ }^{10}$ are yet to conduct a broad assessment of the disability and mortality burden of NCDs among adolescents. Although most EU Member

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## Research in context

## Evidence before this study

We searched Embase and PubMed for research articles published in English on Nov 22, 2021, using the following terms in titles or abstracts: ("adolescent" OR "young people") AND ("disability" OR "mortality") AND ("Europe" OR "European Union") AND ("non communicable disease" OR "NCD"). Although we identified several studies, these primarily examined adolescent mortality, mainly at the global level, and did not specifically focus on non-communicable diseases (NCDs). Moreover, studies either included smaller age groups ( $10-14$ years, $10-19$ years) or were country specific, disease specific, or part of a wider study on mortality or disability burden in other age groups. We only found one study, reporting analyses from 2015 on NCDs in adolescents that confirmed that NCDs are a major public health problem among adolescents globally, and that mental disorders were a large proportion of disability-adjusted life-years (DALYs) in people aged 10-19 years. To our knowledge, a comprehensive and detailed assessment of the burden of both mortality and disability of NCDs and their trends across EU Member States in adolescents aged 10-24 years old has not previously been published.

## Added value of this study

This study provides a comprehensive description of the mortality and disability burden of NCDs among adolescents aged 10-24 years in EU Member States from 1990 to 2019. We retrieved estimates from Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019, the largest systematic, data-driven, and most recent peer-reviewed assessment of mortality and disability burden by age group, sex, cause, and location. GBD 2019 estimates replace those from previous GBD cycles, as in each iteration the GBD generates revised estimates
for the whole time series based on the most updated data and modelling methodology. This study highlights that for the adolescent population mortality has substantially decreased in the past 30 years, and adds to previous studies the important aspect of the rising trend of years of life lost (YLL) rate attributed to mental disorders in this population. It also describes the heavy disability burden attributed to NCDs at the regional and country level in the EU and the concerning increase of years lived with disability (YLDs) due to mental disorders. We also report wide variation in both the mortality and disability burden of NCDs by age group, sex, and location, suggesting opportunities for improvements. We were also able to identify association between the EU Member State level of socioeconomic development and the DALY burden of specific NCDs.

## Implications of all the available evidence

These findings provide data for evidence-based decision making and highlight priority areas for interventions and investments, such as the importance of promotion of mental wellbeing and prevention of mental disorders, improvements in access to quality mental health services, and investments in dedicated primary and specialist health-care services. The extent of current disability burden of NCDs in adolescents suggests there is a need to scale up high-quality health-care services; establish, develop, and strengthen public health prevention policies, school programmes, specialised training pathways; and ensure that investments address the specific needs of adolescent health. Leadership around these elements could be enhanced by greater access to primary data sources to increase the accuracy of future findings and facilitate timely response to rapid changes in adolescents' health and wellbeing, such as those caused by the COVID-19 pandemic.

States have high economic development and relatively high-quality health services, and fall into the category of NCD-predominant countries, ${ }^{\text {e }}$ differences in culture, governance, and prioritisation of public health policies and investments mean it is a region where changing NCD profiles among adolescents can be explored. Moreover, despite prevention policies implemented in the EU leading to progress in the reduction of premature mortality from NCDs, such as control measures targeting tobacco products, alcoholic beverages, and unhealthy food for young people, about a third of the EU population aged 15 years or older still lives with an NCD, and $€ 700$ billion is spent on treating NCDs annually in the region. ${ }^{11}$ Given considerable heterogeneity and inconsistency in data collection systems and major data gaps, we used estimates from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2019 to: provide a comprehensive assessment of the burden of mortality and disability due to NCDs in adolescents aged 10-24 years in EU Member States by cause, sex, age, location, and trend over time for the 30 -year period; and
evaluate the association between the disability-adjusted life-year (DALY) rates, which comprise both years lived with disability (YLDs) and years of life lost (YLLs), of the NCDs with the developmental stage of each EU Member State, using a composite measure of income per capita, average educational attainment, and fertility rate. Growing concerns about the effects of the COVID-19 pandemic and its containment measures on NCDs and their risk factors among adolescents ${ }^{12,13}$ suggest that this assessment can be considered a pre-pandemic baseline from which subsequent data can be compared at the regional and country level.

## Methods

## Overview

This study adopted the broad age definition for adolescence from 10 to 24 years because it accurately captures the biological, social, and neurocognitive development of this population. ${ }^{1}$ We included the UK in these analyses, as it was still an EU Member State in 2019.

Estimates were retrieved from GBD 2019, which provides a complete set of comparable health estimates for 204 countries, including the 28 EU Member States, for 286 causes of death, 369 causes of disease and injury, and 87 risk factors. GBD 2019 generated estimates using 86249 sources, and produced estimates of incidence, prevalence, mortality, YLDs, YLLs, DALYs, life expectancy, and health-adjusted life expectancy. To estimate deaths due to different causes, GBD 2019 used vital registration and verbal autopsy data as sources, modelled using the Cause of Death Ensemble model, which used geospatial information from covariates to produce estimates of death for all locations across time (1990-2019). Deaths from vital registration systems coded as unspecified were reassigned using statistical methods. ${ }^{14}$ For most diseases and injuries, data were also modelled using a spatiotemporal Gaussian process regression to allow for smoothing over age, time, and location, and a Bayesian meta-regression modelling tool (DisMod-MR 2.1) that ensured internally consistent estimates among all epidemiological metrics for most causes, by age, sex, location, and year. ${ }^{14}$ Methods for GBD 2019 estimates are described in detail in the capstone papers and appendices. ${ }^{14}$ The GBD 2019 cause list is composed of a four-level hierarchy, with each level comprising mutually exclusive and collectively exhaustive causes. There are 22 level 2 causes, 174 level 3 causes, and 301 level 4 causes (including 131 level 3 causes that are not further disaggregated at level 4). GBD 2019 estimates generated and reported here are in accordance with the Guidelines for Accurate and Transparent Health Estimates Reporting. ${ }^{15}$

## Data analysis

Causes are reported following the GBD hierarchy. To give a general insight of the predominant causes of burden, we analysed all three level 1 causes: communicable, maternal, neonatal, and nutritional conditions; NCDs; and injuries. At level 2 and 3, we exclusively focused on NCD causes (appendix pp 31-33). We excluded self-harm and interpersonal violence from the analysis because the GBD hierarchy includes these in the injuries group (level 1).
Estimates were retrieved for the 28 EU Member States. The analyses covered the period 1990 to 2019, and were stratified by sex and age groups as follows: 10-14 years (younger adolescents), 15-19 years (older adolescents), and 20-24 years (young adults). ${ }^{6}$ Mortality, YLLs, YLDs, and DALYs were all reported as rates per 100000 population. DALYs are the sum of YLLs and YLDs. YLLs are calculated by subtracting the age at death from the longest possible life expectancy for a person at that age. YLDs are estimated by multiplying the prevalence counts with the disability weight for a given disease or injury. As described in detail in the GBD 2019 capstone paper, ${ }^{14}$ disability weights represent the magnitude of health loss associated with specific health outcomes, and are used to estimate YLDs through
a series of severity splits. These metrics were subsequently subdivided by level of causes, specifically total all-cause, level 1, NCD level 2, and cause-specific NCD level 3 (appendix pp 31-33); sex (both sexes, female, and male), and age ( $10-24$ years, $10-14$ years, $15-19$ years, and 20-24 years); country ( 28 EU Member States); and trend over time (1990-2019), for which we calculated the percentage change (rate) between 1990 and 2019 in $10-24$-year-olds. All estimates generated in GBD 2019 are accompanied by $95 \%$ uncertainty intervals (UIs), which represent the 25th and 975th ordered estimates of 1000 draw estimates of the posterior distribution. ${ }^{14}$ We considered estimates to be significantly different by determining whether the $95 \%$ UIs overlapped.
Spearman's correlation was used to analyse the social, economic, and demographic diversity of NCD burden between EU Member States by correlating the DALY rates of level 2 NCDs (which comprise both YLDs and YLLs) with each country's score of the Socio-demographic Index (SDI). The SDI is a composite measure of a country's lag-distributed income per capita, average years of schooling, and the fertility rate in females younger than 25 years. ${ }^{14,16}$ The metric is scaled from 0 to 1 , where 0 represents the lowest combination of the three indicators and 1 represents the highest. p values of less than 0.05 were set as the threshold of significance. The analysis was done with IBM SPSS Statistics (version 27.0).

## Role of the funding source

The funder of the study had no role in study design, data collection, analysis, and interpretation, or writing of the report.

## Results

## Mortality

In 2019, total all-cause mortality for adolescents aged $10-24$ years in the EU was $25 \cdot 35$ ( $95 \%$ UI 24•44-26•27) per 100000 population (appendix pp 3-4). NCDs accounted for $38.8 \%(37.4-39.8)$ of total deaths in this age group (appendix pp 34-35). The leading level 2 cause of death for NCDs in adolescents aged $10-24$ years was neoplasms (4.01 [3.62-4.25] per 100000 population), which accounted for $40 \cdot 8 \%(36 \cdot 8-43 \cdot 2)$ of all NCD mortality. The leading level 3 cause of death for NCDs was other malignant neoplasms (1.05 [0.88-1•14) per 100000 population).
In 2019, NCDs were the leading level 1 cause of death in females of all age categories ( $52 \cdot 1 \%$ [ $95 \%$ UI $50 \cdot 3-53 \cdot 3$ ] for $10-24$ years, $63 \cdot 9 \%$ [61.1-65.6] for $10-14$ years, $48 \cdot 0 \%$ [ $45 \cdot 8-49 \cdot 5$ ] for $15-19$ years, and $50 \cdot 6 \%$ [49.0-51.9] for 20-24 years) and in males aged $10-14$ years ( $54 \cdot 1 \%$ [ $52 \cdot 0-56 \cdot 0$ ]; appendix pp 36-37). Additionally, for both sexes, mortality due to NCDs increased across the three age groups from 5.57 $(5 \cdot 31-5 \cdot 84)$ per 100000 population for $10-14$ years to $9.47(8.96-9.99)$ per 100000 population for $15-19$ years, and $14.30(13.67-14.95)$ per 100000 population for


Figure 1: Mortality rate per 100000 population due to level 2 non-communicable diseases in adolescents aged 10-24 years in both sexes, by country, 2019
*This aggregate cause contains the following level 3 causes: congenital birth defects; urinary diseases; gynaecological diseases; haemoglobinopathies and haemolytic anaemias; endocrine, metabolic, blood, and immune disorders; and oral disorders.

20-24 years (appendix pp 34-35). Differences by age and sex in NCD level 2 mortality rates are reported in the appendix (pp 5-6).
In 2019, the highest mortality rate due to level 2 NCD causes (Bulgaria and Estonia) was more than double the lowest rate (France, Belgium, and Spain; figure 1). Significant differences in the excess mortality rate due to NCDs were observed between eight Member States and the EU overall (compostie estimate): Bulgaria, Estonia, Latvia, Lithuania, Romania, Malta, the UK, and Finland. In all EU Member States, the leading level 2 cause of death was neoplasms, except in Estonia, where it was substance use disorders.
From 1990 to 2019, the mortality rate due to NCDs among adolescents aged 10-24 years significantly declined by $40 \cdot 4 \%$ ( $95 \%$ UI $-43 \cdot 0$ to $-37 \cdot 6$; table; appendix p 7). For level 2 causes, the highest reduction in mortality rate from NCDs was observed in cardiovascular diseases ( $-62.00 \%$ [ -64.37 to -59.63$]$ ) and chronic respiratory diseases ( $-58.81 \%$ [ -62.27 to $-50 \cdot 24]$ ), whereas the highest increase was in mental disorders ( $32 \cdot 36 \%$ [2. 25 to $66 \cdot 96]$ ), completely attributed to eating disorders (table; appendix p 7).

## Years of life lost

In 2019, all-cause YLL rates per 100000 population in the EU were 1758.00 ( $95 \%$ UI 1694.58-1822.04) among adolescents aged 10-24 years (appendix p 8). Among NCDs, the leading level 2 cause of YLLs was neoplasms ( $281 \cdot 78$ [254.25-298.92] per 100000 population), whereas
at level 3 , the three leading causes were other malignant neoplasms (74.01 [62.15-80.22] per 100000 population), drug use disorders ( 65.02 [59.34-72.26] per 100000 population), and leukaemia ( $64 \cdot 64$ [60•62-69•01] per 100000 population; appendix pp 38-39).
In 2019, all-cause YLL rates per 100000 population were significantly higher in males (2415.92 [ $95 \%$ UI 2321.65-2509.04]) than in females ( $1060 \cdot 34$ [1024.01-1099.59]), with the largest differences in those aged $20-24$ years, with a male-to-female ratio of $2 \cdot 8: 1$ (appendix p 8). NCDs were the leading cause of YLLs among females in all three age groups $(63.9 \%$ [61.1-65.6] for 10-14 years, $48 \cdot 0 \%$ [45.8-49.5] for $15-19$ years, and $50 \cdot 6 \%$ [ $49 \cdot 0-51 \cdot 9$ ] for $20-24$ years) and in the youngest males ( $54 \cdot 1 \%$ [52.0-56.0] for 10-14 years; appendix pp 36-37). Sex and age-group differences for NCD level 2 causes of YLL are reported in figure 2A and the appendix (pp 9-10). Significant sex differences in YLL rates per 100000 population in adolescents aged $10-24$ years were apparent for several NCD level 3 causes, most notably for drug use disorders ( $98 \cdot 38$ [ $88 \cdot 76-111 \cdot 23$ ] for males vs $29 \cdot 64$ [27.09-32.33] for females), other neurological disorders (45.93 [42.44-49.72] vs $13 \cdot 1$ [12.0-14.4]), alcohol use disorders ( $15 \cdot 25$ [13.04-17•02] vs $3 \cdot 16$ [2•82-3•50]; appendix p 11). In 2019, the five countries with the largest burden of YLL rate per 100000 population for NCDs in adolescents aged 10-24 years were Bulgaria (1381.32 [95\% UI 1102.73-1714.70]), Estonia (1230.34 [1004•84-1511•39]), Latvia (1028•11 [870•39-1237.01]),

|  | Mortality rate per 100000 population |  |  | DALY rate per 100000 population |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1990 | 2019 | Percentage change, 1990 to 2019 | 1990 | 2019 | Percentage change, 1990 to 2019 |
| All non-communicable diseases | $\begin{aligned} & 16 \cdot 50 \\ & (16 \cdot 20 \text { to } 16 \cdot 72) \end{aligned}$ | $\begin{aligned} & 9.83 \\ & (9 \cdot 39 \text { to 10.28) } \end{aligned}$ | $\begin{aligned} & -40 \cdot 41 \% \\ & (-43 \cdot 00 \text { to }-37 \cdot 61) \end{aligned}$ | $\begin{aligned} & 7394 \cdot 59 \\ & \text { (5591-11 to 9580.25) } \end{aligned}$ | $\begin{aligned} & 7015 \cdot 44 \\ & \text { (5181-20 to 9224•35) } \end{aligned}$ | $\begin{aligned} & -5 \cdot 13 \% \\ & (-7 \cdot 55 \text { to }-3 \cdot 21) \end{aligned}$ |
| Neoplasms | $\begin{aligned} & 6.32 \\ & (6.12 \text { to } 6.47) \end{aligned}$ | $\begin{aligned} & 4.01 \\ & \text { (3.62 to } 4.25 \text { ) } \end{aligned}$ | $\begin{aligned} & -36 \cdot 61 \% \\ & (-42 \cdot 27 \text { to }-32 \cdot 78) \end{aligned}$ | $\begin{aligned} & 461.02 \\ & (445.96 \text { to } 472.95) \end{aligned}$ | $\begin{aligned} & 300 \cdot 48 \\ & (271 \cdot 26 \text { to 321.31) } \end{aligned}$ | $\begin{aligned} & -34.82 \% \\ & (-40.62 \text { to }-30 \cdot 47) \end{aligned}$ |
| Lip and oral cavity cancer | $\begin{gathered} 0.04 \\ (0.04 \text { to } 0.04) \end{gathered}$ | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & -33 \cdot 96 \% \\ & (-39 \cdot 54 \text { to }-28 \cdot 14) \end{aligned}$ | $\begin{gathered} 2.66 \\ (2.53 \text { to } 2.81) \end{gathered}$ | $\begin{gathered} 1.78 \\ (1.66 \text { to } 1.91) \end{gathered}$ | $\begin{aligned} & -33 \cdot 06 \% \\ & (-38 \cdot 90 \text { to }-27 \cdot 12) \end{aligned}$ |
| Nasopharynx cancer | $\begin{gathered} 0.04 \\ (0.04 \text { to } 0.04) \end{gathered}$ | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & -41.28 \% \\ & (-48.05 \text { to -32.99) } \end{aligned}$ | $\begin{gathered} 3.07 \\ \text { (2.89 to } 3.26) \end{gathered}$ | $\begin{gathered} 1.85 \\ (1.65 \text { to } 2.06) \end{gathered}$ | $\begin{aligned} & -39 \cdot 93 \% \\ & (-46 \cdot 80 \text { to }-31 \cdot 53) \end{aligned}$ |
| Other pharynx cancer | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -13.21 \% \\ & (-25.89 \text { to 3.02) } \end{aligned}$ | $\begin{gathered} 0.46 \\ (0.42 \text { to } 0.51) \end{gathered}$ | $\begin{gathered} 0.41 \\ (0.36 \text { to } 0.47) \end{gathered}$ | $\begin{aligned} & -11 \cdot 41 \% \\ & (-24 \cdot 25 \text { to } 5 \cdot 13) \end{aligned}$ |
| Oesophageal cancer | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -26 \cdot 32 \% \\ & (-34 \cdot 25 \text { to }-14.02) \end{aligned}$ | $\begin{gathered} 0.68 \\ (0.63 \text { to } 0.73) \end{gathered}$ | $\begin{gathered} 0.5 \\ (0.46 \text { to } 0.56) \end{gathered}$ | $\begin{aligned} & -26 \cdot 12 \% \\ & (-34 \cdot 05 \text { to }-13 \cdot 75) \end{aligned}$ |
| Stomach cancer | $\begin{aligned} & 0.10 \\ & (0.09 \text { to } 0.10) \end{aligned}$ | $\begin{aligned} & 0.03 \\ & (0.03 \text { to } 0.04) \end{aligned}$ | $\begin{aligned} & -65.39 \% \\ & (-68.63 \text { to }-62.07) \end{aligned}$ | $\begin{gathered} 6.67 \\ (6.35 \text { to } 6.99) \end{gathered}$ | $\begin{gathered} 2.32 \\ (2.14 \text { to } 2 \cdot 51) \end{gathered}$ | $\begin{aligned} & -65 \cdot 27 \% \\ & (-68 \cdot 54 \text { to }-61 \cdot 93) \end{aligned}$ |
| Colon and rectum cancer | $\begin{aligned} & 0.13 \\ & (0.13 \text { to } 0.14) \end{aligned}$ | $\begin{aligned} & 0.09 \\ & (0.08 \text { to } 0.10) \end{aligned}$ | $\begin{aligned} & -32 \cdot 71 \% \\ & (-38 \cdot 30 \text { to }-26 \cdot 95) \end{aligned}$ | $\begin{gathered} 9 \cdot 61 \\ (9 \cdot 24 \text { to } 9 \cdot 98) \end{gathered}$ | $\begin{gathered} 6.57 \\ (6.06 \text { to } 7.08) \end{gathered}$ | $\begin{aligned} & -31 \cdot 58 \% \\ & (-37 \cdot 40 \text { to }-25 \cdot 59) \end{aligned}$ |
| Liver cancer | $\begin{aligned} & 0.08 \\ & (0.08 \text { to } 0.08) \end{aligned}$ | $\begin{aligned} & 0.07 \\ & (0.06 \text { to } 0.07) \end{aligned}$ | $\begin{aligned} & -13 \cdot 45 \% \\ & (-20.87 \text { to }-4 \cdot 91) \end{aligned}$ | $\begin{gathered} 5.72 \\ (5.46 \text { to } 6.00) \end{gathered}$ | $\begin{gathered} 4 \cdot 96 \\ (4 \cdot 58 \text { to } 5 \cdot 37) \end{gathered}$ | $\begin{aligned} & -13 \cdot 18 \% \\ & (-20 \cdot 43 \text { to }-4 \cdot 74) \end{aligned}$ |
| Gallbladder and biliary tract cancer | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -32 \cdot 91 \% \\ & (-39 \cdot 98 \text { to }-23 \cdot 07) \end{aligned}$ | $\begin{gathered} 0.41 \\ (0.34 \text { to } 0.44) \end{gathered}$ | $\begin{gathered} 0.27 \\ (0.25 \text { to } 0.3) \end{gathered}$ | $\begin{aligned} & -32 \cdot 66 \% \\ & (-39 \cdot 71 \text { to }-22 \cdot 71) \end{aligned}$ |
| Pancreatic cancer | $\begin{gathered} 0.03 \\ (0.03 \text { to } 0.03) \end{gathered}$ | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & -19.65 \% \\ & (-28.73 \text { to }-9.72) \end{aligned}$ | $\begin{gathered} 2.03 \\ (1.91 \text { to } 2.15) \end{gathered}$ | $\begin{gathered} 1.63 \\ (1.47 \text { to } 1.81) \end{gathered}$ | $\begin{aligned} & -19.67 \% \\ & (-28.65 \text { to }-9.85) \end{aligned}$ |
| Larynx cancer | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -43.85 \% \\ & (-48.99 \text { to }-38.68) \end{aligned}$ | $\begin{gathered} 0.59 \\ (0.54 \text { to } 0.65) \end{gathered}$ | $\begin{gathered} 0.37 \\ (0.32 \text { to } 0.41) \end{gathered}$ | $\begin{aligned} & -38.03 \% \\ & (-43 \cdot 52 \text { to }-32 \cdot 58) \end{aligned}$ |
| Tracheal, bronchus, and lung cancer | $\begin{aligned} & 0.13 \\ & (0.12 \text { to } 0.13) \end{aligned}$ | $\begin{aligned} & 0.08 \\ & (0.07 \text { to } 0.09) \end{aligned}$ | $\begin{aligned} & -35 \cdot 97 \% \\ & (-42 \cdot 35 \text { to }-28 \cdot 10) \end{aligned}$ | $\begin{gathered} 8.76 \\ (8.37 \text { to } 9 \cdot 15) \end{gathered}$ | $\begin{gathered} 5 \cdot 62 \\ (5 \cdot 12 \text { to } 6 \cdot 17) \end{gathered}$ | $\begin{aligned} & -35 \cdot 85 \% \\ & (-42 \cdot 23 \text { to }-27 \cdot 99) \end{aligned}$ |
| Malignant skin melanoma | $\begin{aligned} & 0.10 \\ & (0.07 \text { to } 0.12) \end{aligned}$ | $\begin{aligned} & 0.08 \\ & (0.05 \text { to } 0.10) \end{aligned}$ | $\begin{aligned} & -11 \cdot 37 \% \\ & (-37 \cdot 22 \text { to } 7 \cdot 00) \end{aligned}$ | $\begin{gathered} 7.07 \\ \text { (5.14 to } 8.85 \text { ) } \end{gathered}$ | $\begin{gathered} 6.88 \\ (4 \cdot 44 \text { to } 8 \cdot 14) \end{gathered}$ | $\begin{aligned} & -2.71 \% \\ & (-31.93 \text { to } 18.35) \end{aligned}$ |
| Non-melanoma skin cancer | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -35 \cdot 15 \% \\ & (-42 \cdot 61 \text { to }-24 \cdot 91) \end{aligned}$ | $\begin{gathered} 0.66 \\ (0.60 \text { to } 0.71) \end{gathered}$ | $\begin{gathered} 0.43 \\ (0.39 \text { to } 0.47) \end{gathered}$ | $\begin{aligned} & -35 \cdot 05 \% \\ & (-42 \cdot 48 \text { to }-24 \cdot 87) \end{aligned}$ |
| Breast cancer | $\begin{aligned} & 0.05 \\ & (0.05 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & 0.03 \\ & (0.03 \text { to } 0.04) \end{aligned}$ | $\begin{aligned} & -34 \cdot 91 \% \\ & (-41 \cdot 12 \text { to }-28 \cdot 20) \end{aligned}$ | $\begin{gathered} 3.90 \\ (3.67 \text { to } 4 \cdot 15) \end{gathered}$ | $\begin{gathered} 2.68 \\ (2.43 \text { to } 2.95) \end{gathered}$ | $\begin{aligned} & -31 \cdot 32 \% \\ & (-38 \cdot 15 \text { to }-23 \cdot 90) \end{aligned}$ |
| Cervical cancer | $\begin{aligned} & 0.04 \\ & (0.03 \text { to } 0.05) \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & -53 \cdot 01 \% \\ & (-59 \cdot 70 \text { to }-44 \cdot 39) \end{aligned}$ | $\begin{gathered} 3.09 \\ (2.38 \text { to } 3.4) \end{gathered}$ | $\begin{gathered} 1.49 \\ (1.24 \text { to } 1.72) \end{gathered}$ | $\begin{aligned} & -51.75 \% \\ & (-58.62 \text { to }-42.71) \end{aligned}$ |
| Uterine cancer | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -28.44 \% \\ & (-36 \cdot 45 \text { to }-18 \cdot 94) \end{aligned}$ | $\begin{gathered} 0.32 \\ (0.29 \text { to } 0 \cdot 35) \end{gathered}$ | $\begin{gathered} 0.24 \\ (0.21 \text { to } 0.27) \end{gathered}$ | $\begin{aligned} & -24 \cdot 07 \% \\ & (-33 \cdot 32 \text { to }-13 \cdot 51) \end{aligned}$ |
| Ovarian cancer | $\begin{aligned} & 0.11 \\ & (0.09 \text { to } 0.11) \end{aligned}$ | $\begin{aligned} & 0.07 \\ & (0.06 \text { to } 0.08) \end{aligned}$ | $\begin{aligned} & -34.00 \% \\ & (-45 \cdot 95 \text { to }-8 \cdot 11) \end{aligned}$ | $\begin{gathered} 7.72 \\ (6.57 \text { to } 8 \cdot 28) \end{gathered}$ | $\begin{gathered} 5 \cdot 18 \\ (4 \cdot 48 \text { to } 6 \cdot 18) \end{gathered}$ | $\begin{aligned} & -32 \cdot 99 \% \\ & (-45 \cdot 09 \text { to }-6 \cdot 30) \end{aligned}$ |
| Prostate cancer | $\begin{aligned} & 0.01 \\ & (0.00 \text { to 0.01) } \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -24.99 \% \\ & (-43.26 \text { to } 8.07) \end{aligned}$ | $\begin{gathered} 0.51 \\ (0.35 \text { to } 0.6) \end{gathered}$ | $\begin{gathered} 0.43 \\ (0.33 \text { to } 0.67) \end{gathered}$ | $\begin{aligned} & -16 \cdot 33 \% \\ & (-37 \cdot 24 \text { to 21•13) } \end{aligned}$ |
| Testicular cancer | $\begin{aligned} & 0.18 \\ & (0.17 \text { to } 0.20) \end{aligned}$ | $\begin{aligned} & 0.10 \\ & (0.09 \text { to } 0.11) \end{aligned}$ | $\begin{aligned} & -46 \cdot 67 \% \\ & (-53 \cdot 97 \text { to }-37 \cdot 89) \end{aligned}$ | $\begin{gathered} 14.00 \\ \text { (13.03 to } 15 \cdot 2) \end{gathered}$ | $\begin{gathered} 8.62 \\ (7.48 \text { to } 10.13) \end{gathered}$ | $\begin{aligned} & -38 \cdot 43 \% \\ & (-46 \cdot 69 \text { to }-26 \cdot 98) \end{aligned}$ |
| Kidney cancer | $\begin{aligned} & 0.06 \\ & (0.05 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & 0.05 \\ & (0.05 \text { to } 0.06) \end{aligned}$ | $\begin{gathered} -3.94 \% \\ (-13.76 \text { to } 7 \cdot 43) \end{gathered}$ | $\begin{gathered} 4 \cdot 12 \\ (3.89 \text { to } 4.35) \end{gathered}$ | $\begin{gathered} 3.99 \\ (3.65 \text { to } 4.37) \end{gathered}$ | $\begin{aligned} & -3 \cdot 18 \% \\ & (-13 \cdot 14 \text { to } 8.91) \end{aligned}$ |
| Bladder cancer | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -29.00 \% \\ & (-35.00 \text { to }-22 \cdot 42) \end{aligned}$ | $\begin{gathered} 0.88 \\ (0.83 \text { to } 0.95) \end{gathered}$ | $\begin{gathered} 0.66 \\ (0.6 \text { to } 0.71) \end{gathered}$ | $\begin{aligned} & -25 \cdot 72 \% \\ & (-31 \cdot 91 \text { to }-18 \cdot 13) \end{aligned}$ |
| Brain and CNS cancer | $\begin{aligned} & 1.01 \\ & (0.86 \text { to } 1.23) \end{aligned}$ | $\begin{aligned} & 0.80 \\ & (0.53 \text { to } 0.90) \end{aligned}$ | $\begin{aligned} & -20 \cdot 92 \% \\ & (-55 \cdot 57 \text { to }-9 \cdot 71) \end{aligned}$ | $\begin{gathered} 73 \cdot 56 \\ (62 \cdot 02 \text { to } 89 \cdot 41) \end{gathered}$ | $\begin{gathered} 58.46 \\ (38 \cdot 55 \text { to } 65 \cdot 75) \end{gathered}$ | $\begin{aligned} & -20 \cdot 53 \% \\ & (-55 \cdot 31 \text { to }-9.09) \end{aligned}$ |
| Thyroid cancer | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -42 \cdot 24 \% \\ & (-47 \cdot 52 \text { to }-32 \cdot 32) \end{aligned}$ | $\begin{gathered} 1.78 \\ (1.63 \text { to } 1.93) \end{gathered}$ | $\begin{gathered} 1.13 \\ (1.02 \text { to } 1.29) \end{gathered}$ | $\begin{aligned} & -36 \cdot 27 \% \\ & (-42 \cdot 70 \text { to }-25 \cdot 51) \end{aligned}$ |
| Mesothelioma | $\begin{aligned} & 0.01 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -14 \cdot 41 \% \\ & (-41.60 \text { to } 6.91) \end{aligned}$ | $\begin{gathered} 0.39 \\ (0.31 \text { to } 0.57) \end{gathered}$ | $\begin{gathered} 0 \cdot 34 \\ (0.28 \text { to } 0.38) \end{gathered}$ | $\begin{aligned} & -14 \cdot 42 \% \\ & (-41 \cdot 55 \text { to } 6 \cdot 88) \end{aligned}$ |
| Hodgkin lymphoma | $\begin{aligned} & 0.30 \\ & (0.24 \text { to } 0.33) \end{aligned}$ | $\begin{aligned} & 0.11 \\ & (0.10 \text { to } 0.15) \end{aligned}$ | $\begin{aligned} & -61 \cdot 87 \% \\ & (-67 \cdot 17 \text { to -50.97) } \end{aligned}$ | $\begin{gathered} 22 \cdot 10 \\ (17 \cdot 75 \text { to } 24 \cdot 29) \end{gathered}$ | $\begin{gathered} 9.43 \\ \text { (8.07 to } 12.45) \end{gathered}$ | $\begin{aligned} & -57.32 \% \\ & (-63 \cdot 71 \text { to }-44 \cdot 81) \end{aligned}$ |
| Non-Hodgkin lymphoma | $\begin{aligned} & 0.53 \\ & (0.51 \text { to } 0.55) \end{aligned}$ | $\begin{aligned} & 0.33 \\ & (0.30 \text { to } 0.36) \end{aligned}$ | $\begin{aligned} & -38 \cdot 46 \% \\ & (-43 \cdot 45 \text { to }-31 \cdot 88) \end{aligned}$ | $\begin{gathered} 38.55 \\ (37.07 \text { to } 40.05) \end{gathered}$ | $\begin{gathered} 23 \cdot 93 \\ (22 \cdot 11 \text { to } 26 \cdot 39) \end{gathered}$ | $\begin{aligned} & -37.93 \% \\ & (-43.13 \text { to }-30 \cdot 95) \end{aligned}$ |
|  |  |  |  |  |  | e continues on next page) |


|  | Mortality rate per 100000 population |  |  | DALY rate per 100000 population |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1990 | 2019 | Percentage change, 1990 to 2019 | 1990 | 2019 | Percentage change, 1990 to 2019 |
| (Continued from previous page) |  |  |  |  |  |  |
| Multiple myeloma | $\begin{aligned} & 0.01 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{gathered} -5 \cdot 49 \% \\ (-22.86 \text { to 15.11) } \end{gathered}$ | $\begin{gathered} 0.35 \\ (0.28 \text { to } 0.39) \end{gathered}$ | $\begin{gathered} 0.33 \\ (0.27 \text { to } 0.38) \end{gathered}$ | $\begin{aligned} & -4.81 \% \\ & (-22.21 \text { to 16.04) } \end{aligned}$ |
| Leukaemia | $\begin{aligned} & 1.75 \\ & (1.69 \text { to } 1.81) \end{aligned}$ | $\begin{aligned} & 0.91 \\ & (0.86 \text { to } 0.97) \end{aligned}$ | $\begin{aligned} & -47 \cdot 81 \% \\ & (-51 \cdot 21 \text { to }-43 \cdot 69) \end{aligned}$ | $\begin{gathered} 127 \cdot 46 \\ (123 \cdot 25 \text { to } 131 \cdot 6) \end{gathered}$ | $\begin{gathered} 68.64 \\ (63.95 \text { to } 73.69) \end{gathered}$ | $\begin{aligned} & -46 \cdot 14 \% \\ & (-49 \cdot 95 \text { to }-41 \cdot 92) \end{aligned}$ |
| Other neoplasms | $\begin{aligned} & 0.03 \\ & (0.02 \text { to 0.04) } \end{aligned}$ | $\begin{aligned} & 0.03 \\ & (0.02 \text { to } 0.03) \end{aligned}$ | $\begin{gathered} -3 \cdot 37 \% \\ (-32.86 \text { to 19.83) } \end{gathered}$ | $\begin{gathered} 2.37 \\ (1.80 \text { to } 3.21) \end{gathered}$ | $\begin{gathered} 2 \cdot 17 \\ (1.65 \text { to } 2.60) \end{gathered}$ | $\begin{aligned} & -8.33 \% \\ & (-32.97 \text { to 10.63) } \end{aligned}$ |
| Other malignant neoplasms | $\begin{gathered} 1.52 \\ \text { (1.38 to 1.59) } \end{gathered}$ | $\begin{aligned} & 1.05 \\ & (0.88 \text { to } 1.14) \end{aligned}$ | $\begin{aligned} & -30 \cdot 96 \% \\ & (-40.75 \text { to }-25 \cdot 24) \end{aligned}$ | $\begin{aligned} & 111.51 \\ & (101.05 \text { to } 116.76) \end{aligned}$ | $\begin{gathered} 79.17 \\ (66.46 \text { to } 86 \cdot 48) \end{gathered}$ | $\begin{aligned} & -29.01 \% \\ & (-38.83 \text { to }-22.78) \end{aligned}$ |
| Cardiovascular diseases | $\begin{aligned} & 2.96 \\ & (2.88 \text { to } 3.04) \end{aligned}$ | $\begin{aligned} & 1.13 \\ & \text { (1.06 to } 1.19 \text { ) } \end{aligned}$ | $\begin{aligned} & -62.00 \% \\ & (-64.37 \text { to }-59.63) \end{aligned}$ | $\begin{aligned} & 249 \cdot 35 \\ & (234 \cdot 21 \text { to } 266 \cdot 61) \end{aligned}$ | $\begin{aligned} & 119 \cdot 45 \\ & (105 \cdot 24 \text { to } 135 \cdot 71) \end{aligned}$ | $\begin{aligned} & -52 \cdot 10 \% \\ & (-55 \cdot 50 \text { to }-48 \cdot 70) \end{aligned}$ |
| Rheumatic heart disease | $\begin{gathered} 0.17 \\ (0.16 \text { to } 0.17) \end{gathered}$ | $\begin{aligned} & 0.04 \\ & (0.03 \text { to } 0.04) \end{aligned}$ | $\begin{aligned} & -77 \cdot 67 \% \\ & (-80-38 \text { to }-74 \cdot 85) \end{aligned}$ | $\begin{gathered} 11 \cdot 90 \\ (11 \cdot 17 \text { to } 12 \cdot 58) \end{gathered}$ | $\begin{gathered} 2 \cdot 90 \\ (2 \cdot 57 \text { to } 3 \cdot 24) \end{gathered}$ | $\begin{aligned} & -75.63 \% \\ & (-78.69 \text { to }-72 \cdot 57) \end{aligned}$ |
| Ischaemic heart disease | $\begin{aligned} & 0.64 \\ & (0.61 \text { to } 0.67) \end{aligned}$ | $\begin{aligned} & 0.20 \\ & (0.18 \text { to } 0.22) \end{aligned}$ | $\begin{aligned} & -69.05 \% \\ & (-71.99 \text { to }-65.00) \end{aligned}$ | $\begin{gathered} 43.78 \\ (41.62 \text { to } 45.99) \end{gathered}$ | $\begin{gathered} 13 \cdot 68 \\ (12 \cdot 56 \text { to } 15 \cdot 15) \end{gathered}$ | $\begin{aligned} & -68.75 \% \\ & (-71.65 \text { to }-64 \cdot 72) \end{aligned}$ |
| Stroke | $\begin{aligned} & 1.15 \\ & (1.09 \text { to } 1.21) \end{aligned}$ | $\begin{aligned} & 0.32 \\ & (0.29 \text { to } 0.35) \end{aligned}$ | $\begin{aligned} & -72 \cdot 45 \% \\ & (-75 \cdot 16 \text { to }-69 \cdot 34) \end{aligned}$ | $\begin{aligned} & 106.97 \\ & (97.41 \text { to 117.94) } \end{aligned}$ | $\begin{gathered} 47.55 \\ (39.23 \text { to } 56.93) \end{gathered}$ | $\begin{aligned} & -55 \cdot 55 \% \\ & (-60 \cdot 74 \text { to }-50 \cdot 71) \end{aligned}$ |
| Hypertensive heart disease | $\begin{aligned} & 0.03 \\ & (0.02 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & -30 \cdot 41 \% \\ & (-46 \cdot 03 \text { to }-6.92) \end{aligned}$ | $\begin{gathered} 1.86 \\ \text { (1.43 to 2.11) } \end{gathered}$ | $\begin{gathered} 1.30 \\ (0.97 \text { to } 1.55) \end{gathered}$ | $\begin{aligned} & -30 \cdot 14 \% \\ & (-45 \cdot 26 \text { to }-7 \cdot 21) \end{aligned}$ |
| Non-rheumatic valvular heart disease | $\begin{gathered} 0.08 \\ (0.07 \text { to 0.08) } \end{gathered}$ | $\begin{aligned} & 0.05 \\ & (0.05 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & -33 \cdot 99 \% \\ & (-42 \cdot 33 \text { to }-23 \cdot 86) \end{aligned}$ | $\begin{gathered} 5.4 \\ (4.97 \text { to } 5.81) \end{gathered}$ | $\begin{gathered} 3.57 \\ (3.24 \text { to } 3.97) \end{gathered}$ | $\begin{aligned} & -33 \cdot 95 \% \\ & (-42 \cdot 22 \text { to }-23 \cdot 87) \end{aligned}$ |
| Cardiomyopathy and myocarditis | $\begin{aligned} & 0.49 \\ & (0.43 \text { to } 0.57) \end{aligned}$ | $\begin{aligned} & 0.26 \\ & (0.22 \text { to } 0.31) \end{aligned}$ | $\begin{aligned} & -48 \cdot 12 \% \\ & (-55 \cdot 30 \text { to }-36 \cdot 24) \end{aligned}$ | $\begin{gathered} 36 \cdot 54 \\ (31 \cdot 98 \text { to } 41 \cdot 32) \end{gathered}$ | $\begin{gathered} 19 \cdot 5 \\ (17.13 \text { to } 22 \cdot 87) \end{gathered}$ | $\begin{aligned} & -46 \cdot 62 \% \\ & (-53 \cdot 59 \text { to }-35 \cdot 22) \end{aligned}$ |
| Endocarditis | $\begin{aligned} & 0.04 \\ & (0.04 \text { to } 0.07) \end{aligned}$ | $\begin{aligned} & 0.05 \\ & (0.02 \text { to } 0.06) \end{aligned}$ | $\begin{gathered} 13 \cdot 52 \% \\ (-55 \cdot 14 \text { to } 62 \cdot 70) \end{gathered}$ | $\begin{gathered} 3.03 \\ (2.51 \text { to } 4.62) \end{gathered}$ | $\begin{gathered} 3 \cdot 42 \\ (1 \cdot 75 \text { to } 4 \cdot 26) \end{gathered}$ | $\begin{aligned} & 12.76 \% \\ & (-54.50 \text { to } 60 \cdot 20) \end{aligned}$ |
| Aortic aneurysm | $\begin{aligned} & 0.06 \\ & (0.06 \text { to } 0.07) \end{aligned}$ | $\begin{aligned} & 0.04 \\ & (0.04 \text { to } 0.05) \end{aligned}$ | $\begin{aligned} & -34 \cdot 78 \% \\ & (-42 \cdot 20 \text { to }-25 \cdot 29) \end{aligned}$ | $\begin{gathered} 4 \cdot 32 \\ (3.96 \text { to } 4.66) \end{gathered}$ | $\begin{gathered} 2.81 \\ \text { (2.54 to } 3.10 \text { ) } \end{gathered}$ | $\begin{aligned} & -34 \cdot 92 \% \\ & (-42 \cdot 30 \text { to }-25 \cdot 43) \end{aligned}$ |
| Other cardiovascular and circulatory diseases | $\begin{gathered} 0.30 \\ (0.28 \text { to } 0.34) \end{gathered}$ | $\begin{aligned} & 0.16 \\ & (0.14 \text { to } 0.20) \end{aligned}$ | $\begin{aligned} & -47 \cdot 64 \% \\ & (-53 \cdot 26 \text { to }-37 \cdot 53) \end{aligned}$ | $\begin{gathered} 35 \cdot 56 \\ \text { (28.29 to } 45.62 \text { ) } \end{gathered}$ | $\begin{gathered} 24.72 \\ (18.03 \text { to } 34.22) \end{gathered}$ | $\begin{aligned} & -30 \cdot 48 \% \\ & (-38 \cdot 01 \text { to }-23 \cdot 39) \end{aligned}$ |
| Chronic respiratory diseases | $\begin{aligned} & 0.62 \\ & (0.56 \text { to } 0.65) \end{aligned}$ | $\begin{aligned} & 0.26 \\ & (0.24 \text { to } 0.29) \end{aligned}$ | $\begin{aligned} & -58.81 \% \\ & (-62.27 \text { to }-50 \cdot 24) \end{aligned}$ | $\begin{aligned} & 315 \cdot 34 \\ & (216 \cdot 22 \text { to } 447 \cdot 66) \end{aligned}$ | $\begin{aligned} & 286.65 \\ & (186.47 \text { to } 427.65) \end{aligned}$ | $\begin{aligned} & -9 \cdot 10 \% \\ & (-17.36 \text { to } 0.36) \end{aligned}$ |
| Chronic obstructive pulmonary disease | $\begin{gathered} 0.13 \\ (0.12 \text { to } 0.14) \end{gathered}$ | $\begin{aligned} & 0.07 \\ & (0.07 \text { to } 0.09) \end{aligned}$ | $\begin{aligned} & -43 \cdot 65 \% \\ & (-50 \cdot 45 \text { to }-32 \cdot 58) \end{aligned}$ | $\begin{gathered} 30 \cdot 64 \\ (25 \cdot 37 \text { to } 35 \cdot 74) \end{gathered}$ | $\begin{gathered} 25 \cdot 70 \\ \text { (20.54 to } 30 \cdot 95 \text { ) } \end{gathered}$ | $\begin{aligned} & -16 \cdot 13 \% \\ & (-22.76 \text { to }-9 \cdot 10) \end{aligned}$ |
| Pneumoconiosis | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -51 \cdot 97 \% \\ & (-61 \cdot 14 \text { to }-36 \cdot 90) \end{aligned}$ | $\begin{gathered} 0.20 \\ (0.18 \text { to } 0.23) \end{gathered}$ | $\begin{gathered} 0.10 \\ (0.08 \text { to } 0.12) \end{gathered}$ | $\begin{aligned} & -51 \cdot 16 \% \\ & (-59 \cdot 49 \text { to }-37.99) \end{aligned}$ |
| Asthma | $\begin{aligned} & 0.38 \\ & (0.33 \text { to } 0.41) \end{aligned}$ | $\begin{aligned} & 0.1 \\ & (0.09 \text { to } 0.12) \end{aligned}$ | $\begin{aligned} & -73.21 \% \\ & (-75.86 \text { to }-66.90) \end{aligned}$ | $\begin{aligned} & 270 \cdot 58 \\ & (174.63 \text { to } 400 \cdot 11) \end{aligned}$ | $\begin{aligned} & 242 \cdot 61 \\ & (147 \cdot 7 \text { to } 383 \cdot 76) \end{aligned}$ | $\begin{aligned} & -10 \cdot 34 \% \\ & (-20 \cdot 31 \text { to 0.46) } \end{aligned}$ |
| Interstitial lung disease and pulmonary sarcoidosis | $\begin{gathered} 0.04 \\ (0.03 \text { to } 0.05) \end{gathered}$ | $\begin{aligned} & 0.04 \\ & (0.03 \text { to } 0.05) \end{aligned}$ | $\begin{gathered} 5 \cdot 96 \% \\ (-30 \cdot 52 \text { to } 32 \cdot 52) \end{gathered}$ | $\begin{gathered} 3.26 \\ (2.52 \text { to } 4.04) \end{gathered}$ | $\begin{gathered} 3.38 \\ (2.29 \text { to } 4.02) \end{gathered}$ | $\begin{gathered} 3.59 \% \\ (-28.84 \text { to 26.10) } \end{gathered}$ |
| Other chronic respiratory diseases | $\begin{aligned} & 0.07 \\ & (0.04 \text { to } 0.07) \end{aligned}$ | $\begin{aligned} & 0.04 \\ & (0.03 \text { to } 0.05) \end{aligned}$ | $\begin{aligned} & -45 \cdot 60 \% \\ & (-56.53 \text { to }-8.81) \end{aligned}$ | $\begin{gathered} 10.66 \\ (8.85 \text { to } 12.33) \end{gathered}$ | $\begin{gathered} 14.86 \\ (11.67 \text { to } 18.08) \end{gathered}$ | $\begin{aligned} & 39.47 \% \\ & \text { (21.16 to 68.42) } \end{aligned}$ |
| Digestive diseases | $\begin{aligned} & 0.80 \\ & (0.78 \text { to } 0.83) \end{aligned}$ | $\begin{aligned} & 0.39 \\ & (0.37 \text { to } 0.42) \end{aligned}$ | $\begin{aligned} & -51 \cdot 40 \% \\ & (-54.62 \text { to }-48.09) \end{aligned}$ | $\begin{aligned} & 133.81 \\ & \text { (108.81 to 169.8) } \end{aligned}$ | $\begin{aligned} & 103 \cdot 19 \\ & \text { (78.74 to 137•38) } \end{aligned}$ | $\begin{aligned} & -22.88 \% \\ & (-27.90 \text { to }-18 \cdot 26) \end{aligned}$ |
| Cirrhosis and other chronic liver diseases | $\begin{gathered} 0.39 \\ (0.37 \text { to } 0.41) \end{gathered}$ | $\begin{aligned} & 0.15 \\ & (0.14 \text { to } 0.17) \end{aligned}$ | $\begin{aligned} & -61.08 \% \\ & (-64.62 \text { to }-56.85) \end{aligned}$ | $\begin{gathered} 29.86 \\ (28.14 \text { to } 31.92) \end{gathered}$ | $\begin{gathered} 13.09 \\ (11.57 \text { to } 14.94) \end{gathered}$ | $\begin{aligned} & -56 \cdot 15 \% \\ & (-60 \cdot 29 \text { to }-52 \cdot 20) \end{aligned}$ |
| Upper digestive system diseases | $\begin{aligned} & 0.08 \\ & (0.07 \text { to } 0.08) \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & -73 \cdot 23 \% \\ & (-76 \cdot 10 \text { to }-69 \cdot 75) \end{aligned}$ | $\begin{gathered} 42 \cdot 47 \\ (26 \cdot 44 \text { to } 70 \cdot 23) \end{gathered}$ | $\begin{gathered} 36.19 \\ (20.95 \text { to } 63.71) \end{gathered}$ | $\begin{aligned} & -14 \cdot 80 \% \\ & (-21 \cdot 15 \text { to }-10 \cdot 23) \end{aligned}$ |
| Appendicitis | $\begin{aligned} & 0.05 \\ & (0.03 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & -69.98 \% \\ & (-74 \cdot 37 \text { to }-52.73) \end{aligned}$ | $\begin{gathered} 8.98 \\ (6.47 \text { to } 12.55) \end{gathered}$ | $\begin{gathered} 7.39 \\ (4.80 \text { to 11.1) } \end{gathered}$ | $\begin{aligned} & -17 \cdot 76 \% \\ & (-32 \cdot 31 \text { to }-1 \cdot 46) \end{aligned}$ |
| Paralytic ileus and intestinal obstruction | $\begin{aligned} & 0.07 \\ & (0.06 \text { to } 0.08) \end{aligned}$ | $\begin{aligned} & 0.05 \\ & (0.05 \text { to } 0.07) \end{aligned}$ | $\begin{aligned} & -24 \cdot 14 \% \\ & (-32 \cdot 57 \text { to }-12 \cdot 44) \end{aligned}$ | $\begin{gathered} 5 \cdot 61 \\ (4.65 \text { to } 6.23) \end{gathered}$ | $\begin{gathered} 4 \cdot 4 \\ (3 \cdot 72 \text { to } 5 \cdot 18) \end{gathered}$ | $\begin{aligned} & -21 \cdot 50 \% \\ & (-29 \cdot 31 \text { to }-10 \cdot 85) \end{aligned}$ |
| Inguinal femoral and abdominal hernia | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -69.74 \% \\ & (-73.02 \text { to }-63.05) \end{aligned}$ | $\begin{gathered} 8.17 \\ \text { (5.03 to 12.55) } \end{gathered}$ | $\begin{gathered} 6 \cdot 2 \\ (3 \cdot 72 \text { to } 9 \cdot 66) \end{gathered}$ | $\begin{aligned} & -24.06 \% \\ & (-32.63 \text { to }-15.71) \end{aligned}$ |
| Inflammatory bowel disease | $\begin{aligned} & 0.05 \\ & (0.04 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & 0.04 \\ & (0.04 \text { to } 0.05) \end{aligned}$ | $\begin{gathered} -7 \cdot 94 \% \\ (-35 \cdot 06-6 \cdot 70) \end{gathered}$ | $\begin{gathered} 12.18 \\ (8.87 \text { to } 16.06) \end{gathered}$ | $\begin{gathered} 13 \cdot 38 \\ (9.60 \text { to } 17.81) \end{gathered}$ | $\begin{gathered} 9.84 \% \\ (-0.88 \text { to } 18.84) \end{gathered}$ |
| Vascular intestinal disorders | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & -33 \cdot 51 \% \\ & (-42 \cdot 43 \text { to }-22 \cdot 53) \end{aligned}$ | $\begin{gathered} 1.8 \\ (1.6 \text { to } 2.04) \end{gathered}$ | $\begin{gathered} 1.26 \\ (1.10 \text { to } 1.45) \end{gathered}$ | $\begin{aligned} & -29.99 \% \\ & (-38.77 \text { to }-19.78) \end{aligned}$ <br> e continues on next page) |


|  | Mortality rate per 100000 population |  |  | DALY rate per 100000 population |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1990 | 2019 | Percentage change, 1990 to 2019 | 1990 | 2019 | Percentage change, 1990 to 2019 |
| (Continued from previous page) |  |  |  |  |  |  |
| Gallbladder and biliary diseases | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -47 \cdot 21 \% \\ & (-55 \cdot 57 \text { to }-33 \cdot 61) \end{aligned}$ | $\begin{gathered} 14.57 \\ \text { (8.82 to } 22.32 \text { ) } \end{gathered}$ | $\begin{gathered} 13 \cdot 9 \\ \text { (8.40 to } 21.85 \text { ) } \end{gathered}$ | $\begin{aligned} & -4 \cdot 63 \% \\ & (-11 \cdot 67 \text { to } 2 \cdot 30) \end{aligned}$ |
| Pancreatitis | $\begin{aligned} & 0.09 \\ & (0.08 \text { to } 0.09) \end{aligned}$ | $\begin{aligned} & 0.05 \\ & (0.04 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & -42 \cdot 43 \% \\ & (-50 \cdot 53 \text { to }-31 \cdot 94) \end{aligned}$ | $\begin{gathered} 6.62 \\ \text { (5.94 to } 7.35 \text { ) } \end{gathered}$ | $\begin{gathered} 4.09 \\ (3.56 \text { to } 4.72) \end{gathered}$ | $\begin{aligned} & -38.20 \% \\ & (-46.01 \text { to }-28.41) \end{aligned}$ |
| Other digestive diseases | $\begin{gathered} 0.03 \\ (0.02 \text { to } 0.04) \end{gathered}$ | $\begin{aligned} & 0.03 \\ & (0.02 \text { to } 0.04) \end{aligned}$ | $\begin{aligned} & -5 \cdot 22 \% \\ & (-51.06 \text { to 15.59) } \end{aligned}$ | $\begin{gathered} 3.54 \\ (2.85 \text { to } 4.48) \end{gathered}$ | $\begin{gathered} 3.29 \\ (2.36 \text { to } 4.06) \end{gathered}$ | $\begin{aligned} & -7 \cdot 31 \% \\ & (-36 \cdot 65 \text { to } 5 \cdot 40) \end{aligned}$ |
| Neurological disorders | $\begin{aligned} & 1.45 \\ & (1.41 \text { to } 1.50) \end{aligned}$ | $\begin{aligned} & 1.03 \\ & (0.97 \text { to } 1.09) \end{aligned}$ | $\begin{aligned} & -29 \cdot 25 \% \\ & (-34 \cdot 04 \text { to }-24 \cdot 15) \end{aligned}$ | $\begin{aligned} & 996.17 \\ & \text { (321.61 to 2018.69) } \end{aligned}$ | $\begin{aligned} & 985 \cdot 14 \\ & (292 \cdot 58 \text { to 2019.32) } \end{aligned}$ | $\begin{aligned} & -1 \cdot 11 \% \\ & (-10 \cdot 77 \text { to 5•54) } \end{aligned}$ |
| Parkinson's disease | $\begin{aligned} & 0.00 \\ & (0.00 \text { to 0.00) } \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -31 \cdot 45 \% \\ & (-43 \cdot 52 \text { to }-16 \cdot 55) \end{aligned}$ | $\begin{gathered} 0.11 \\ (0.09 \text { to } 0.13) \end{gathered}$ | $\begin{gathered} 0.08 \\ (0.06 \text { to } 0.10) \end{gathered}$ | $\begin{aligned} & -25 \cdot 92 \% \\ & (-37 \cdot 78 \text { to }-12 \cdot 75) \end{aligned}$ |
| Idiopathic epilepsy | $\begin{aligned} & 0.69 \\ & (0.66 \text { to } 0.73) \end{aligned}$ | $\begin{aligned} & 0.53 \\ & (0.48 \text { to } 0.57) \end{aligned}$ | $\begin{aligned} & -23 \cdot 74 \% \\ & (-31 \cdot 41 \text { to }-17 \cdot 55) \end{aligned}$ | $\begin{aligned} & 152.76 \\ & \text { (104.4 to 220.04) } \end{aligned}$ | $\begin{aligned} & 140 \cdot 18 \\ & (87 \cdot 22 \text { to } 225 \cdot 90) \end{aligned}$ | $\begin{aligned} & -8.23 \% \\ & (-30.47 \text { to 19.70) } \end{aligned}$ |
| Multiple sclerosis | $\begin{aligned} & 0.02 \\ & (0.02 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & -26.81 \% \\ & (-41.08 \text { to 13.84) } \end{aligned}$ | $\begin{gathered} 5.61 \\ (3.99 \text { to } 7.67) \end{gathered}$ | $\begin{gathered} 5 \cdot 93 \\ (4 \cdot 22 \text { to } 8 \cdot 18) \end{gathered}$ | $\begin{gathered} 5 \cdot 72 \% \\ (-4.62 \text { to } 20 \cdot 57) \end{gathered}$ |
| Motor neuron disease | $\begin{aligned} & 0.06 \\ & (0.06 \text { to } 0.07) \end{aligned}$ | $\begin{aligned} & 0.06 \\ & (0.05 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & -12 \cdot 42 \% \\ & (-19 \cdot 69 \text { to }-5 \cdot 21) \end{aligned}$ | $\begin{gathered} 5 \cdot 19 \\ (4 \cdot 89 \text { to } 5 \cdot 55) \end{gathered}$ | $\begin{gathered} 4 \cdot 68 \\ (4 \cdot 27 \text { to } 5 \cdot 10) \end{gathered}$ | $\begin{aligned} & -9 \cdot 72 \% \\ & (-15 \cdot 94 \text { to }-3 \cdot 27) \end{aligned}$ |
| Headache disorders | .. | .. | . | $\begin{aligned} & 761 \cdot 17 \\ & (79.43 \text { to 1792.62) } \end{aligned}$ | $\begin{aligned} & 769.30 \\ & (78.52 \text { to } 1814 \cdot 32) \end{aligned}$ | $\begin{gathered} 1.07 \% \\ (-3.41 \text { to } 3 \cdot 70) \end{gathered}$ |
| Other neurological disorders | $\begin{aligned} & 0.67 \\ & (0.65 \text { to } 0.70) \end{aligned}$ | $\begin{aligned} & 0.43 \\ & (0.40 \text { to } 0.46) \end{aligned}$ | $\begin{aligned} & -36 \cdot 56 \% \\ & (-41 \cdot 28 \text { to }-31 \cdot 01) \end{aligned}$ | $\begin{gathered} 71 \cdot 33 \\ (60 \cdot 51 \text { to } 86 \cdot 13) \end{gathered}$ | $\begin{gathered} 64 \cdot 96 \\ (47 \cdot 53 \text { to } 93 \cdot 37) \end{gathered}$ | $\begin{aligned} & -8.94 \% \\ & (-25.33 \text { to 14.49) } \end{aligned}$ |
| Mental disorders | $\begin{aligned} & 0.01 \\ & (0.01 \text { to 0.02) } \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{gathered} 32.36 \%^{*} \\ (2.25 \text { to } 66.96) \end{gathered}$ | $\begin{aligned} & 2008.04 \\ & \text { (1420.6 to 2729.61) } \end{aligned}$ | $\begin{aligned} & 2040 \cdot 59 \\ & (1433.96 \text { to } 2774 \cdot 62) \end{aligned}$ | $\begin{gathered} 1.62 \% \\ (-0.61 \text { to } 3.87) \end{gathered}$ |
| Schizophrenia | . | . | .. | $\begin{gathered} 63.18 \\ (40 \cdot 35 \text { to } 96.96) \end{gathered}$ | $\begin{gathered} 60 \cdot 24 \\ (38 \cdot 50 \text { to } 92 \cdot 15) \end{gathered}$ | $\begin{aligned} & -4.65 \% \\ & (-11.64 \text { to } 1.59) \end{aligned}$ |
| Depressive disorders | . | . | . | $\begin{aligned} & 587.35 \\ & (384.87 \text { to } 850 \cdot 24) \end{aligned}$ | $\begin{aligned} & 569 \cdot 42 \\ & (365 \cdot 86 \text { to } 847 \cdot 34) \end{aligned}$ | $\begin{gathered} -3.05 \% \\ (-9.63 \text { to } 3.40) \end{gathered}$ |
| Bipolar disorder | . | . | . | $\begin{aligned} & 184 \cdot 63 \\ & \text { (100•79 to 295•7) } \end{aligned}$ | $\begin{aligned} & 187.81 \\ & (102.26 \text { to } 301.80) \end{aligned}$ | $\begin{gathered} 1.72 \% \\ (-1.93 \text { to } 5.58) \end{gathered}$ |
| Anxiety disorders | . | . | . | $\begin{aligned} & 612.59 \\ & (398.42 \text { to } 900.04) \end{aligned}$ | $\begin{aligned} & 641 \cdot 37 \\ & (416 \cdot 23 \text { to } 938 \cdot 58) \end{aligned}$ | $\begin{gathered} 4.70 \% \\ (0.65 \text { to } 8.99) \end{gathered}$ |
| Eating disorders | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{gathered} 32 \cdot 36 \% \\ (2 \cdot 25 \text { to } 66.96) \end{gathered}$ | $\begin{aligned} & 130 \cdot 56 \\ & \text { (79.11 to 199.61) } \end{aligned}$ | $\begin{aligned} & 150 \cdot 46 \\ & (90 \cdot 24 \text { to } 230 \cdot 68) \end{aligned}$ | $\begin{aligned} & 15 \cdot 24 \% \\ & \text { (9.65 to 20.43) } \end{aligned}$ |
| Autism spectrum disorders | . | . | . | $\begin{gathered} 89.21 \\ \text { (57.78 to 127.52) } \end{gathered}$ | $\begin{gathered} 92.27 \\ (60.45 \text { to } 132.16) \end{gathered}$ | $\begin{gathered} 3 \cdot 43 \% \\ (0.55 \text { to } 6 \cdot 17) \end{gathered}$ |
| Attention deficit hyperactivity disorder | . | . | . | $\begin{aligned} & 30 \cdot 39 \\ & \text { (17.04 to 52.32) } \end{aligned}$ | $\begin{aligned} & 32.22 \\ & (17.80 \text { to } 55.80) \end{aligned}$ | $\begin{gathered} 6.03 \% \\ (0.48 \text { to } 11.90) \end{gathered}$ |
| Conduct disorder | . | . | . | $\begin{aligned} & 227.6 \\ & (128.22 \text { to } 360 \cdot 70) \end{aligned}$ | $\begin{aligned} & 234 \cdot 52 \\ & (132 \cdot 20 \text { to } 374 \cdot 35) \end{aligned}$ | $\begin{gathered} 3.04 \% \\ (0.84 \text { to } 5 \cdot 27) \end{gathered}$ |
| Idiopathic developmental intellectual disability | . | . | . | $\begin{gathered} 33 \cdot 67 \\ (15 \cdot 13 \text { to } 57 \cdot 43) \end{gathered}$ | $\begin{gathered} 24 \cdot 14 \\ (9 \cdot 31 \text { to } 42 \cdot 55) \end{gathered}$ | $\begin{aligned} & -28 \cdot 29 \% \\ & (-38 \cdot 34 \text { to }-23 \cdot 60) \end{aligned}$ |
| Other mental disorders | . | . | . | $\begin{gathered} 48.87 \\ (26.04 \text { to } 79.52) \end{gathered}$ | $\begin{gathered} 48 \cdot 14 \\ (25 \cdot 31 \text { to } 77 \cdot 72) \end{gathered}$ | $\begin{gathered} -1.49 \% \\ (-6.71 \text { to } 3.85) \end{gathered}$ |
| Substance use disorders | $\begin{aligned} & 1 \cdot 30 \\ & (1 \cdot 24 \text { to } 1 \cdot 37) \end{aligned}$ | $\begin{aligned} & 1.10 \\ & (1.01 \text { to } 1.21) \end{aligned}$ | $\begin{aligned} & -15 \cdot 28 \% \\ & (-23 \cdot 50 \text { to }-4 \cdot 57) \end{aligned}$ | $\begin{aligned} & 492 \cdot 33 \\ & \text { (358.21 to 650.25) } \end{aligned}$ | $\begin{aligned} & 503 \cdot 94 \\ & (361 \cdot 14 \text { to } 665 \cdot 94) \end{aligned}$ | $\begin{gathered} 2.36 \% \\ (-2.42 \text { to } 7.78) \end{gathered}$ |
| Alcohol use disorders | $\begin{aligned} & 0.19 \\ & (0.18 \text { to } 0.20) \end{aligned}$ | $\begin{aligned} & 0.14 \\ & (0.12 \text { to } 0.15) \end{aligned}$ | $\begin{aligned} & -27 \cdot 27 \% \\ & (-37 \cdot 58 \text { to }-17 \cdot 87) \end{aligned}$ | $\begin{aligned} & 204.46 \\ & (125.09 \text { to } 318 \cdot 64) \end{aligned}$ | $\begin{aligned} & 187.23 \\ & (112.67 \text { to 299.64) } \end{aligned}$ | $\begin{aligned} & -8.43 \% \\ & (-14.78 \text { to }-3.61) \end{aligned}$ |
| Drug use disorders | $\begin{aligned} & 1.11 \\ & (1.05 \text { to } 1.17) \end{aligned}$ | $\begin{aligned} & 0.96 \\ & (0.88 \text { to } 1.07) \end{aligned}$ | $\begin{aligned} & -13 \cdot 22 \% \\ & (-22.66 \text { to }-0.90) \end{aligned}$ | $\begin{aligned} & 287.87 \\ & (218.6 \text { to } 368 \cdot 70) \end{aligned}$ | $\begin{aligned} & 316 \cdot 72 \\ & (234 \cdot 37 \text { to } 412 \cdot 93) \end{aligned}$ | $\begin{aligned} & 10.02 \% \\ & \text { (3.03 to 17.91) } \end{aligned}$ |
| Diabetes and kidney diseases | $\begin{gathered} 0.46 \\ (0.44 \text { to } 0.47) \end{gathered}$ | $\begin{aligned} & 0.22 \\ & (0.21 \text { to } 0.24) \end{aligned}$ | $\begin{aligned} & -51 \cdot 23 \% \\ & (-54.66 \text { to }-47.98) \end{aligned}$ | $\begin{gathered} 69.75 \\ (58.24 \text { to } 84.76) \end{gathered}$ | $\begin{gathered} 67.92 \\ \text { (51.26 to 88.78) } \end{gathered}$ | $\begin{aligned} & -2 \cdot 62 \% \\ & (-13 \cdot 50 \text { to } 8 \cdot 34) \end{aligned}$ |
| Diabetes | $\begin{aligned} & 0.18 \\ & (0.18 \text { to } 0.19) \end{aligned}$ | $\begin{aligned} & 0.10 \\ & (0.09 \text { to } 0.11) \end{aligned}$ | $\begin{aligned} & -46 \cdot 34 \% \\ & (-50.04 \text { to }-42 \cdot 76) \end{aligned}$ | $\begin{gathered} 32.56 \\ (25.46 \text { to } 42.02) \end{gathered}$ | $\begin{gathered} 42 \cdot 59 \\ (29.59 \text { to } 60 \cdot 23) \end{gathered}$ | $\begin{aligned} & 30 \cdot 83 \% \\ & (14 \cdot 12 \text { to } 44 \cdot 41) \end{aligned}$ |
| Chronic kidney disease | $\begin{aligned} & 0.27 \\ & (0.26 \text { to } 0.28) \end{aligned}$ | $\begin{aligned} & 0.12 \\ & (0.11 \text { to } 0.13) \end{aligned}$ | $\begin{aligned} & -54.13 \% \\ & (-57.79 \text { to }-50.04) \end{aligned}$ | $\begin{aligned} & 36 \cdot 78 \\ & (29.79 \text { to } 45 \cdot 67) \end{aligned}$ | $\begin{gathered} 25 \cdot 21 \\ (18 \cdot 50 \text { to } 33 \cdot 33) \end{gathered}$ | $\begin{aligned} & -31 \cdot 45 \% \\ & (-38 \cdot 30 \text { to }-25 \cdot 46) \end{aligned}$ |
| Acute glomerulonephritis | $\begin{aligned} & 0.01 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -74 \cdot 99 \% \\ & (-79 \cdot 98 \text { to }-68 \cdot 66) \end{aligned}$ | $\begin{gathered} 0.41 \\ (0.35 \text { to } 0.49) \end{gathered}$ | $\begin{gathered} 0.12 \\ (0.10 \text { to } 0.13) \end{gathered}$ | $\begin{aligned} & -71 \cdot 73 \% \\ & (-77 \cdot 32 \text { to }-65 \cdot 33) \end{aligned}$ |
| (Table continues on next page) |  |  |  |  |  |  |


|  | Mortality rate per 100000 population |  |  | DALY rate per 100000 population |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1990 | 2019 | Percentage change, 1990 to 2019 | 1990 | 2019 | Percentage change, 1990 to 2019 |
| (Continued from previous page) |  |  |  |  |  |  |
| Skin and subcutaneous diseases | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & 0.02 \\ & (0.01 \text { to } 0.03) \end{aligned}$ | $\begin{aligned} & -7.51 \% \\ & (-38.94 \text { to } 9.70) \end{aligned}$ | $\begin{gathered} 731 \cdot 21 \\ (487 \cdot 33 \text { to 1051•3) } \end{gathered}$ | $\begin{aligned} & 774.92 \\ & \text { (512.68 to 1117.83) } \end{aligned}$ | $\begin{gathered} 5 \cdot 98 \% \\ (4.17 \text { to } 7 \cdot 50) \end{gathered}$ |
| Dermatitis | .. | .. | . | $\begin{aligned} & 171.24 \\ & (94.57 \text { to } 280 \cdot 83) \end{aligned}$ | $\begin{aligned} & 180 \cdot 58 \\ & (99 \cdot 20 \text { to } 296 \cdot 53) \end{aligned}$ | $\begin{gathered} 5 \cdot 45 \% \\ (3 \cdot 14 \text { to } 7 \cdot 84) \end{gathered}$ |
| Psoriasis | . | . | . | $\begin{aligned} & 100 \cdot 98 \\ & (69.49 \text { to } 136 \cdot 48) \end{aligned}$ | $\begin{gathered} 93.69 \\ (64.76 \text { to } 126.6) \end{gathered}$ | $\begin{aligned} & -7.22 \% \\ & (-10 \cdot 78 \text { to }-3 \cdot 44) \end{aligned}$ |
| Bacterial skin diseases | $\begin{gathered} 0.01 \\ (0.01 \text { to } 0.02) \end{gathered}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & 27.07 \% \\ & (-26.87 \text { to } 54.15) \end{aligned}$ | $\begin{gathered} 6.81 \\ (3.63 \text { to } 12.3) \end{gathered}$ | $\begin{gathered} 7.21 \\ (3.92 \text { to } 12 \cdot 73) \end{gathered}$ | $\begin{aligned} & 5 \cdot 82 \% \\ & (-2.50 \text { to 12.14) } \end{aligned}$ |
| Scabies | .. | .. | .. | 12 (6.39 to 19.95) | $\begin{gathered} 9.79 \\ \text { (5.21 to } 16 \cdot 32 \text { ) } \end{gathered}$ | $\begin{aligned} & -18.44 \% \\ & (-20.76 \text { to }-16.15) \end{aligned}$ |
| Fungal skin diseases | .. | . | .. | $\begin{gathered} 26.05 \\ (9.86 \text { to } 57.17) \end{gathered}$ | $\begin{gathered} 26.39 \\ (9.98 \text { to } 57.99) \end{gathered}$ | $\begin{gathered} 1 \cdot 32 \% \\ (-0.10 \text { to } 2 \cdot 72) \end{gathered}$ |
| Viral skin diseases | .. | . | .. | $\begin{gathered} 82 \cdot 32 \\ (52.54 \text { to } 123.64) \end{gathered}$ | $\begin{gathered} 85.86 \\ \text { (55.49 to 128.88) } \end{gathered}$ | $\begin{gathered} 4.31 \% \\ (2.61 \text { to } 6.07) \end{gathered}$ |
| Acne vulgaris | . | . | . | $\begin{aligned} & 253.02 \\ & (149.86 \text { to } 400 \cdot 58) \end{aligned}$ | $\begin{aligned} & 293 \cdot 19 \\ & (174 \cdot 43 \text { to } 464 \cdot 77) \end{aligned}$ | $\begin{aligned} & 15 \cdot 88 \% \\ & (13 \cdot 70 \text { to 18.20) } \end{aligned}$ |
| Alopecia areata | . | . | . | $\begin{gathered} 7.05 \\ (4.44 \text { to } 10.68) \end{gathered}$ | $\begin{gathered} 7.01 \\ \text { (4.39 to 10.61) } \end{gathered}$ | $\begin{aligned} & -0.49 \% \\ & (-5.86 \text { to } 5.53) \end{aligned}$ |
| Pruritus | .. | . | .. | $\begin{gathered} 5 \cdot 16 \\ (2.34 \text { to } 9.82) \end{gathered}$ | $\begin{gathered} 5 \cdot 27 \\ (2.4 \text { to } 10.08) \end{gathered}$ | $\begin{gathered} 2.21 \% \\ (-0.84 \text { to } 5.66) \end{gathered}$ |
| Urticaria | .. | . | . | $\begin{gathered} 36.57 \\ \text { (22.68 to } 55 \cdot 92 \text { ) } \end{gathered}$ | $\begin{gathered} 34.64 \\ (21.53 \text { to } 53.01) \end{gathered}$ | $\begin{aligned} & -5 \cdot 28 \% \\ & (-8.54 \text { to }-1.74) \end{aligned}$ |
| Decubitus ulcer | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -48 \cdot 30 \% \\ & (-67 \cdot 63 \text { to }-29 \cdot 59) \end{aligned}$ | $\begin{gathered} 0.52 \\ (0.36 \text { to } 0.73) \end{gathered}$ | $\begin{gathered} 0.51 \\ (0.34 \text { to } 0.71) \end{gathered}$ | $\begin{aligned} & -3.19 \% \\ & (-11.98 \text { to 5.52) } \end{aligned}$ |
| Other skin and subcutaneous diseases | $\begin{aligned} & 0.01 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -57.16 \% \\ & (-64.92 \text { to }-44.05) \end{aligned}$ | $\begin{gathered} 29.49 \\ (14.21 \text { to } 54.82) \end{gathered}$ | $\begin{gathered} 30 \cdot 78 \\ \text { (14.58 to } 57 \cdot 44 \text { ) } \end{gathered}$ | $\begin{gathered} 4.36 \% \\ (2.36 \text { to } 6.00) \end{gathered}$ |
| Sense organ diseases | .. | .. | .. | $\begin{aligned} & 161 \cdot 30 \\ & \text { (104.92 to 232.98) } \end{aligned}$ | $\begin{aligned} & 150.24 \\ & \text { (98.94 to 216.39) } \end{aligned}$ | $\begin{aligned} & -6.86 \% \\ & (-10.66 \text { to }-3.53) \end{aligned}$ |
| Blindness and vision loss | .. | . | .. | $\begin{gathered} 57.93 \\ \text { (35.68 to } 88.02 \text { ) } \end{gathered}$ | $\begin{gathered} 55 \cdot 65 \\ \text { (33•94 to } 85 \cdot 36 \text { ) } \end{gathered}$ | $\begin{aligned} & -3.95 \% \\ & (-7.47 \text { to }-1.02) \end{aligned}$ |
| Age-related and other hearing loss | . | . | . | $\begin{gathered} 89.07 \\ (53.43 \text { to } 131.61) \end{gathered}$ | $\begin{gathered} 79.48 \\ \text { (48.09 to 118.58) } \end{gathered}$ | $\begin{aligned} & -10.77 \% \\ & (-16.00 \text { to }-5 \cdot 55) \end{aligned}$ |
| Other sense organ diseases | .. | .. | . | $\begin{gathered} 14 \cdot 30 \\ (7.93 \text { to } 23 \cdot 33) \end{gathered}$ | $\begin{gathered} 15 \cdot 12 \\ (8.43 \text { to } 24.67) \end{gathered}$ | $\begin{gathered} 5.73 \% \\ (0.53 \text { to } 11.81) \end{gathered}$ |
| Musculoskeletal disorders | $\begin{gathered} 0.14 \\ (0.09 \text { to 0.19) } \end{gathered}$ | $\begin{aligned} & 0.09 \\ & (0.07 \text { to 0.14) } \end{aligned}$ | $\begin{aligned} & -33 \cdot 92 \% \\ & (-42 \cdot 01 \text { to }-11 \cdot 15) \end{aligned}$ | $\begin{aligned} & 975 \cdot 56 \\ & (670 \cdot 99 \text { to 1372.96) } \end{aligned}$ | $\begin{aligned} & 974 \cdot 22 \\ & \text { (674 to } 1377 \cdot 19) \end{aligned}$ | $\begin{aligned} & -0.14 \% \\ & (-2.31 \text { to } 2 \cdot 10) \end{aligned}$ |
| Rheumatoid arthritis | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.02) \end{aligned}$ | $\begin{aligned} & 0.01 \\ & (0.01 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & -55 \cdot 60 \% \\ & (-63 \cdot 33 \text { to }-38 \cdot 51) \end{aligned}$ | $\begin{gathered} 9.19 \\ \text { (5.98 to } 13 \cdot 52 \text { ) } \end{gathered}$ | $\begin{gathered} 9 \cdot 80 \\ (6 \cdot 18 \text { to } 14 \cdot 89) \end{gathered}$ | $\begin{aligned} & 6 \cdot 59 \% \\ & (-3 \cdot 50 \text { to } 15 \cdot 33) \end{aligned}$ |
| Low back pain | .. | .. | .. | $\begin{aligned} & 678.57 \\ & \text { (439.08 to 992.73) } \end{aligned}$ | $\begin{aligned} & 634 \cdot 68 \\ & (410 \cdot 14 \text { to } 938 \cdot 51) \end{aligned}$ | $\begin{aligned} & -6.47 \% \\ & (-8.88 \text { to }-3.94) \end{aligned}$ |
| Neck pain | .. | . | .. | $\begin{gathered} 157 \cdot 22 \\ (89 \cdot 41 \text { to } 267 \cdot 77) \end{gathered}$ | $\begin{aligned} & 172.02 \\ & \text { (97.60 to 290.28) } \end{aligned}$ | $\begin{aligned} & 9.41 \% \\ & (6.44 \text { to } 12 \cdot 68) \end{aligned}$ |
| Gout | . | . | .. | $\begin{gathered} 0.35 \\ (0.15 \text { to } 0.68) \end{gathered}$ | $\begin{gathered} 0.38 \\ (0.16 \text { to } 0.71) \end{gathered}$ | $\begin{gathered} 6.34 \% \\ (2.60 \text { to } 13.07) \end{gathered}$ |
| Other musculoskeletal disorders | $\begin{aligned} & 0.12 \\ & (0.08 \text { to } 0.17) \end{aligned}$ | $\begin{aligned} & 0.08 \\ & (0.07 \text { to } 0.13) \end{aligned}$ | $\begin{aligned} & -31.37 \% \\ & (-39.81 \text { to }-7.66) \end{aligned}$ | $\begin{aligned} & 130 \cdot 22 \\ & \text { (76.37 to 204•72) } \end{aligned}$ | $\begin{gathered} 157 \cdot 34 \\ \text { (91.23 to } 246 \cdot 73 \text { ) } \end{gathered}$ | $\begin{aligned} & 20 \cdot 82 \% \\ & (14 \cdot 31 \text { to 29.20) } \end{aligned}$ <br> e continues on next page) |

Lithuania (1004.40 [842.92-1192.36]), and Romania ( $918 \cdot 53$ [779.76-1079.00]; appendix pp 12-13). The highest YLL rate (in Bulgaria) was double the lowest (in France). Neoplasms were the leading cause of YLL rate in all Member States in adolescents aged 10-24 years, except for Estonia, where it was substance use disorders (appendix pp 12-13). In comparison to the EU overall, eight Member States had significantly higher YLL rates
due to NCDs (Bulgaria, Estonia, Latvia, Lithuania, Malta, Romania, the UK, and Finland), whereas five had lower rates (Italy, the Netherlands, Spain, Belgium, and France).
Among adolescents aged 10-24 years, YLL rates due to NCDs decreased by $40 \cdot 56 \%$ ( $95 \%$ UI $-43 \cdot 16$ to $-37 \cdot 74$ ) from 1990 to 2019 (appendix pp 14, 38-39). The only NCD level 2 cause of YLLs that increased was mental disorders,

|  | Mortality rate per 100000 population |  |  | DALY rate per 100000 population |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 1990 | 2019 | Percentage change, 1990 to 2019 | 1990 | 2019 | Percentage change, 1990 to 2019 |
| (Continued from previous page) |  |  |  |  |  |  |
| Other non-communicable diseases | $\begin{gathered} 2.41 \\ (2.11 \text { to } 2.62) \end{gathered}$ | $\begin{aligned} & 1.57 \\ & \text { (1.42 to } 1.85 \text { ) } \end{aligned}$ | $\begin{aligned} & -34.70 \% \\ & (-39.50 \text { to }-21.57) \end{aligned}$ | $\begin{aligned} & 800 \cdot 72 \\ & \text { (594.95 to 1076.26) } \end{aligned}$ | $\begin{aligned} & 708.7 \\ & \text { (515.60 to 964.73) } \end{aligned}$ | $\begin{aligned} & -11 \cdot 49 \% \\ & (-14.60 \text { to }-8.10) \end{aligned}$ |
| Congenital birth defects | $\begin{aligned} & 1.53 \\ & (1.24 \text { to } 1.70) \end{aligned}$ | $\begin{aligned} & 0.87 \\ & (0.71 \text { to } 1.10) \end{aligned}$ | $\begin{aligned} & -42.91 \% \\ & (-48.73 \text { to }-21.92) \end{aligned}$ | $\begin{aligned} & 191.85 \\ & \text { (161.2 to 226.95) } \end{aligned}$ | $\begin{aligned} & 143.82 \\ & (117.64 \text { to } 175.65) \end{aligned}$ | $\begin{aligned} & -25 \cdot 03 \% \\ & (-30.85 \text { to }-12.47) \end{aligned}$ |
| Urinary diseases and male infertility | $\begin{aligned} & 0.09 \\ & (0.08 \text { to } 0.10) \end{aligned}$ | $\begin{aligned} & 0.05 \\ & (0.05 \text { to } 0.06) \end{aligned}$ | $\begin{aligned} & -45 \cdot 11 \% \\ & (-49 \cdot 24 \text { to }-35 \cdot 04) \end{aligned}$ | $\begin{gathered} 14 \cdot 45 \\ (11 \cdot 1 \text { to } 19 \cdot 37) \end{gathered}$ | $\begin{gathered} 11 \cdot 37 \\ \text { (7.99 to } 16.99) \end{gathered}$ | $\begin{aligned} & -21 \cdot 31 \% \\ & (-29.82 \text { to }-9.92) \end{aligned}$ |
| Gynaecological diseases | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.01) \end{aligned}$ | $\begin{aligned} & 0.00 \\ & (0.00 \text { to } 0.00) \end{aligned}$ | $\begin{aligned} & -65 \cdot 55 \% \\ & (-71 \cdot 31 \text { to }-43 \cdot 29) \end{aligned}$ | $\begin{aligned} & 277 \cdot 7 \\ & (180 \cdot 92 \text { to } 410 \cdot 57) \end{aligned}$ | $\begin{aligned} & 272 \cdot 17 \\ & (176 \cdot 44 \text { to } 402 \cdot 67) \end{aligned}$ | $\begin{aligned} & -1.99 \% \\ & (-4.86 \text { to 1.22) } \end{aligned}$ |
| Haemoglobinopathies and haemolytic anaemias | $\begin{gathered} 0.22 \\ (0.22 \text { to } 0.23) \end{gathered}$ | $\begin{aligned} & 0.08 \\ & (0.08 \text { to } 0.09) \end{aligned}$ | $\begin{aligned} & -63 \cdot 33 \% \\ & (-66 \cdot 84 \text { to }-59 \cdot 22) \end{aligned}$ | $\begin{aligned} & 34 \cdot 79 \\ & (27 \cdot 39 \text { to } 45 \cdot 83) \end{aligned}$ | $\begin{gathered} 13.88 \\ (10.67 \text { to } 18.53) \end{gathered}$ | $\begin{aligned} & -60 \cdot 11 \% \\ & (-64.82 \text { to }-54 \cdot 56) \end{aligned}$ |
| Endocrine, metabolic, blood, and immune disorders | $\begin{aligned} & 0.56 \\ & (0.44 \text { to } 0.66) \end{aligned}$ | $\begin{aligned} & 0.57 \\ & (0.49 \text { to } 0.77) \end{aligned}$ | $\begin{gathered} 1 \cdot 17 \% \\ (-7 \cdot 60 \text { to } 24 \cdot 29) \end{gathered}$ | $\begin{aligned} & 183 \cdot 24 \\ & (124 \cdot 57 \text { to } 260 \cdot 31) \end{aligned}$ | $\begin{aligned} & 176.43 \\ & (122.63 \text { to } 245.60) \end{aligned}$ | $\begin{aligned} & -3.72 \% \\ & (-8.14 \text { to } 2.88) \end{aligned}$ |
| Oral disorders | .. | . | . | $\begin{aligned} & 98.69 \\ & \text { (53.76 to 163.39) } \end{aligned}$ | $\begin{gathered} 91.03 \\ \text { (50.27 to } 150.71 \text { ) } \end{gathered}$ | $\begin{aligned} & -7.76 \% \\ & (-10.76 \text { to }-4.85) \end{aligned}$ |
| Data in parentheses are 95\% uncertainty intervals. *Note that deaths were only attributed to eating disorders. |  |  |  |  |  |  |

albeit not significantly, from $0 \cdot 93(0 \cdot 80-1 \cdot 10)$ in 1990 to $1.23(1 \cdot 00-1 \cdot 50)$ in 2019 (change $32 \cdot 18 \%$ [1.67-66.49]), and for which YLLs were only attributed to eating disorders (appendix pp 38-39).

## Years lived with disability

The all-cause YLD rate across the EU in 2019 was $7322 \cdot 85$ ( $95 \%$ UI $5268 \cdot 10-9748 \cdot 95$ ) per 100000 population among adolescents aged 10-24 years and increased by age group (appendix p 15). The leading level 1 causes of YLDs in adolescents aged 10-24 years were NCDs (6328.51 [4489.66-8533.25] per 100000 population), which overall constituted $86 \cdot 4 \%(83 \cdot 5-88 \cdot 8)$ of all YLDs (appendix p 34). The leading NCD level 2 causes of YLDs were mental disorders (2039. 36 [1432.56-2773.47] per 100000 population), and the top three level 3 causes of YLDs were headache disorders (769•30 [78-52-1814-32] per 100000 population), anxiety disorders ( 641.37 [416.23-938.51] per 100000 population), and low back pain ( $634 \cdot 68$ [410.14-938.51] per 100000 population; appendix $\mathrm{pp} 40-42$ ).
Among adolescents aged 10-24 years, all-cause YLD rates per 100000 population in 2019 were higher in females ( $8383 \cdot 40$ [ $95 \%$ UI 6003•72-11292.01]) than in males (6322.73 [4586.09-8354.55]; appendix p 15). NCDs were the leading level 1 cause of YLDs, with the greatest burden in individuals aged 20-24 years ( $7813 \cdot 15$ [5546.85-10334.38] per 100000 population) (appendix pp 34-35). For all three age subgroups, mental disorders were the leading level 2 cause of YLDs in the EU overall (appendix pp 16-17). Differences by age group and sex in level 2 causes are reported in figure 2 B and the appendix (pp 16-17). For level 3 causes, significant differences in YLD rates per 100000 population between females and males aged 10-24 years were observed for
eating disorders (236.68 [141•97-365•30] for females vs $66 \cdot 76$ [38.98-104.81] for males) and autism spectrum disorders $(32 \cdot 77$ [21.26-47.87] vs $148 \cdot 39$ [97.20-211.37]; appendix p 18 ).
In 2019, among adolescents aged 10-24 years, country NCD YLD rates per 100000 population ranged from $4593 \cdot 38$ ( $95 \%$ UI 3234.52-6166.79) in Romania to 7018. 56 (4996.04-9428.21) in Portugal (appendix pp 19-20). However, no significant differences were observed between individual Member States and the EU overall. Mental disorders were the leading cause of YLDs in all countries.
Among adolescents aged $10-24$ years, there was no change in all-cause YLD rates from 1990 (7372.49 [ $95 \%$ UI 5298.54-9758.09] per 100000 population) to 2019 (7322.85 [5268•10-9748.95] per 100000 population; appendix p 15), although a slight increase in YLDs due to NCDs was observed ( $1.44 \%$ [ $0.09-2.79$ ]; appendix pp 21, 40-42). Within NCD level 2 causes, from 1990 to 2019, the greatest increase in YLD rates was observed for diabetes and kidney diseases ( $37.8 \%$ (25.1-51.5), mainly due to an increase in level 3 cause diabetes ( $80.5 \%$ [69•5-90 4 ]; appendix pp 40-42).

## Disability-adjusted life-years

In 2019, the all-cause rate of DALYs per 100000 population was $9080 \cdot 85$ ( $95 \%$ UI 7024.87-11479.33) among adolescents aged 10-24 years (appendix p 22). NCDs accounted for $77 \cdot 1 \%$ (73.5-80.5) of DALYs among adolescents aged 10-24 years in the EU (appendix pp 34-35). Mental disorders (2040.59 [1433.96-2774.62] per 100000 population) were the leading level 2 cause (table), accounting for $29.1 \%(20.4-39 \cdot 6)$ of the overall NCD DALY rate. Headache disorders (769.30 [78.52-1814.32] per 100000 population), anxiety disorders


Figure 2: YLL (A) and YLD (B) rates per 100000 population due to level 2 non-communicable diseases in adolescents aged 10-24 years in EU Member States, by sex, 2019
YLDs=years lived with disability. YLLs=years of life lost. *This aggregate cause contains the following level 3 causes: congenital birth defects; urinary diseases; gynaecological diseases; haemoglobinopathies and haemolytic anaemias; endocrine, metabolic, blood, and immune disorders; and oral disorders.
( $641 \cdot 37$ [416.23-938.58] per 100000 population), and low back pain ( $634 \cdot 68$ [410•14-938.51] per 100000 population) were the top three level 3 causes.
The total all-cause DALY rate per 100000 population in 2019 increased with age and was higher in females than males in all age groups (appendix p 22). NCDs were the leading causes of DALYs in all age groups and in both sexes (appendix pp 34-37). Differences between sexes were larger in the age groups of 15-19 years and $20-24$ years. For adolescents aged $10-24$ years, sex differences were significant for level 2 causes of substance use disorders, neurological disorders, and other NCDs (appendix pp 23-24), and at level 3 they were significant for drug use disorders (221.64 [156.16-299.71] per 100000 population for females vs $406 \cdot 38$ [304.06-522.44] per 100000 population for males) and eating disorders (239.16 [143.64-367.68] per 100000 population vs $66 \cdot 82$ [39.04-104.88] per 100000 population; appendix p 25).
In 2019, DALY rates per 100000 population due to NCDs in adolescents aged 10-24 years ranged from $5248 \cdot 13$ [ $95 \%$ UI 3890.06-6787.39]) in the Czech Republic to 7828.83 [5815.44-10207.98]) in the UK (figure 3). In all EU Member States, mental disorders were the leading level 2 cause of DALYs from NCDs (figure 3), accounting for more than $22 \cdot 5 \%(15 \cdot 8-30 \cdot 6)$ of the DALY burden. Significantly higher rate differences between Member States and the EU overall were observed at level 2 causes for the following diseases and countries: cardiovascular diseases (Bulgaria, Romania, and Latvia), digestive diseases (Bulgaria, Romania, and

Lithuania), diabetes and kidney diseases (Bulgaria), neoplasms (Bulgaria, Romania, Latvia, and Malta), and substance use disorders (Estonia; appendix pp 26-28).
In the 30 -year period, the DALY rate due to NCDs across the EU decreased by $5 \cdot 1 \%$ ( $95 \%$ UI $-7 \cdot 6$ to $-3 \cdot 2$; table; appendix p 29). Among level 2 NCD causes, there was a significant change in the DALY rate from 1990 to 2019 for cardiovascular diseases, which decreased by $52 \cdot 10 \%$ ( $-55 \cdot 50$ to $-48 \cdot 70$ ), and neoplasms, which decreased by $34 \cdot 82 \%$ ( $-40 \cdot 62$ to $-30 \cdot 47$; table).

## Correlation between SDI and NCD DALY rates

In 2019, the SDI ranged from 0.74 (Portugal) to 0.90 (Germany and Luxembourg; appendix p 43). Moderate rank correlations of higher developmental index and higher DALY rates of substance use disorders ( $r_{s}=0 \cdot 58$, $\mathrm{p}=0 \cdot 0012$ ) and skin and subcutaneous diseases ( $r_{s}=0.45$, $\mathrm{p}=0.017$ ) and of lower developmental index and higher DALY rates of cardiovascular diseases ( $r_{s}=-0 \cdot 46$, $\mathrm{p}=0 \cdot 015$ ), neoplasms ( $r_{s}=-0 \cdot 57, \mathrm{p}=0 \cdot 0015$ ), and sense organ diseases $\left(r_{s}=-0.61, \mathrm{p}=0.0005\right)$ were observed (appendix pp 30, 44).

## Discussion

This study presents the first systematic analysis of the NCD burden among adolescents in the EU Member States using GBD 2019 estimates. It found that the burden of NCD mortality and disability increases between the age groups $10-14$ and $20-24$ years. Despite substantial decreases in mortality over the past three decades, disability has remained mostly unchanged over this time,


Figure 3: DALY rate per 100000 population due to level 2 non-communicable diseases in adolescents aged 10-24 years in both sexes, by country, 2019 DALY=disability-adjusted life-year. *This aggregate cause contains the following level 3 causes: congenital birth defects; urinary diseases; gynaecological diseases; haemoglobinopathies and haemolytic anaemias; endocrine, metabolic, blood, and immune disorders; oral disorders.
and the rising trend of YLLs attributed to mental disorders and their YLD burden are concerning. In line with previous evidence reporting that sex differences tend to increase with age, ${ }^{4,17}$ our findings show that sex differences are wider in young adults. Furthermore, although males have a higher mortality and a major burden attributed to substance use disorders, females present a higher disability burden, particularly attributable to mental disorders, with an emerging mortality burden of eating disorders. Substantial variations of the NCD burden by country were also found. Mortality and YLLs from NCDs predominated in eastern European countries (Bulgaria, Estonia, Latvia, Lithuania, and Romania), in comparison to greater prominence from disability in western European countries (the UK, Portugal, Ireland, Germany, and Luxembourg).
This study highlights the need to scale up wideranging interventions to address the challenge of NCDs in adolescents in EU Member States, particularly aiming in reducing the disability burden of these diseases. These interventions comprise holistic multilevel public health approaches, ${ }^{\text {, }}$ including evidence-based preventive interventions, investments in dedicated primary and specialist health-care services including specialist training in adolescent medicine, ${ }^{18}$ and health-promoting school programmes. ${ }^{19}$ Effective interventions should also consider structural and proximal social and environmental determinants of
health, such as improving access to education and employment, as well as commercial determinants that shape ill health. ${ }^{20,21}$
Within the EU, despite the fifth European Youth Goal ${ }^{10}$ to promote social inclusion of all young people, to achieve better mental health and wellbeing and end stigmatisation of mental health issues, mental disorders were the major contributors of the NCD burden in all EU Member States and in adolescents. Previous studies have reported mental disorders as leading causes of disability among adolescents, ${ }^{8}$ and that the onset of the first mental disorder emerges in a third of individuals before the age of 14 years, in almost half by 18 years, and nearly two-thirds before 25 years. ${ }^{22}$ Yet only $20-40 \%$ of adolescents with mental health problems are diagnosed by health services and only $25 \%$ receive appropriate treatment. ${ }^{23}$ This problem is compounded by low help-seeking behaviour ${ }^{24}$ and is probably exacerbated by barriers to accessing mental health services, ${ }^{25}$ such as stigma, service cost, the absence of health services, or the requirement for parental consent. Gender inequalities in health primarily emerge during adolescence, ${ }^{26}$ and this difference reinforces the importance of prioritising adolescents of all genders as an age group for targeted gender-sensitive health policies, indicators, and programmes. Examples include mainstreaming gender in health service delivery and access, in medical research,
in health planning processes, and in the training of health-care professionals, which would be expected to enhance the effectiveness of actions to address the burden of NCDs. Moreover, the correlation between DALY rates and SDI of each EU Member State also confirms the need to address underlying determinants of health and suggests that country-specific approaches are needed. ${ }^{27}$ For example, Bulgaria and Romania, which have the lowest expenditure on health in the EU, ${ }^{28}$ would benefit from greater investments to improve access to and quality of health services, including for adolescents, ${ }^{29}$ national health system monitoring or quality assurance systems, and prevention, ${ }^{28}$ whereas Estonia, with the highest burden of substance use disorder in adolescents, would benefit from increased drug-related expenditure, including for tackling gaps in data collection, which accounted for only $0.02 \%$ of gross domestic product in 2011, well below the EU average. ${ }^{30}$
Understanding and responding to these barriers is particularly urgent given the impact of the COVID-19 pandemic on adolescent health and health-related quality of life. ${ }^{12}$ In this context, besides mental disorders, ${ }^{31}$ there are also concerns about the impact of the COVID-19 pandemic on reducing access to health services for other NCDs, such as cancer. Despite significant improvements in mortality reduction due to neoplasms in EU Member States, these gains might be jeopardised by the disruptions to cancer care services faced during COVID-19 pandemic. ${ }^{32}$ Additionally, considering the rising trend of disability due to diabetes, the alarming increase of type 2 diabetes in adolescents, ${ }^{33,34}$ and long-term effects of COVID-19 on obesity and type 1 diabetes, reasonable prevention strategies and health system responses should be prioritised.
GBD 2019 has some key limitations, such as availability of primary data, the uncertainty for some estimates represented by a wide $95 \%$ UIs, as well as in the determination and classification of some nonfatal disorders. Further details in GBD 2019 limits are described elsewhere. ${ }^{14}$ Our analysis has several limitations related to variation in the availability and quality of primary data for adolescent health, including paucity of data for some age groups (especially 10-14 years), for many health outcomes during adolescence, ${ }^{35}$ and some EU Member States, particularly in central and eastern Europe. These estimates of disease burden are surrounded by considerable uncertainties and different data availability between countries can generate difficulties in the interpretation of comparisons. Additionally, not all sources of uncertainty could be routinely captured in either the epidemiological or cause-of-death modelling processes. It is important to note that both disability and mortality rates of mental disorders will have been underestimated as self-harm and interpersonal and sexual violence were excluded from the analysis (due to GBD 2019 grouping these
within injures group). In addition, mental disorders and self-harm are often underdiagnosed or misdiagnosed, among other reasons, due to implicit stigma affecting both patients and clinicians. Reporting bias might be relevant as well in stigmatised disorders such as mental disorders and substance use disorders. Finally, although we used SDI to describe socioeconomic differences among countries, other indicators might be more relevant for adolescents, and further disaggregation, such as ethnicity, could provide additional information.
Despite two decades of attention to adolescentfriendly health services that consider the context of adolescent's biological and social development, ${ }^{36}$ these data on NCDs are consistent with concerns that the quality of health care currently provided to adolescents in the EU is less than optimal. ${ }^{18}$ Addressing NCDs in adolescents is complex, as adolescence is a period in which both NCDs begin and many NCD risk behaviours start, with the related burden of diseases becoming visible only in adulthood, as it is estimated that about $70 \%$ of premature deaths occurring during adulthood result from health-related behaviours initiated in childhood and adolescence. ${ }^{6}$ Although various plans and strategies are in place at the regional level (ie, the EU level), with some evidence of national plans, the high disability burden due to adolescent NCDs indicates inadequate implementation of key policies and severe underfunding in many countries. NCDs in adolescents have been largely ignored in global targets for the UN Sustainable Development Goals (SDGs). ${ }^{37}$ Yet responses are urgently needed as these data on adolescents in 2019 will be reflected in national adult targets for NCDs within the 2030 UN SDGs.

## Contributors

BA, DB, LM, and SS conceptualised the study. BA drafted the manuscript. BA and LM had access to and verified the data. BA provided the analysis, DB, LM, and SS helped in the interpretation of results. MP and SH contributed to the overall generation of GBD estimates. SS, FB, GS, GC, LR, MP, SH, and PP contributed to reviewing and finalising the manuscript. BA, DB, and LM had final responsibility for the decision to submit for publication. All other authors provided data, developed models, reviewed results, provided guidance on methods, or reviewed and contributed to the manuscript. All authors approved the final version of the manuscript (appendix pp 45-46).

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## Declaration of interests

We declare no competing interests.

## Data sharing

To download the data used in these analyses, please visit the Global Health Data Exchange at http://ghdx.healthdata.org/gbd-results-tool.

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## References

1 Sawyer SM, Azzopardi PS, Wickremarathne D, Patton GC. The age of adolescence. Lancet Child Adolesc Health 2018; 2: 223-28.
2 Temmerman M, Khosla R, Bhutta ZA, Bustreo F. Towards a new Global Strategy for Women's, Children's and Adolescents' Health. BMJ 2015; 351: h4414.
3 Boerma T, Requejo J, Victora C, et al. Countdown to 2030: tracking progress towards universal coverage for reproductive, maternal, newborn, and child health. Lancet 2018; 391: 1538-48.
4 Ward J, Azzopardi P, Francis K, et al. Global, regional, and national mortality among young people aged 10-24 years, 1950-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2021; 398: 1593-618.
5 The Lancet Child \& Adolescent Health. Universal health coverage and the forgotten generation. Lancet Child Adolesc Health 2019; 3: 749.
6 Sawyer SM, Afifi RA, Bearinger LH, et al. Adolescence: a foundation for future health. Lancet 2012; 379: 1630-40.
7 WHO. Noncommunicable diseases. April 13, 2021. https://www. who.int/news-room/fact-sheets/detail/noncommunicable-diseases (accessed Jan 18, 2022).
8 Akseer N, Mehta S, Wigle J, et al. Non-communicable diseases among adolescents: current status, determinants, interventions and policies. BMC Public Health 2020; 20: 1908.
9 Patton GC, Sawyer SM, Santelli JS, et al. Our future: a Lancet commission on adolescent health and wellbeing. Lancet 2016; 387: 2423-78.
10 Council of the European Union, Representatives of the Governments of the Member States (The Member States). Resolution of the Council of the European Union and the Representatives of the Governments of the Member States meeting within the Council on a framework for European cooperation in the youth field: the European Union Youth Strategy 2019-2027. Dec 18, 2018. https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:42018Y1218(01) (accessed Jan 19, 2022).
11 European Chronic Disease Alliance. Towards an EU Strategic Framework for the Prevention of Non-communicable Diseases (NCDs). May, 2019. https://easl.eu/wp-content/uploads/2019/05/ Final-NCD-Paper-full-version.pdf (accessed Jan 18, 2022).
12 UN. Policy brief: the impact of COVID-19 on children. April 15, 2020. https://unsdg.un.org/sites/default/ files/2020-04/160420_Covid_Children_Policy_Brief.pdf (accessed Jan 18, 2022).

13 Palmer K, Monaco A, Kivipelto M, et al. The potential long-term impact of the COVID-19 outbreak on patients with non-communicable diseases in Europe: consequences for healthy ageing. Aging Clin Exp Res 2020; 32: 1189-94.
14 Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2020; 396: 1204-22.
15 Stevens GA, Alkema L, Black RE, et al. Guidelines for Accurate and Transparent Health Estimates Reporting: the GATHER statement. PLoS Med 2016; 13: e1002056.
16 Wang H, Abbas KM, Abbasifard M, et al. Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950-2019: a comprehensive demographic analysis for the Global Burden of Disease Study 2019. Lancet 2020; 396: 1160-203.
17 WHO. Regional Office for Europe. Growing up unequal: gender and socioeconomic differences in young people's health and well-being. 2016. https://apps.who.int/iris/handle/10665/326320 (accessed Jan 18, 2022).
18 Michaud PA, Weber MW, Namazova-Baranova L, Ambresin AE. Improving the quality of care delivered to adolescents in Europe: a time to invest. Arch Dis Child 2019; 104: 214-16.
19 WHO, UNESCO, UNICEF, WFP, eds. Making every school a health-promoting school: implementation guidance. June 22, 2021. https://www.who.int/publications/i/item/9789240025073 (accessed Jan 19, 2022).
20 Viner RM, Ozer EM, Denny S, et al. Adolescence and the social determinants of health. Lancet 2012; 379: 1641-52.
21 Kickbusch I, Allen L, Franz C. The commercial determinants of health. Lancet Glob Health 2016; 4: e895-96.
22 Solmi M, Radua J, Olivola M, et al. Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies. Mol Psychiatry 2021; published online June 2. https://doi.org/10.1038/ s41380-021-01161-7.
23 Sanci L, Lewis D, Patton G. Detecting emotional disorder in young people in primary care. Curr Opin Psychiatry 2010; 23: 318-23.
24 Kaess M, Brunner R, Parzer P, et al. Risk-behaviour screening for identifying adolescents with mental health problems in Europe. Eur Child Adolesc Psychiatry 2014; 23: 611-20.
25 Tylee A, Haller DM, Graham T, Churchill R, Sanci LA. Youth-friendly primary-care services: how are we doing and what more needs to be done? Lancet 2007; 369: 1565-73.
26 Kennedy E, Binder G, Humphries-Waa K, et al. Gender inequalities in health and wellbeing across the first two decades of life: an analysis of 40 low-income and middle-income countries in the Asia-Pacific region. Lancet Glob Health 2020; 8: e1473-88.
27 Azzopardi PS, Hearps SJC, Francis KL, et al. Progress in adolescent health and wellbeing: tracking 12 headline indicators for 195 countries and territories, 1990-2016. Lancet 2019; 393: 1101-18.
28 OECD/European Observatory on Health Systems and Policies. State of Health in the EU. Belgium: country health profile 2021. Dec 13, 2021. https://doi.org/10.1787/57e3abb5-en (accessed Jan 18, 2022).
29 Saloustros E, Stark DP, Michailidou K, et al. The care of adolescents and young adults with cancer: results of the ESMO/SIOPE survey. ESMO Open 2017; 2: e000252.
30 European Monitoring Centre for Drugs and Drug Addiction. Estonia, country drug report 2019. 2019. https://www.emcdda. europa.eu/system/files/publications/11337/estonia-cdr-2019_0.pdf (accessed Jan 18, 2022).
31 Racine N, McArthur BA, Cooke JE, Eirich R, Zhu J, Madigan S. Global prevalence of depressive and anxiety symptoms in children and adolescents during COVID-19: a meta-analysis. JAMA Pediatr 2021; 175: 1142-50.
32 Graetz D, Agulnik A, Ranadive R, et al. Global effect of the COVID-19 pandemic on paediatric cancer care: a cross-sectional study. Lancet Child Adolesc Health 2021; 5: 332-40.
33 Liu J, Ren ZH, Qiang H, et al. Trends in the incidence of diabetes mellitus: results from the Global Burden of Disease Study 2017 and implications for diabetes mellitus prevention. BMC Public Health 2020; 20: 1415.

34 Lascar N, Brown J, Pattison H, Barnett AH, Bailey CJ, Bellary S, Type 2 diabetes in adolescents and young adults. Lancet Diabetes Endocrinol 2018; 6: 69-80.
35 Patton G, Azzopardi P, Kennedy E, Coffey C, Mokdad A. Global measures of health risks and disease burden in adolescents. Disease control priorities, vol 8, 3rd edn. Child and adolescent health and development. Washington, DC: The International Bank for Reconstruction and Development/The World Bank, 2017: 57-72.

36 Ambresin AE, Bennett K, Patton GC, Sanci LA, Sawyer SM Assessment of youth-friendly health care: a systematic review of indicators drawn from young people's perspectives. J Adolesc Health 2013; 52: 670-81.
37 UN. Transforming our world: the 2030 Agenda for Sustainable Development. 2015. https://sdgs.un.org/2030agenda (accessed Jan 18, 2022).

