Treatable Mortality in an International Perspective: Feasibility Study for Methodological Improvements

FINAL REPORT

Maastricht University

September 2020

Third EU Health Programme

EUROPEAN COMMISSION

Consumers, Health, Agriculture and Food Executive Agency

European Commission
B-1049 Brussels

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2020

EN

More information on the European Union is available on the internet (http://europa.eu).

Luxembourg: Publications Office of the European Union, 2020

ISBN
doi:TBA

DELIVERABLE D6 – FINAL REPORT
Treatable Mortality in an International Perspective: Feasibility Study for Methodological Improvements.

Date of delivery: 23 October 2020
Type of deliverable: Final report

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ABSTRACT

The avoidable mortality indicator is headline indicator of relative health system performance in EU policy processes. However, the usefulness and reliability of the avoidable mortality indicator for cross-national comparisons of health system performance are limited by the quality of underlying data, the challenges in selecting causes of death and age limits, the association with other indicators, and the lack of control for context. This study examined the feasibility and impact of certain refinements of avoidable mortality on a base ranking of countries, including adjustments for disease prevalence, disease stage, lags and potential learning effects, using alternative outcome measures like DALYs or YLL instead of deaths, different age thresholds, and linking specific functions of health systems to specific outcomes (sentinel mortality). The study finds that the inclusion of measures of years of life lost and relaxing of age-restrictions are feasible given data availability and their implementation will improve the use of avoidable mortality for cross-country benchmarks of health system performance. We also recommend that a new shorter list of avoidable causes of death should be considered, which should focus on causes of death that correspond to particular points of failure in care provision.

SOMMAIRE

L'indicateur de mortalité évitable est l'indicateur principal de la performance relative des systèmes de santé dans les processus politiques de l'UE. Toutefois, l'utilité et la fiabilité de l'indicateur de mortalité évitable pour les comparaisons transnationales des performances des systèmes de santé sont limitées par la qualité des données sous-jacentes, les difficultés de sélection des causes de décès et des limites d'âge, l'association avec d'autres indicateurs et le fait qu'on ne maîtrise pas suffisamment le contexte. Cette étude a examiné la faisabilité et l'impact de certaines précisions de la mortalité évitable sur un classement fondamental des pays, en incluant les ajustements concernant la prévalence des maladies, le stade de la maladie, les décalages et les effets d'apprentissage potentiels, l'utilisation de mesures alternatives des résultats comme les AVCI ou les AVP au lieu des décès, les différents seuils d'âge, et en établissant le lien entre des fonctions spécifiques des systèmes de santé et des résultats spécifiques (mortalité sentinelle). L'étude conclut qu'il est possible d'inclure des indicateurs relatifs à des années de vie perdues étant donné que des données sont disponibles et que leur intégration permettra de mieux utiliser la mortalité évitable dans les critères internationaux de performance des systèmes de santé. Nous recommandons également d'envisager une nouvelle liste plus courte de causes de décès évitables, qui devrait se concentrer sur les causes de décès imputables à des échecs particuliers en matière de prestation de soins.

EXECUTIVE SUMMARY

Context

Cause-specific mortality data have so far been the main source of information for international benchmarks of quality of care as measured at the outcome level. The avoidable mortality indicator promises to leverage this information to provide a theoretically sound summary measure of health system performance. However, avoidable mortality relies heavily on the selection of causes of death and age thresholds. The usefulness and reliability of the avoidable mortality indicator for cross-national comparisons of health system performance are limited by the quality of underlying data, the challenges in selecting causes of death and age limits, the association with other indicators, and the lack of control for context. In addition, avoidable mortality, even when decomposed into treatable and preventable mortality, is not granular enough to account for the quality of particular functions of healthcare systems thereby limiting its utility for the generation of policy advice. Hence, there is a clear need to improve the avoidable mortality indicator.

Aim

The ultimate aim of this study was to advance the science and practice of cross-country comparisons of health system performance in Europe. The specific objective was to examine the feasibility and impact of certain refinements of avoidable mortality on a base ranking of countries, including:

- disease prevalence,
- disease stage (i.e. refined prevalence),
- lead times (or lags) and potential learning effects,
- using alternative outcome measures like DALYs or YLL instead of deaths,
- different age thresholds,
- linking specific functions of health systems to specific outcomes (sentinel mortality).

Literature and data review

In order to support the feasibility study, a review of scientific studies, documents of international organisations, and available data was performed. The focus of the review were European countries and other high-income settings.

The literature review included 44 documents that focused on describing and evaluating the avoidable mortality indicator, and 68 empirical studies that used the indicator and were published in the last decade. The review revealed that the core aspects of avoidable mortality, the optimal selection of causes of death and age cut-offs in high-income settings, remain an active area of research. There was also a clearly expressed need for approaches that account for variations in the socioeconomic context and morbidity patterns in country comparisons, although most authors expressed doubt whether this is feasible at this time.

The data review revealed that high-quality cause-specific mortality data for the countries of interest were accessible from Eurostat, but were not as detailed as required by the latest OECD/Eurostat avoidable causes of death list. Morbidity data overall were not readily available. The only morbidity data with adequate geographic coverage consisted of self-reported prevalence for broad disease groups collected by the European Health Interview Survey, which includes diabetes mellitus, hypertension, ischaemic heart diseases, cerebrovascular diseases, chronic lower respiratory diseases, asthma, and kidney problems. The burden of disease data were readily accessible from the Institute of Health Metrics and Evaluation (University of Washington).

Feasibility and sensitivity study

Methods

Avoidable mortality rates were calculated using the standard approach and the associated country ranks were used as the baseline. We estimated the cause-specific case fatality rate per 100,000 prevalent cases between the ages 15 and 75. The adjustment in terms of disease stage composition was not possible due to data limitations. To explore the lagged prevalence adjustment, we calculated avoidable mortality incorporating a two-year lag between the prevalence and mortality rates. To test for learning effects, we identified a subset of countries and diseases with persistently high mortality and prevalence rates and tested for the effect of the passage of time on the disease-specific age-standardised mortality rate by sex on this sample, controlling for the mortality rate at the start of the period, country, prevalence rate (when possible), healthcare expenditure (to control for general healthcare investment), and gross domestic product per capita in purchasing power parity dollars (to control for general standard of living). For adjustment in terms of alternative outcome measures, we calculated three age-adjusted indicators: avoidable years of life lost (YLL), avoidable years lived with disability (YLD), and avoidable disability adjusted life-years (DALYs) per 100,000 population. For adjustment in terms of alternative age thresholds, we tested three different scenarios: no age thresholds (i.e. all deaths due to the specified causes of death are considered treatable), expanding the age range to 0-79 in all causes to better reflect the prevalent mortality conditions, sex-specific age ranges to better reflect the sex differences in mortality rates. We performed the sensitivity analysis of country ranks to the adjustments by comparing country ranks based on each of the proposed adjustment strategies with the baseline ranks using the Spearman's rank correlation coefficient. Finally, we outlined and explored a novel approach avoidable mortality by identifying and comparing cause-specific mortality for causes of death that may indicate the performance of health systems at various points of a generic patient pathway.

Main results

- Adjustments that rely on the availability of morbidity data are currently not feasible. There is a significant paucity of publicly accessible, timely, and objectively measured morbidity data across all disease groups associated with the avoidable mortality indicator.
- Adjusting avoidable mortality in terms of alternative age thresholds or alternative outcomes is possible given the data currently available. While the first set of adjustments has only a small impact on country ranks (rank change of 1-3 places), the second adjustment profoundly changes them (rank change of more than 8 places). There is also country-specific variation in the average impact of the changes, which may be due to differences in the relative importance old-age mortality and mortality due to cardiovascular disease.
- The country-specific effects of adjusting age thresholds likely reflect a more accurate representation of mortality at older ages. Therefore, including deaths at all ages in the avoidable mortality indicator represents a helpful conceptual simplification and accounts for differences in old-age mortality rates.
- Interpreting the disability-based avoidable burden of disease estimates (YLD and DALYs) is challenging due to the case fatality rates being estimated assuming spatial smoothness (e.g., similar values in neighbouring countries) to overcome missing data for some causes of death and geographies. This would invalidate any benchmarks based on the indicator if its purpose is to compare the ability of neighbouring health systems to prevent death, since the assumption of spatial smoothness may be violated. This is less concerning for YLL estimates, which rely on the more complete mortality data only.
- The novel systems-informed approach to avoidable mortality is feasible and was evaluated as theoretically promising by the external experts we consulted, but would require a more rigorous exploration before routine use.

Recommendations

- The inclusion of measures of years of life lost and relaxing of age-restrictions are feasible given data availability and their implementation will improve the use of avoidable mortality for cross-country benchmarks of health system performance.
- The development of a new shorter list of avoidable causes of death should be considered. The current OECD/Eurostat list may be too detailed for implementation as evidenced by the lack of mortality and morbidity data. A shorter list could increase the availability of relevant high-quality morbidity data in the near future by creating a more realistic scope for data collection in the participating countries. The shorter list should focus on causes of death that are informative of the key functions of a health system and correspond to particular points of failure in care provision.

SYNTHÈSE

Contexte

Les données relatives à la mortalité liées à des causes spécifiques ont jusqu'à présent été la principale source d'information pour élaborer les critères internationaux de qualité des soins tels que mesurés au niveau des résultats. L'indicateur de mortalité évitable est censé exploiter ces informations pour fournir une mesure synthétique théoriquement solide des performances du système de santé. Cependant, la mesure de la mortalité évitable dépend fortement de la sélection des causes de décès et des seuils d'âge. L'utilité et la fiabilité de l'indicateur de mortalité évitable dans le cadre de comparaisons transnationales de la performance des systèmes de santé sont limitées par la qualité des données sous-jacentes, les difficultés de sélection des causes de décès et des limites d'âge, l'association avec d'autres indicateurs et enfin, par le fait que le contexte n'est pas suffisamment maîtrisable. En outre, la mortalité évitable, même lorsqu'elle est décomposée en mortalité évitable et imputées à des causes que l'on peut soigner, n'est pas suffisamment particularisée pour rendre compte de la qualité des fonctions spécifiques des systèmes de santé, ce qui limite son utilité pour l'élaboration de conseils stratégiques. Améliorer l'indicateur de mortalité évitable s'avère donc indispensable.

Objectif

La finalité de cette étude était de faire progresser la science ainsi que la pratique des comparaisons des performances des systèmes de santé à l'échelle européenne. L'objectif spécifique était d'analyser la faisabilité et l'impact de certaines mesures servant à mieux délimiter la mortalité évitable sur un classement fondamental des pays, notamment :

- la prévalence des maladies,
- le stade de la maladie (c'est-à-dire une prévalence affinée),
- les délais (ou retards) et les effets potentiels d'apprentissage,
- l'utilisation de mesures alternatives de résultats comme les AVCIs ou AVP au lieu des décès,
- différents seuils d'âge,
- le lien entre des fonctions spécifiques des systèmes de santé à des résultats spécifiques (mortalité sentinelle).

Analyse documentaire et des données

Afin d'appuyer l'étude de faisabilité, des études scientifiques, des documents rédigés par des organisations internationales et des données disponibles ont été analysés. L'examen s'est concentré sur les pays européens et d'autres pays à revenus élevés.

L'analyse documentaire a porté sur 44 documents axés sur la description et l'évaluation de l'indicateur de mortalité évitable, et 68 études empiriques utilisant cet indicateur et publiées au cours de la dernière décennie. L'analyse a révélé que les aspects fondamentaux de la mortalité évitable, la sélection optimale des causes de décès et les seuils d'âge dans les pays à revenus élevés restent un domaine de recherche actif. Le besoin d'approches qui tiennent compte des variations du contexte socio-économique et des schémas de morbidité dans les comparaisons entre pays a également été clairement exprimé, bien que la plupart des auteurs aient exprimé des doutes quant à la faisabilité d'une telle démarche à l'heure actuelle.

L'examen des données a révélé qu'Eurostat fournit des données de haute qualité sur la mortalité par cause spécifique pour les pays concernés. Néanmoins ; celles-ci ne seraient pas aussi détaillées que l'exige la dernière liste OCDE/Eurostat des causes de décès évitables. Les données de morbidité dans leur ensemble n'étaient pas facilement disponibles. Les seules données de morbidité ayant une couverture géographique adéquate étaient les prévalences déclarées par l'enquête européenne par interview sur la santé qui portent sur de larges groupes de maladies telles que le diabète sucré, l'hypertension, les maladies cardiaques ischémiques, les maladies vasculaires cérébrales, les maladies chroniques des voies respiratoires inférieures, l'asthme et les problèmes rénaux. Les données sur la charge de morbidité étaient facilement accessibles auprès de l'Institute of Health Metrics and Evaluation (Université de Washington).

Étude de faisabilité et de sensibilité

Méthodes

Les taux de mortalité évitables ont été calculés en utilisant l'approche standard et les classements des pays associés ont servi de base de référence. Nous avons estimé le taux de mortalité imputable à des causes spécifiques pour 100 000 cas fréquents chez les 15 à 75 ans. L'ajustement en termes de composition par stade de la maladie n'a pas été possible en raison de l'insuffisance des données. Pour étudier l'ajustement de la prévalence décalée, nous avons calculé la mortalité évitable en intégrant un décalage de deux ans entre les taux de prévalence et de mortalité. Pour tester les effets de l'apprentissage, nous avons identifié un sous-ensemble de pays et de maladies présentant des taux de mortalité et de prévalence élevés de manière persistante. Puis nous avons testé l'effet du temps écoulé sur le taux de mortalité par maladie spécifique, standardisé pour l'âge et par sexe sur cet échantillon, en identifiant le taux de mortalité au début de la période, compte tenu du pays, du taux de prévalence (si possible), des dépenses de santé (pour chiffrer l'investissement général dans les soins de santé) et du produit intérieur brut par habitant en euros en parité de pouvoir d'achat (pour évaluer le niveau de vie général). Afin d'adapter les mesures alternatives de résultats, nous avons calculé trois indicateurs ajustés en fonction de l'âge : les années de vie perdues évitables (AVP), les années de vie vécues avec handicap évitables (AVCI) et les années de vie corrigées du facteur invalidité (AVAI) pour 100 000 habitants. Pour l'ajustement en termes de seuils d'âge alternatifs, nous avons testé trois scénarios différents : aucun seuil d'âge n'est appliqué (c'est-à-dire que tous les décès imputables aux causes spécifiées sont considérés comme pouvant être évités par le biais de traitements) ; la tranche d'âge est élargie à 0-79 ans quelle que soit la cause du décès pour mieux refléter les facteurs prévalents de mortalité – idem pour les tranches d'âge spécifiques au sexe pour mieux refléter les différences de taux de mortalité entre les sexes.
Nous avons effectué l'analyse de sensibilité des classements des pays en comparant les rangs des pays sur la base de chacune des stratégies d'ajustement proposées avec les classements fondamentaux. Pour ce faire, nous avons utilisé le coefficient de corrélation des classements de Spearman. Enfin, nous avons décrit et exploré une nouvelle approche de la mortalité évitable en identifiant et en comparant la mortalité par cause spécifique pour les causes de décès pouvant renseigner sur la performance des systèmes de santé à différentes étapes du parcours d'un patient.

Principaux résultats

- **Les ajustements qui reposent sur la disponibilité des données de morbidité ne sont actuellement pas réalisables.** Les données de morbidité accessibles au public, opportunes et mesurées objectivement pour tous les groupes de maladies associés à l'indicateur de mortalité évitable sont insuffisantes.
- **Améliorer la mesure de la mortalité évitable par le biais de seuils d'âge ou de résultats alternatifs est possible compte tenu des données actuellement disponibles.** Alors que la première série d'ajustements n'a qu'un faible impact sur les classements des pays (changement de rang de 1 à 3 places), la deuxième série d'ajustements les modifie profondément (changement de rang de plus de 8 places). L'impact moyen des changements varie également selon les pays, dû sans doute à des différences en termes d'importance relative de la mortalité des personnes.
- **Les effets spécifiques à chaque pays de l'ajustement des seuils d'âge reflètent vraisemblablement une représentation plus précise de la mortalité à un âge plus avancé.** Par conséquent, inclure dans l'indicateur de mortalité évitable des décès à tous les âges représente une simplification

conceptuelle utile et tient compte des différences dans les taux de mortalité des personnes âgées.

- **L'interprétation des estimations de la charge de morbidité évitable fondée sur l'incapacité (AVAI et AVCI) est difficile en raison des taux de létalité estimés en supposant une certaine régularité spatiale (par exemple, des valeurs similaires dans les pays voisins) pour pallier le manque de données pour certaines causes de décès et certaines zones géographiques.** Cela invaliderait toute référence basée sur l'indicateur si celui-ci a pour but de comparer la capacité des systèmes de santé voisins à prévenir les décès, puisque l'hypothèse de la régularité spatiale peut être faussée. Cela est moins préoccupant pour les estimations de l'AVP, qui reposent uniquement sur les données de mortalité plus complètes.
- **La nouvelle approche systémique de la mortalité évitable est réalisable et a été jugée théoriquement prometteuse par les experts externes que nous avons consultés, mais nécessiterait une exploration plus rigoureuse.**

Recommandations

- **L'inclusion de mesures des années de vie perdues et l'assouplissement des restrictions liées à l'âge sont possibles compte tenu de la disponibilité des données, et leur mise en œuvre permettra d'améliorer l'utilisation de la mortalité évitable pour l'évaluation comparative des performances des systèmes de santé entre les pays.**
- **L'élaboration d'une nouvelle liste plus courte de causes de décès évitables devrait être envisagée.** La liste actuelle de l'OCDE/Eurostat est peut-être trop détaillée pour servir de référence, comme en témoigne le manque de données sur la mortalité et la morbidité. Élaborer une liste abrégée pourrait améliorer la disponibilité de données de morbidité pertinentes et de qualité dans un avenir proche à travers la mise en place d'une méthodologie plus réaliste pour la collecte de données dans les pays participants. **La liste abrégée devrait se concentrer sur les causes de décès qui peuvent éclairer sur les fonctions clés d'un système de santé et correspondent à des points faibles particuliers dans la prestation des soins.**

CHAPTER 1. INTRODUCTION

Structure of the report

This report is structured as follows:

- Chapter 1 Introduction
- Chapter 2 Summary of the data and literature reviews
- Chapter 3 Summary of the study protocol
- Chapter 4 Summary of the data analysis
- Chapter 5 Avoidable mortality in a systems perspective
- Chapter 6 Conclusions and recommendations
- Appendix 1: Annotated review of avoidable mortality studies 2010-2020
- Appendix 2: Data and code
- Appendix 3: Calculating treatable years of life lost

The remainder of the introduction summarises the tender process to date and summarises the tasks featured in this report.

This report draws on all previous deliverables in the project.

Key developments in the tender process to date

Signature of the contract: 20 December 2020. Contract number: 20197303 - RfS-CHAFEA-2019-HEALTH-13 under FWC SANCO/2016/A1/039 (Amenable mortality)

Kick-off meeting: Luxembourg, 30 January 2020.

Task 1 has been completed and relevant report submitted on 27 February 2020.

Task 2 has been completed and the relevant report submitted on 27 March 2020.

Update meeting in preparation for the Interim report: Online, 13 May 2020.

The Interim report (tasks 3 and 4) was delivered on 6 July 2020 and presented on 22 July 2020.

The Draft final report (task 5) was delivered on 18 September and presented on 5 October.

Summary of the tasks performed

This report follows up on the feedback received in relation to the draft final report. The following tasks have been accomplished:

- Visualisations of changes in country ranks were added
- Impact of adjustments are reported not as an absolute rank change but as percentage against a baseline (EU median value)
- Selection of possible causes for a shorter list was described in more detail.
- The average impact of all adjustments per country were highlighted and discussed.

CHAPTER 2. SUMMARY OF THE DATA AND LITERATURE REVIEWS

Overview of the task

Task 1 provides an overview of the available data on disease prevalence, disease-specific mortality rates, and the burden of disease (DALYs and/or YLL) for each of the treatable causes of death in the OECD/Eurostat, per capita health expenditures, cross-referenced by the EU28+2. This task will also provide a literature review related to three domains of treatable mortality:

- the methodological approaches to calculating treatable mortality and their challenges,
- limitations of treatable mortality as an indicator of health system performance, and
- an appraisal of the quality of the underlying data available.

Data review

We have reviewed of the following sources of data:

- UNIDEMO, EHIS and SHA 2011 data (Eurostat),
- The European Surveillance System (TESSy/ECDC),
- European network of population-based registries for the epidemiological surveillance of congenital anomalies (EUROCAT),
- European Renal Association - European Dialysis and Transplant Association dataset (ERA-EDTA),
- European Cancer Information System (ECIS),
- the Human Cause of Death Database (Max Planck Institute for Demographic Research and the French National Demographic Institute – INED),
- the OECD Health Statistics database,
- the Global Burden of Disease (GBD) Study 2017 results database (Institute for Health Metrics and Evaluation),
- World Health Organisation Mortality Database, and
- national statistics institutes.

The availability of cause of death data is high, particularly in the Eurostat database, but it does not match the OECD/Eurostat list exactly. We list the causes of death we were able to explore in the next section.

Morbidity data are much more limited. Relevant timely incidence data are available only for cancers (ECIS) and selected infectious diseases (TESSy). However, for those two sources of data, incomplete geographic coverage, and lack of disaggregation by sex and age, respectively, prevented us from using them. For other causes of death, comparable data for the EU is available only for broad disease groups, a single year (2014), and is based on self-reports (EHIS: diabetes mellitus, hypertension, ischaemic heart diseases, cerebrovascular diseases, chronic lower respiratory diseases, asthma, and kidney problems). Other potential sources of morbidity data, such as hospital discharge data (WHO HFA: cerebrovascular disease, ischaemic heart disease, circulatory system disease, digestive system disease, respiratory system disease) has apparently been discontinued by 2010 in all target countries reporting. In addition, the comparability of the latter data is uncertain as the standardisation process is not reported, and the data are not disaggregated according to sex and age.

An expanded search uncovered no publicly accessible and systematically collected data on mortality and morbidity by disease stage for any disease that matches the geographic scope required for this study. This includes oncological diseases and diabetes mellitus. The burden of disease data is only available from one source, IHME, but its method of generation is opaque. The sources and methods used to create the estimates vary by disease group, location, and year estimated. This makes assessing the reliability of the estimates and avoiding circular reasoning (e.g., calculating case fatality rates by using morbidity rates that in turn were estimated using assumed case fatality rates) very difficult. We therefore only used GBD data for the burden-based adjustment and elected not to extract other morbidity data from that source.

Table 1 provides a summary of data extracted by disease category that was used in the later stages of the study. It provides information on the data source (including link to metadata), the level of disaggregation by sex and age, coverage (geographic and over time), and estimated risk of bias. All values were disaggregated by sex, unless otherwise noted.

The assessment of risk of bias was based on the data collection method. Vital registration, routine economic statistics, and for-purpose surveillance systems were considered low risk. Estimated values were considered medium risk if the methods of their production were opaque. Self-reported data was considered high risk, since the true underlying diagnosis remains unverified by expert examination.

Table 1. Summary of extracted data.

Disease category	Identification method (ICD-10 code or other)	Source (metadata)	Age-groups	Coverage	Risk of bias
		Death counts			
Tuberculosis	A15-A19, B90	Eurostat hlth_cd_aro (https://ec.europa.eu/eurostat/cache/metadata/en/hlth_cdeath_esms.htm)	Age: 0, 1-4, 5-9, …, 95+	2011-2017 All target countries. (Some missing data in the lower age-groups in Cyprus, Iceland, and Slovenia)	Low
Viral hepatitis and sequelae of viral hepatitis	B15-B19, B94.2				
Chronic viral hepatitis B and C	B18.0-B18.2				
Human immunodeficiency virus [HIV] disease	B20-B24				
Malignant neoplasm of lip, oral cavity, pharynx	C00-C14				
Malignant neoplasm of oesophagus	C15				
Malignant neoplasm of stomach	C16				
Malignant neoplasm of colon, rectosigmoid junction, rectum, anus and anal canal	C18-C21				
Malignant neoplasm of liver and intrahepatic bile ducts	C22				
Malignant neoplasm of trachea, bronchus and lung	C33-C34				
Malignant melanoma of skin	C43				
Malignant neoplasm of breast	C50				
Malignant neoplasm of cervix uteri	C53				
Malignant neoplasm of other parts of uterus	C54-C55				
Malignant neoplasm of bladder	C67				
Malignant neoplasm of thyroid gland	C73				

Hodgkin disease and lymphomas	C81-C86				
Leukaemia	C91-C95				
Diabetes mellitus	E10-E14				
Ischaemic heart diseases	I20-I25				
Acute myocardial infarction including subsequent myocardial infarction	I21-I22				
Cerebrovascular diseases	I60-I69				
Influenza (including swine flu)	J09-J11				
Pneumonia	J12-J18				
Chronic lower respiratory diseases	J40-J47				
Asthma and status asthmaticus	J45-J46				
Other lower respiratory diseases	J40-J44, J47				
Ulcer of stomach, duodenum and jejunum	K25-K28				
Chronic liver disease	K70-K73, K74				
Diseases of kidney and ureter	N00-N29				
Pregnancy, childbirth and the puerperium	O00-O99				
Certain conditions originating in the perinatal period	P00-P96				
Transport accidents	V01-V99, Y85				
Other accidents	W20-W64, W75-X39, X50-X59, Y86				
Intentional self-harm	X60-X84, Y870				
Assault	X85-Y09, Y871				
Event of undetermined intent	Y10-Y34, Y872				
Prevalence / incidence					
Asthma	Self-report	Eurostat hlth_ehis_cd1b (https://ec.europa.eu/eurostat/cache/metadata/en/hlth_det_esms.htm)	Age: 15-24, 25-34, …, 75+	2014 All target countries	High
Chronic lower respiratory diseases (excluding asthma)	Self-report				
Heart attack or chronic consequences of heart attack	Self-report				
Coronary heart disease or angina pectoris	Self-report				
High blood pressure	Self-report				
Stroke or chronic consequences of stroke	Self-report				
Cirrhosis of the liver	Self-report				
Kidney problems	Self-report				
Diabetes	Self-report				
Disease burden					
HIV/AIDS	B20-B24.9	GBD Results Tool http://ghdx.healthdata.org/record/ihme-data/gbd-2017-cause-icd-code-mappings	Age: 0, 1-4, 5-9, …, 90-95, 95+	1990-2017 All target countries	Medium
Sexually transmitted infections (except HIV/AIDS)	A50-A58, A60-A60.9, A63-A63.8, B63, I98.0, K67.0-K67.2, M03.1, M73.0-M73.1				
Tuberculosis	A15-A19.9, B90-B90.9, K67.3, K93.0, M49.0, N74.1, P37.0, U84.3				
Enteric infections	A00-A00.9, A01.0-A09.9, A80-A80.9, R19.7				
Malaria	B50-B53.8				
Haemophilus and pneumococcal meningitis	A39-A39.9, A87-A87.9, G00.0-G00.8, G03-G03.8				
Diphtheria	A36-A36.9				
Whooping cough	A37-A37.9				
Tetanus	A33-A35.0				
Measles	B05-B05.9				
Varicella	B01-B02.9, P35.8				
Viral hepatitis	B15-B17.9, B19-B19.9, B94.2, P35.3				

Upper respiratory infections	J00-J02.8, J03-J03.8, J04-J04.2, J05-J05.1, J06.0-J06.8, J36-J36.0				
Maternal disorders	N96, N98-N98.9, O00-O07.9, O09-O16.9, O20-O26.9, O28-O36.9, O40-O48.1, O60-O77.9, O80-O92.7, O96-O98.6, O98.8-O99.9				
Neonatal disorders	P00-P04.2, P04.5-P05.9, P07-P15.9, P19-P22.9, P24-P29.9, P36-P36.9, P38-P39.9, P50-P61.9, P70-P70.1, P70.3-P72.9, P74-P78.9, P80-P81.9, P83-P84, P90-P94.9, P96, P96.3-P96.4, P96.8				
Cancer of lip and oral cavity	C00-C08.9, D10.0-D10.5, D11-D11.9				
Cancer of pharynx	C11-C11.9, D10.6, C09-C10.9, C12-C13.9, D10.7				
Oesophageal cancer	C15-C15.9, D00.1, D13.0				
Stomach cancer	C16-C16.9, D00.2, D13.1, D37.1				
Colon and rectum cancer	C18-C21.9, D01.0-D01.3, D12-D12.9, D37.3-D37.5				
Liver cancer	C22-C22.9, D13.4				
Tracheal, bronchus, and lung cancer	C33-C34.9, D02.1-D02.3, D14.2-D14.3, D38.1				
Melanoma	C43-C43.9, D03-D03.9, D22-D23.9, D48.5				
Breast cancer	C50-C50.9, D05-D05.9, D24-D24.9, D48.6, D49.3				
Cervical cancer	C53-C53.9, D06-D06.9, D26.0				
Uterine cancer	C54-C54.9, D07.0-D07.2, D26.1-D26.9				
Testicular cancer	C62-C62.9, D29.2-D29.8, D40.1-D40.8				
Bladder cancer	C67-C67.9, D09.0, D30.3, D41.4-D41.8, D49.4				
Thyroid cancer	C73-C73.9, D09.3, D09.8, D34-D34.9, D44.0				
Hodgkin lymphoma	C81-C81.9				
ALL	C91.0				
Other neoplasms	D32-D33.9, D35.3-D35.4, D42-D43.9, D45-D47.9, D49.6, K62.0-K62.1, K63.5, N60-N60.9, N84.0-N84.1, N87-N87.9				
Ischaemic heart disease	I20-I25.9				
Stroke	G45-G46.8, I60-I63.9, I65-I66.9, I67.0-I67.3, I67.5-I67.6, I68.1-I68.2, I69.0-I69.3				
Hypertensive heart disease	I11-I11.9				
Aortic aneurysm	I71-I71.9				
Rheumatic heart disease	I01-I01.9, I02.0, I05-I09.9				
Chronic obstructive pulmonary disease	J41-J44.9				
Asthma	J45-J46.9				
Peptic ulcer disease	K25-K28.9, K31, K31.1-K31.6, K31.8				
Appendicitis	K35-K37.9, K38.3-K38.9				
Abdominal hernias	K40-K42.9, K44-K46.9				

Gallbladder and biliary disease	K80-K83.9				
Pancreatitis	K85-K86.9				
Epilepsy	G40-G41.9				
Alcohol use disorders	F10-F10.9, G31.2, G72.1, P04.3, Q86.0, R78.0, X45-X45.9, X65-X65.9, Y15-Y15.9				
Drug use disorders	F11-F16.9, F18-F19.9, P04.4, P96.1, R78.1-R78.5				
Diabetes mellitus	E10-E10.1, E10.3-E11.1, E11.3-E11.9, P70.2				
Chronic kidney disease	D63.1, E10.2, E11.2, I12-I13.9, N02-N08.8, N15.0, N18-N18.9, Q61-Q62.8				
Neural tube disorders	Q00-Q01.9, Q05-Q05.9				
Congenital heart anomalies	Q20-Q28.9				
Urolithiasis	N20-N23.0				
Transport injuries	V00-V86.9, V87.2-V87.3, V88.2-V88.3, V90-V98.8				
Unintentional injuries	L55-L55.9, L56.3, L56.8-L56.9, L58-L58.9, W00-W46.2, W49-W62.9, W64-W70.9, W73-W75.9, W77-W81.9, W83-W94.9, W97.9, W99-X06.9, X08-X39.9, X46-X48.9, X50-X54.9, X57-X58.9, Y40-Y84.9, Y88-Y88.3				
Self-harm	X60-X64.9, X66-X84.9, Y87.0				
Interpersonal violence	X85-Y08.9, Y87.1				
Economic data					
Total health expenditure per capita (PPS EUR)	Not applicable	Eurostat hlth_sha11_hf (https://ec.europa.eu/eurostat/cache/metadata/en/hlth_sha11_esms.htm)	Not applicable	2011-2017 All target countries	Low
Gross domestic product per capita (PPS EUR)	Not applicable	Eurostat nama_10_pc (https://ec.europa.eu/eurostat/cache/metadata/en/nama10_esms.htm)	Not applicable	2011-2017 All target countries	Low

Literature review

Methods

We pursued the available literature on three topics:

- the methodological approaches to calculating treatable mortality and their challenges,
- limitations of treatable mortality as an indicator of health system performance, and
- an appraisal of the quality of the underlying data available.

We performed this task in two steps. In the first, we performed a rapid review[1] of the methodological literature relevant to avoidable, treatable, and preventable mortality. In

[1] Haby, M. M., Chapman, E., Clark, R., Barreto, J., Reveiz, L., & Lavis, J. N. (2016). What are the best methodologies for rapid reviews of the research evidence for evidence-informed decision making in health policy and practice: a rapid review. Health research policy and systems, 14(1), 83.

the second, we updated the most recent (2011) annotated bibliography of the empirical literature that uses avoidable mortality indicator as the primary outcome.

Inclusion and exclusion criteria

We included both scientific publications and grey literature (e.g. policy documents) in both steps. We included only English language publications to limit the scope of the search and avoid translation delays.

The second step limited the search to 2010-2020, since the previous annotated bibliographies by Nolte & McKee[2] and Castelli & Nizalova[3] already covered the time periods up to 2004, and 2004-2010, respectively. We also included only empirical studies in this step and excluded reviews, opinions, methods papers, and other non-empirical formats.

Sources of data

We included the following databases in the first step of the review: MEDLINE, CINAHL, Science Citation Index - Expanded, Social Sciences Citation Index, and Emerging Sourced Citation Index. In addition, we hand-searched online resources of the European Commission (including Eurostat), the Institute for Health Metrics and Evaluation, the OECD, WHO, and the World Bank. We also included the websites of EU-funded projects on treatable mortality (AMIEHS). We screened the collections of literature reviews, including PDQ-Evidence, HSE (healthsystemsevidence.org), Health Evidence (healthevidence.org), and the Cochrane Library. Finally, we scanned the reference lists of included documents for additional relevant publications.

The second step followed the established methods of the previous two annotated bibliographies and included only MEDLINE, Science Citation Index – Expanded, Social Sciences Citation Index, and Emerging Sourced Citation Index, as well as websites of governmental institutions.

Search strategy

We identified the relevant records by searching for related keywords in the title. In Table 2a, we present the search strategies for each step of the review for the Web of Science interface. The keyword strategy was developed and refined based on increasing familiarity with the literature. The specific strategy used was appropriately modified for each database.

Table 2a. Keyword strategies by objective.	
Step 1: Methods for calculating treatable mortality and their challenges & Limitations of treatable mortality indicators as a health performance indicator	Amenable, avoidable, preventable, treatable AND mortality AND Application*, approach*, bias*, calculation*, comparab*, concept*, challenge*, limitation*, method*, quality, problem*, quant*, reliab*, strength*, valid*, weak*, effectiveness
Step 2: Annotated bibliography of avoidable mortality studies	amenable mortality, avoidable mortality, preventable mortality, preventable causes, amenable causes, avoidable causes, unnecessary deaths, untimely deaths, preventable deaths, quality of health care,

[2] Nolte, E. & McKee, M. (2004). Does Health Care Save Lives? Avoidable Mortality Revisited, The Nuffield Trust.

[3] Castelli, A. and Nizalova, O. (2011) Avoidable mortality: What it means and how it is measured. University of York.

	mortality amenable, deaths amenable, mortality preventable, mortality avoidable, deaths preventable, deaths avoidable

Publication selection extraction, and evaluation

The selection of included publications was conducted in three phases: screening by title and keywords, screening abstracts, and full text screening. Each phase was conducted by one researcher. In case of ambiguity, a second researcher assisted in the selection. Reasons for exclusion were noted for each excluded publication to ensure consistency with PRISMA standards.

The extraction sheet used for step 1 of the review focused on summarising the included publications and extracting the passages related to the task objectives. We included the following domains on the extraction sheet:

- Study identifier (First author, year)
- Publication type (scientific paper, government report, database metadata)
- Study design (empirical study, simulation study, opinion, indicator description)
- Relevant passages

Since the aim of the review was to collect as many potential methods of calculating the indicator and their limitations, as well as the broader conceptual limitations of treatable mortality more generally, we did not explicitly assess the quality of the documents we uncovered in step 1.

In step 2 of the review, we followed the domains established by the preceding two annotated bibliographies and extracted information in the following domains:

- Study region
- Time period under investigation
- Aim of study and definition of avoidable mortality
- Causes of death and age group(s) under study
- Analytical design
- Main result

Data synthesis

We provide a narrative synthesis of the compiled literature to provide an overview of key themes in each of the three review objectives: methods of calculating treatable mortality (including different indicator definitions used), limitations of treatable mortality as a health system performance indicator in a comparative perspective, and the (quality of) underlying sources of data used in the empirical studies that apply the indicator.

<u>Main results</u>

Our search uncovered 44 documents in step 1, and 68 empirical studies in step 2. We list the core review that provided the most comprehensive information of the indicator and its limitations in Table 2c. Two of these reviews summarise the available empirical literature in an annotated bibliography. We provide the annotated bibliography of the 68 empirical studies that used avoidable mortality published 2010-2020 in the next section.

Table 2b. Core reviews.
"Avoidable" Mortality and Health Services: A Review of Aggregate Data Studies. (1990, June). J Epidemiol Community Health. doi: 10.1136/jech.44.2.106

* Nolte, E. & McKee, M. (2004). Does Health Care Save Lives? Avoidable Mortality Revisited, *The Nuffield Trust.*
Kamarudeen, S. (2010). Amenable mortality as an indicator of healthcare quality - a literature review. *Health statistics quarterly*(47), 66-80. doi:10.1057/hsq.2010.16
* Castelli, A. and Nizalova, O. (2011) Avoidable mortality: What it means and how it is measured. *University of York*.
Perez, G., Rodriguez-Sanz, M., Cirera, E., Perez, K., Puigpinos, R., & Borrell, C. (2014). Approaches, strengths, and limitations of avoidable mortality. *Journal of Public Health Policy, 35*(2), 171-184. doi:10.1057/jphp.2014.8
Note: * Include annotated bibliographies.

We found that the definitions of avoidable, preventable and treatable mortality crystallised over time around the Nolte & McKee definition[4], sometimes with the addition of preventable mortality causes identified by Page and colleagues[5]. Nevertheless, in the empirical literature over the last ten years, the use of localised versions of the list became increasingly common (e.g. Canada[6] and Brazil[7]). The lists are all slightly differ from one another in the selection of causes of death. Likewise, the debate around the appropriate age cut-offs has not been resolved with frequent adaptations being made by researchers one way or another, often in response to data availability.

We uncovered several core reviews of avoidable mortality (Table 2b) that examined the limitations of the avoidable mortality indicator in the context of cross-national comparisons of health system performance or healthcare quality. The core of this discussion can be summarised in four domains: (1) quality of underlying data, (2) challenges in selecting causes of death and age limits, (3) association with other indicators, and (4) lack of control for context (Table 2c).

Table 2c. Summary of limitations of the avoidable mortality indicator

Domain	*Specific issues*
Quality of underlying data	Differences in coding deaths between contexts Different ability of countries to detect cases Small numbers increase the influence of random variation in mortality; likely to be most present in well-performing places and will increase over time
Identifying causes of death and age limits	Majority of causes on various lists are not wholly avoidable Difficulty with assigning causes to categories treatable and preventable (or identifying the relevant proportions) Improvements in mortality are also derived from outside the healthcare system Age limits are (mostly) not evidence-based bur rather arbitrary
Association with other indicators	The value avoidable mortality is empirically not associated with healthcare inputs

[4] Nolte, E. & McKee, M. (2004). Does Health Care Save Lives? Avoidable Mortality Revisited, *The Nuffield Trust.*

[5] Page, A., Tobias, M., Glover, J., Wright, C., Hetzel, D., & Fisher, E. (2006). Australian and New Zealand atlas of avoidable mortality. Adelaide: PHIDU, University of Adelaide.

[6] Canadian Institute for Health Information. (2012). Health Indicators 2012. Ottawa, Canada: Canadian Institute for Health Information.

[7] Malta, D. C., Duarte, E. C., Almeida, M. F. D., Dias, M. A. D. S., Morais Neto, O. L. D., Moura, L. D., ... & Souza, M. D. F. M. D. (2007). Lista de causas de mortes evitáveis por intervenções do Sistema Único de Saúde do Brasil.

	It is well-associated with socioeconomic variables; it likely captures differences in health behaviours and healthcare utilisation preferences and abilities
Lack of control for context	There is no control for differences in prevalent socioeconomic or health conditions between countries or over time

The literature includes some potential solutions regarding the limitations listed, quantification of their effect, or a better contextualisation of the results.

The AMIEHS (Avoidable Mortality in the European Union) project[8] produced a selection of causes of death for which there is was a persuasive association between the introduction of a concrete healthcare innovation and mortality reduction (colorectal cancer, cervical cancer, and cerebrovascular disease). Similarly, Vergara-Duarte et al.[9] identified so-called "sentinel" causes of avoidable mortality with a high-efficacy treatment available based on a literature review and expert consensus. However, the two lists do not overlap as cervical cancer and cerebrovascular disease were considered to have only medium-efficacy interventions, and colorectal cancer did not make the list.

Weber & Clerc[10] performed of sensitivity analyses of country rankings regarding the age limits used and varying attributional weights of certain causes of death to healthcare quality. They found the rankings to be mostly robust to such changes (mostly changes of 1-2 ranks), although some country ranks (e.g., Finland) were highly sensitive. Similar results were found by Soltes & Gavurova[11] who tested the sensitivity of country ranking to different definitions of avoidable mortality.

The lack of association between healthcare inputs and avoidable mortality may be due to the inputs not representing quality of healthcare, reverse causality (higher expenditures in response to high mortality rates), not accounting for variation in disease incidence, or a lack of accounting for potential lags in effect[12]. Nevertheless, there is broad consensus in the literature that the disparities in resources that societies can mobilise for healthcare and the differences in disease prevalence should be explicitly considered. The Healthcare quality and access index developed by the GBD collaborators seeks to control for cross-country differences in risk factor prevalence (non-cancer diseases) and incidence rates (cancers), as well differences in socioeconomic development[13]. However, as mentioned above, the GBD relies on a complex estimation method that renders the connection between underlying data and the estimate opaque. Other papers also note the challenge of finding good sources of morbidity data that could be used to control for cross-country differences in incidence and prevalence rates of avoidable mortality conditions.

[8] Hoffmann, R., Plug, I., Khoshaba, B., McKee, M., Mackenbach, J. P., & Grp, A. W. (2013). Amenable mortality revisited: the AMIEHS study. Gaceta Sanitaria, 27(3), 199-206. doi:10.1016/j.gaceta.2012.08.004

[9] Vergara-Duarte, M., Borrell, C., Perez, G., Martin-Sanchez, J. C., Cleries, R., Buxo, M., . . . Benach, J. (2018). Sentinel Amenable Mortality: A New Way to Assess the Quality of Healthcare by Examining Causes of Premature Death for Which Highly Efficacious Medical Interventions Are Available. Biomed Research International, 2018, 5456074. doi:10.1155/2018/5456074

[10] Weber, A., & Clerc, M. (2017). Deaths amenable to health care: Converging trends in the EU? Health policy (Amsterdam, Netherlands), 121(6), 644-652. doi:10.1016/j.healthpol.2017.03.017

[11] Soltes, M., & Gavurova, B. (2015). Quantification and comparison of avoidable mortality - causal relations and modification of concepts. Technological and Economic Development of Economy, 21(6), 917-938. doi:10.3846/20294913.2015.1106421

[12] Kamarudeen, S. (2010). Amenable mortality as an indicator of healthcare quality - a literature review. Health statistics quarterly(47), 66-80. doi:10.1057/hsq.2010.16

[13] Fullman, N., Yearwood, J., Abay, S. M., Abbafati, C., Abd-Allah, F., Abdela, J., ...Lozano, R. (2018). Measuring performance on the Healthcare Access and Quality Index for 195 countries and territories and selected subnational locations: a systematic analysis from the Global Burden of Disease Study 2016. Lancet, 391(10136), 2236–2271. doi: 10.1016/S0140-6736(18)30994-2

In summary, the concept of avoidable mortality continues to evolve. The first key innovation is an improved selection process of causes of death and associated age ranges that is based on a systematic literature and expert consultation processes and that focuses on improving the fit of the concept to a local context. The second is the development of methods that control for cross-country variation in morbidity and socioeconomic conditions. These innovations promise to address most of the limitations we identified in Table 8. However, implementing these innovations in the European Union is challenging due to the variety of different local contexts that the list would need to adjust to, as well as the apparent paucity of good quality data on incidence and prevalence of the relevant conditions.

An annotated bibliography of avoidable mortality studies for the period 2010-2020 is available in Annex 1.

CHAPTER 3. SUMMARY OF THE STUDY PROTOCOL

Overview of the task

Task 2 provided a protocol for the core study (Task 4), which incorporated feedback from the kick-off meeting, insights from Task 1, as well as an external review with Commission staff and three experts from academia.

Expert review process

<u>Identification and recruitment</u>

Five experts from academia were identified for the external review process and a priority list was drafted and included in project proposal. The criteria used for their identification were their publication record on treatable mortality specifically, or health system performance assessment and mortality studies more generally. The priority list was discussed at the kick-off meeting and agreed to.

The experts were approached via email and invited to participate in the study in the last week of February or the first two weeks of March 2020, depending on their position on the priority list. Two experts were not able to participate due prior engagements and due to the time constraints of this project, respectively.

<u>Consultation</u>

The three experts that agreed to participate, Professors Johan P. Mackenbach, Carme Borrell, and Doctor Nicole Rosenkötter, were sent a draft version of the protocol for Tasks 3 and 4, a brief summary of the overall study, and a list of questions (Table 3) to guide them during the review process.

Table 3. Guiding questions for the expert review
1. Are all the key limitations of avoidable mortality and their potential solutions considered in the list of adjustments to be explored?
2. The list includes controlling for disease prevalence, disease stage (i.e. refined prevalence), lead times (or lags), potential learning effects, using alternative outcome measures like DALYs or YLL instead of deaths, and different age thresholds to define treatable deaths.
3. Are the proposed methods of overcoming data limitations (Task 3) adequate?
4. Are the proposed methods of controlling for cross-country variation in disease prevalence adequate?
5. Are the proposed methods of controlling for cross-country variation in disease stage (refined prevalence) adequate?
6. Are the proposed methods of exploring the effects of lead or lag times between prevalence and mortality rates adequate?
7. Are the proposed methods of exploring the potential learning effects adequate?
8. Are the proposed methods of exploring alternative outcome measures adequate?
9. Are the proposed methods of exploring the effects of alternative age thresholds to define avoidable deaths adequate?
10. Are the methods proposed to quantify the effect of each adjustment adequate?
11. Is the list of sentinel causes of death adequate for the EU28+2 context, or should it be adjusted?
12. Are the methods proposed to explore the role of healthcare expenditures on avoidable mortality rankings adequate?

Overall, the experts provided very valuable comments on how to approach certain methodological shortcomings, which we incorporated in the rest of this chapter. There were also recommendations to use more complex methods that may address certain limitations of our approach (e.g., Bayesian modelling), which go beyond the scope of the agreed upon scope of the project yet could certainly be interesting for future research and we briefly highlight them where appropriate.

Study protocol

Missing data

Based on our preliminary overview, we anticipated that the problem of missing data will be a key obstacle. The problem can take on several forms. The first concerns the problem of missing data over all domains of data for a relevant cause of death for all countries and throughout the period. The second is the problem insufficient granularity in disease categories for some domains of data (e.g., more granular mortality than morbidity data) for all countries and throughout the period. The third potential problem is missing data in some countries or in some years.

The first problem is most common for diseases with a relatively low prevalence or incidence for all countries and years and a low perceived relevance of the disease. In those cases, we explored four strategies. The first was to use a more general disease category, e.g., "endocrine disorders" instead of only "thyroid" and "adrenal disorders". This may have overestimated the absolute value of treatable mortality, but we would assume that the amount of overestimation is similar in the comparative perspective and thus did not influence the country ranks. The second option was to exclude the missing disease or disease category from the calculation of country rankings. This would underestimate the absolute value of treatable mortality, but similar to the first case, we assumed the underestimation to be comparable for all included countries. Third, we explored the possibility of borrowing data (e.g., age distributions) from related causes of death. The final option was to extract estimates from the epidemiological literature, which may be missing for certain Member States. We exclusively used the first and second strategies in the core analyses.

The second problem would introduce bias due to using numerators and denominators for imperfectly aligned disease categories (e.g., strokes and cerebrovascular diseases) for all countries and years, which is particularly relevant if the two numbers are derived from different sources. This may be especially important when calculating cause-specific deaths per prevalent population. In order to address this challenge, we noted the precise definition of the disease category in the relevant metadata. When only less granular data were available for either the numerator or denominator, we explored the possibility of distributing deaths into more precise categories based on similar disease categories or results of epidemiological studies. However, due to missingness usually being very widespread (especially for morbidity data), we used the more general diagnostic category for both values in the end.

The third and final problem were differences in data availability between countries and time periods. The latter type of missingness negatively affected the analysis of lags, but was overall the least consequential for the overall analysis. We explored interpolation and extrapolation using available data points to overcome this challenge, but the severe lack of morbidity data made this strategy impossible. The exclusion of some countries from the analysis due to missing data would pose a much greater challenge to the overall analysis. We anticipated that countries with less effective health information systems (including missing data) would also be countries with less effective healthcare systems. This expectation proved incorrect, since in most cases specific categories of data were missing for most countries included in the analysis. As a result, we analysed only the adjustments for which we could include all the thirty countries.

<u>Data analyses</u>

Calculating adjusted treatable mortality values

We aimed to explore the following list of adjustments of treatable mortality:

- disease prevalence,
- disease stage (i.e. refined prevalence),
- lead times (or lags) and potential learning effects,
- using alternative outcome measures like DALYs or YLL instead of deaths,
- and different age thresholds to define treatable deaths.

In the first step of the sensitivity analysis, we calculated the values of treatable mortality for each of the proposed adjustments. In the second step, described in the next section, we produced country ranks and compared them.

The data used are summarised in Table 1. All calculations were stratified by sex and were age-standardised using the European standard population. Age-standardisation of the mortality rates was performed using the direct method, since the included cause-specific mortality rates are generally known by age group. Age-standardisation of morbidity-adjusted rates was performed using the indirect method. Unless otherwise specified, the standard cut-off age of 75 years was used.

For the first adjustment, we estimated the cause-specific mortality rate per 100,000 prevalent cases between the ages 15 and 75. Due to data limitations, the adjustment in terms of disease stage composition was not possible. To explore the lagged prevalence adjustment, we calculated treatable mortality incorporating a lag between the prevalence and mortality rates. We initially planned to explore a range of lags for each disease, based on estimated average survival after diagnosis and in light of the contribution of dependent and independent comorbidity as derived from the literature. However, the morbidity data limitations made this impossible, allowing only for adjustment incorporating a 2-year lag between self-reported prevalence rates and treatable mortality.

To test for learning effects, we identified a subset of countries and diseases with persistently high mortality and prevalence rates. We expected these to be more prone to relatively short-term changes. We then tested for the effect of the passage of time on the disease-specific age-standardised mortality rate, controlling at for the age-standardised mortality rate at the start of the period, country, sex, age, prevalence rate (when possible), healthcare expenditure (to control for general healthcare investment), and gross domestic product per capita PPP (to control for general standard of living), using a generalised linear model. If a learning effect did occur, we expected to see a decrease in mortality rates over time while controlling for the general state of society (national income) and the healthcare systems (health care expenditure).

For adjustment in terms of alternative outcome measures, we calculated three age-adjusted indicators: treatable YLL, treatable YLD, and treatable DALYs per 100,000 affected by disease.

For adjustment in terms of alternative age thresholds, we tested three different scenarios. The first scenario was to include no age thresholds (i.e. all deaths due to the specified causes of death are considered treatable). The second increased the age range to 0-79 in causes with a current range 0-74 to reflect better the current mortality conditions in the European Union. The third considered sex-specific age ranges, which better reflect the sex differences in life expectancy. We initially also considered exploring a scenario of country-specific age ranges. However, experts advised against this as it may introduce circular reasoning: countries that are unable to save elderly patients thereby exclude deaths in higher age groups. The experts also advised us to also explore age-ranges for individual causes of death based on literature reviews, but we considered this beyond the scope of the study.

Quantification of impact for each adjustment

We approached the sensitivity analysis of country ranks from two directions. The first was to evaluate the differences between the different adjustments in terms of absolute values treatable mortality estimates directly. The second was to evaluate the adjustments in terms of their impacts on country ranks. Following expert advice, we also performed the analyses for selected causes of disease in addition to analysing the summary values.

In terms of the first approach, we calculated a number of descriptive statistics (measures of central tendency – median and mean – and spread – interquartile range) to observe what effect the different adjustments had on the distribution of mortality estimates of the entire sample. Based on expert feedback, we also summarised the extent of inequality between the countries using the coefficient of variation and the Theil and Gini indexes by adjustment and for selected causes of death.

For the second approach, we generated the country rank tables, one for each adjustment, and one for the unadjusted cause-specific mortality rate, which will serve as the index ranking. Here, we report the absolute change in ranking (places lost or gained) that each adjustment strategy represents for each of the countries. Next, we performed a statistical comparison of country ranks based on each of the proposed adjustment strategies with the ranking based on unadjusted treatable mortality. We used the Spearman's rank correlation coefficient (Spearman's rho – a nonparametric measure of rank correlation assessing monotonic relationships) to quantify the extent of agreement between the ranks.

Exploration of sentinel amenable mortality causes

We also developed an indicator of treatable mortality inspired by the concept of sentinel mortality rates. The concept has been defined by Vergara-Duarte and colleagues as "amenable causes of death for which highly effective treatments are available. Such causes of death should be considered sentinel events that can help identify possible limitations in the effectiveness and quality of healthcare systems."[14]

The list from the original publication was not met with unanimous approval by the experts consulted during the review. They indicated that the (1) the selection of appropriate causes would require a major effort, which exceeds the scope of this project, (2) that any country comparisons in the context of sentinel amenable mortality should be done on a case-by-case basis, accompanied by a comprehensive description and analysis of each cause.

In light of this, we proceeded with a case study of a limited number of sentinel amenable mortality causes. The analysis involved two steps. The first step was to outline the novel concept of treatable mortality and identify a starting list of causes of death that may indicate the performance of health systems at various points of the patient pathway. The second step was data extraction, the calculation of the sentinel amenable mortality for each country, and creating a country ranking based on these values.

[14] Vergara-Duarte, M., Borrell, C., Pérez, G., Martín-Sánchez, J. C., Clèries, R., Buxó, M., ...Benach, J. (2018). Sentinel Amenable Mortality: A New Way to Assess the Quality of Healthcare by Examining Causes of Premature Death for Which Highly Efficacious Medical Interventions Are Available. Biomed Res. Int., 2018. doi: 10.1155/2018/5456074

Comparison with health expenditures

We compared the treatable mortality rankings (unadjusted and adjusted) with country rankings based on the overall health expenditure per capita, government expenditure on health, and percentage of healthcare spend out-of-pocket. We used the same statistical framework as when comparing the different treatable mortality adjustment strategies (Spearman's rank correlation coefficient) to illustrate the relationship. Based on expert feedback, we calculated a number of descriptive and inequality measures for overall health expenditure per capita, government expenditure on health, and percentage of healthcare spend out-of-pocket as well, and compared these also against their mortality counterpart values. One expert advised us to engage in a deeper exploration of the relationship between treatable mortality and country characteristics. However, this goes beyond the scope and resources of this project.

CHAPTER 4. SUMMARY OF DATA ANALYSES

Unadjusted treatable mortality

As a starting point, we calculated the avoidable mortality rate (Table 4a) using the causes of death reported in Table 1 and the standard age cut-off of 75 years. We also report the corresponding country ranks for the years. We report the 2014 values and ranks to facilitate comparison with the adjustments that follow. As a sensitivity analysis, we replicated the calculation using GBD mortality estimates and arrived at the same ranks. In Table 4b, we provide the unadjusted avoidable mortality rates by selected disease groups.

Table 4a. Unadjusted avoidable mortality rate

Country	Unadjusted avoidable mortality rate – Women (per 100,000)	Unadjusted avoidable mortality rate – Men (per 100,000)	Rank - Women	Rank - Men
AT	147,25	305,97	13	15
BE	154,65	295,09	16	14
BG	229,77	528,08	25	23
CY	104,34	231,32	2	6
CZ	181,67	433,79	21	20
DE	284,32	555,56	29	25
DK	171,23	267,21	19	10
EE	178,27	554,81	20	24
EL	117,35	306,57	5	16
ES	99,8	252,59	1	7
FI	136,5	316,89	10	18
FR	116,16	257,15	4	8
HR	211,85	502,32	23	22
HU	286,44	647,84	30	28
IE	160,16	273,43	17	11
IS	133,77	192,63	9	1
IT	110,73	220,8	3	3
LT	259,48	821,86	26	30
LU	127,28	276,32	6	12
LV	268,59	789,89	27	29
MT	130,92	289,75	8	13
NL	151,18	217,73	15	2
NO	140,11	221,36	11	5
PL	188,43	465,58	22	21
PT	128,06	316,43	7	17
RO	269,77	624,88	28	27
SE	140,43	221,25	12	4
SI	147,38	362,57	14	19
SK	224,55	563,48	24	26
UK	163,87	264,64	18	9
Mean	172,14	385,93		
Median	152,92	306,27		
IQR	74,36	262,62		
Coefficient of variation	0,32	0,45		
Gini index	0,18	0,24		
Theil index	0,05	0,09		

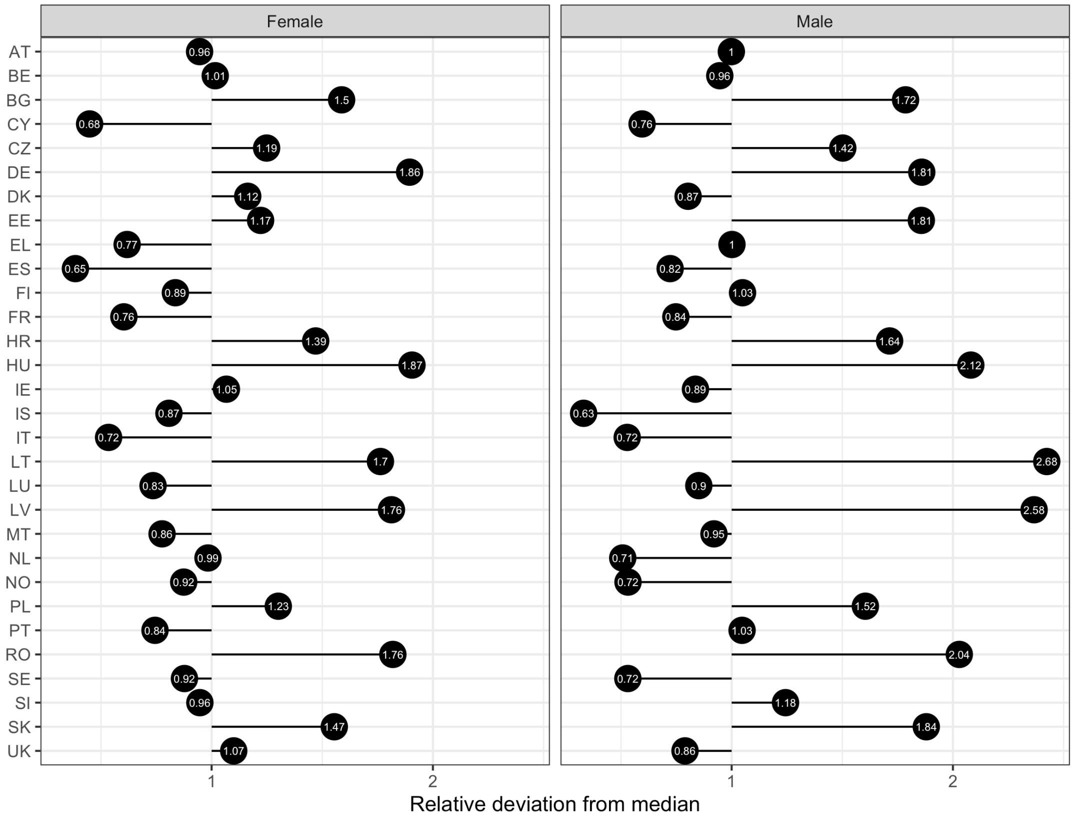

Figure 1 Relative deviation from EU median (baseline)

Table 4b. Mortality rates and country ranks by main disease categories

Country	Cancers (women)	Circulatory disease (women)	Other causes (women)	Cancers (men)	Circulatory disease (men)	Other causes (men)	Cancers (women)	Circulatory disease (women)	Other causes (women)	Cancers (men)	Circulatory disease (men)	Other causes (men)
AT	71,27	27,31	48,66	100,44	77,64	127,89	11	13	16	9	15	16
BE	74,14	21,2	59,31	112,51	52,16	130,42	13	8	23	14	8	17
BG	78,79	97,29	53,7	142,65	226,22	159,22	17	27	20	21	27	20
CY	46,93	26,09	31,31	86,27	72,58	72,47	1	12	4	5	12	3
CZ	75,41	50,39	55,87	130,39	142,48	160,91	14	23	22	19	22	22
DE	146,09	49,7	88,53	206,74	138,87	209,95	30	22	30	29	21	25
DK	95,2	20,46	55,57	106,67	49,51	111,03	28	6	21	13	4	14
EE	76,7	41,53	60,04	159,47	163,61	231,72	16	19	24	23	23	28
EL	59,11	29,83	28,41	124	97,46	85,11	5	16	3	18	18	6
ES	55,36	16,41	28,02	119,93	51,54	81,12	2	3	2	16	7	5
FI	58,1	29,83	48,57	76,23	100,39	140,27	4	16	15	2	19	19
FR	66,85	12,74	36,56	117,07	37,85	102,23	8	1	7	15	1	12
HR	91,39	68,19	52,27	174,13	168,9	159,29	25	24	18	27	24	21
HU	122,67	87,33	76,44	215,79	218,75	213,29	29	26	27	30	26	26
IE	91,84	27,99	40,33	99,6	75,55	98,28	26	14	9	8	14	11
IS	79,73	21,83	32,21	80,8	51,53	60,3	19	9	6	4	6	1
IT	64,26	19,4	27,07	101,53	49,3	69,97	7	5	1	10	3	2
LT	74,12	104,81	80,55	166,79	306,94	348,13	12	28	29	25	29	30
LU	68,45	12,86	45,97	105,81	59,62	110,89	10	2	13	12	9	13
LV	81,31	111,12	76,16	172,07	323,41	294,41	21	30	26	26	30	29
MT	57,18	42,1	31,64	98,61	95,77	95,37	3	20	5	7	17	9
NL	90	19,37	41,81	101,81	40,16	75,75	24	4	10	11	2	4
NO	75,72	20,5	43,88	79,5	50,92	90,94	15	7	12	3	5	7
PL	93,23	43,87	51,33	157,5	120,43	187,65	27	21	17	22	20	23
PT	59,96	25,51	42,59	122,45	69	124,97	6	10	11	17	11	15
RO	87,6	105,18	76,98	174,92	226,89	223,06	23	29	28	28	28	27
SE	67,76	25,71	46,96	65,79	63,14	92,32	9	11	14	1	10	8
SI	79,04	30,89	37,46	137,26	86,19	139,12	18	18	8	20	16	18
SK	86,27	76,81	61,47	162,81	196,84	203,83	22	25	25	24	25	24
UK	81,01	29,61	53,25	92,86	74,09	97,69	20	15	19	6	13	10

Age-standardised disease prevalence

We estimated the cause-specific mortality rate per 100,000 prevalent cases for the disease categories and years in Table 5a.

Table 5a. Combinations of causes of death and prevalent conditions

Cause of death	Prevalent/incident condition	Year
Asthma and status asthmaticus	Asthma	2014
Other lower respiratory diseases	Chronic lower respiratory diseases (excluding asthma)	2014
Ischaemic heart diseases	Coronary heart disease or angina pectoris	2014
Cerebrovascular diseases	High blood pressure	2014
Chronic liver disease	Cirrhosis of the liver	2014
Diseases of kidney and ureter	Kidney problems	2014
Diabetes	Diabetes	2014

We report in Table 5b the number of avoidable deaths per 100,000 prevalent cases for each country. For additional context, we provide the results by disease category in Table 5c.

Table 5b. Avoidable mortality per 100 000 prevalent cases

Country	Avoidable mortality (per 100 000 prevalent cases) - Women	Avoidable mortality (per 100 000 prevalent cases) - Men	Rank - women	Rank - men
AT	207,1	468,41	18	19
BE	182,24	388,75	15	15
BG	352,62	870,13	27	27
CY	160,46	359,49	10	11
CZ	285,78	665,56	24	22
DE	164,11	320,29	12	8
DK	244,42	379,29	22	13
EE	241,89	764,4	21	25
EL	164,98	507,89	13	21
ES	110,05	297,09	4	5
FI	163,45	426,22	11	17
FR	80,48	233,4	2	2
HR	312,12	730,86	25	24
HU	349,01	789,14	26	26
IE	139,66	302,87	6	7
IS	74,93	208,79	1	1
IT	143,85	300,87	7	6
LT	376,52	1150,14	29	28
LU	114,31	266,39	5	3
LV	361,73	1221,65	28	29
MT	207,52	429,99	19	18
NL	146,09	269,45	8	4
NO	186,19	358,6	16	10
PL	181,74	469,07	14	20
PT	107,43	340,18	3	9
RO	675,31	1804,44	30	30
SE	201,33	420,53	17	16
SI	151,92	361,82	9	12
SK	275,95	722,52	23	23
UK	215,47	388,16	20	14
Mean	219.29	540.55		
Median	184.22	404.64		
IQR	120.52	383.02		
Coefficient of variation	0.54	0.64		
Gini index	0.27	0.31		
Theil index	0.12	0.16		

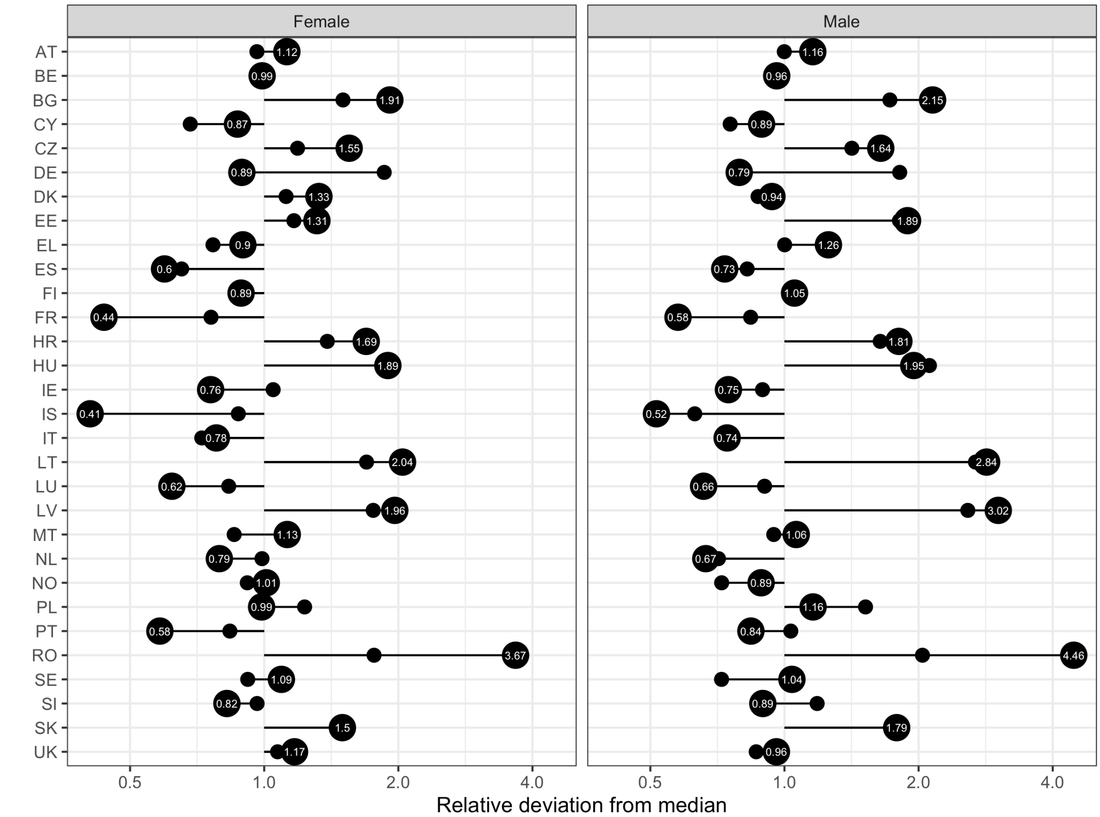

Figure 2 Relative deviation from EU median. Baseline deviation is represented by the small circle. The age-standardised disease prevalence adjusted deviation is represented by the larger circle.

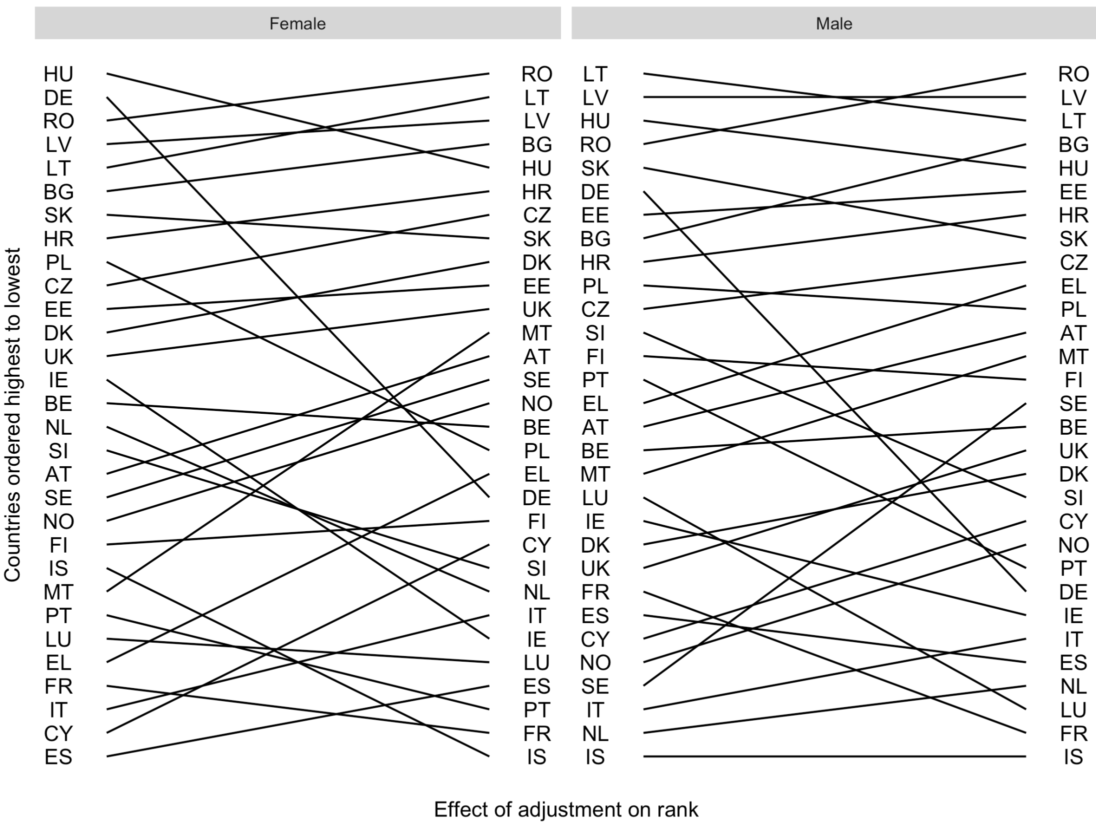

Figure 3 Effect of the age-standardised disease prevalence adjustment on rank.

Table 5c. Mortality per 100 000 prevalent cases and country ranks by selected disease categories

Country	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)
AT	200,17	219,92	126,95	468,27	366,4	240,44	15	27	22	13	28	19
BE	180,9	81,23	143,38	401,58	164,09	281,51	10	9	24	9	11	22
BG	440,74	233,79	68,5	998,59	284,13	324,99	27	28	13	27	24	24
CY	183,84	247,49	24,94	428,19	305,01	124,13	11	29	2	12	26	6
CZ	313,74	182,96	151,59	719,03	319,17	455,12	24	23	26	22	27	28
DE	147,13	135,11	118,66	310,73	179,96	212,66	6	14	20	3	14	15
DK	180,76	214,23	269,76	361,6	369,42	254,08	9	25	30	7	29	20
EE	259,17	150,62	83,34	834,62	169,16	367,48	20	18	15	25	12	26
EL	222,87	68,83	55,9	702,21	150,44	166,13	18	3	11	21	8	11
ES	138,86	75,47	43,39	361,56	105,75	188,47	5	5	6	6	4	13
FI	193,18	70,02	54,29	499,79	91,81	148,69	13	4	10	16	3	10
FR	132,99	44,2	20,72	339,33	110,62	62,37	4	2	1	5	5	1
HR	378,5	203,81	133,38	865,18	249,46	326,35	26	24	23	26	20	25
HU	370,74	178,21	251,5	818,16	237,71	654,41	25	22	28	24	18	29
IE	206,88	78,5	81,3	472,65	88,53	110,58	16	7	14	14	1	5
IS	111,66	26,78	44,77	272,61	135,56	96,18	2	1	7	1	7	2
IT	168,25	176,12	45,08	363,11	257,99	106,93	8	21	8	8	22	4
LT	471,39	144,29	35,13	1427,22	238	317,64	29	15	4	28	19	23
LU	98,22	116,57	89,07	302,3	158,45	106,71	1	11	17	2	10	3
LV	470,16	267,49	37,41	1480,02	588,19	383,71	28	30	5	29	30	27
MT	259,7	216,55	59,68	517,2	291,29	204,29	21	26	12	17	25	14
NL	155,46	104,26	126,58	320,6	169,93	172,33	7	10	21	4	13	12
NO	219,99	131,97	143,77	473,18	157,17	228,08	17	13	25	15	9	18
PL	198,88	150,87	85,83	523,07	217,89	226,68	14	19	16	19	16	17
PT	130,53	131,44	25,24	422,19	184,94	142,83	3	12	3	11	15	8
RO	730,11	145,2	259,24	2116,38	273,48	753,99	30	16	29	30	23	30
SE	245,61	148,91	117,16	577,2	249,83	143,58	19	17	19	20	21	9
SI	192,74	77,48	47,83	404,1	117,23	130,53	12	6	9	10	6	7
SK	308,73	156,82	91,25	791,94	227,2	274,27	23	20	18	23	17	21
UK	259,73	78,72	157,16	519,28	89,8	221,87	22	8	27	18	2	16

Of note is that for a substantial number of age-group-country-disease-group combinations, the proportion of respondents reporting the disease was below 0.1%. Consequently, the number of prevalent cases for these combinations was practically unknown (i.e., only bounded at the top). The majority of these combinations were concentrated in smaller Member States, at younger ages and in the kidney disease category. The reported results assume a value of zero in these cases for further analysis, which may therefore be biased.

Lead times (or lags)

To explore the lags adjustment, we calculated avoidable mortality per 100 000 prevalent cases incorporating a lag of two years between the incidence/prevalence rates and mortality rates for the disease groups in Table 6a. The range of lags we were able to explore was severely constrained by data availability with the 2-year lag being the only option. For additional context, we provide the results by disease category in Table 6b.

Table 6a. Avoidable mortality per 100 000 prevalent cases with 2-year lag.

Country	Avoidable mortality (per 100 000 prevalent cases) - Women	Avoidable mortality (per 100 000 prevalent cases) - Men	Rank - women	Rank - men
AT	213,25	452,45	19	19
BE	186,48	390,47	15	14
BG	325,2	829,33	26	27
CY	129,44	369,05	6	12
CZ	273,46	645,41	24	22
DE	165,54	319,64	12	9
DK	253,6	378,32	22	13
EE	232,67	757,78	21	25
EL	176,5	508,63	13	21
ES	108,56	298,27	3	6
FI	162,62	416,49	11	18
FR	84,86	242,02	1	1
HR	281,25	699,36	25	23
HU	326,66	770,58	27	26
IE	153,78	313,91	9	7
IS	93,67	285,77	2	4
IT	134,28	292,31	7	5
LT	356,76	1173,37	29	29
LU	138,12	277,33	8	2
LV	343,73	1168,16	28	28
MT	210,87	409,29	18	15
NL	157,81	279,61	10	3
NO	196,21	362,61	16	11
PL	180,84	475,83	14	20
PT	108,71	335,55	4	10
RO	633,76	1781,29	30	30
SE	206,64	411,53	17	17
SI	124,85	319	5	8
SK	272,57	729,55	23	24
UK	229,98	409,44	20	16
Mean	215.42	536.74		
Median	191.34	409.36		
Range	84.86-633.76	242.02 - 1781.29		
IQR	125.79	366.71		
Coefficient of variation	0.5	0.63		
Gini index	0.25	0.3		
Theil index	0.11	0.16		

The same caveat regarding certain age-group-country-disease-group combinations applies for this analysis as well (see previous section).

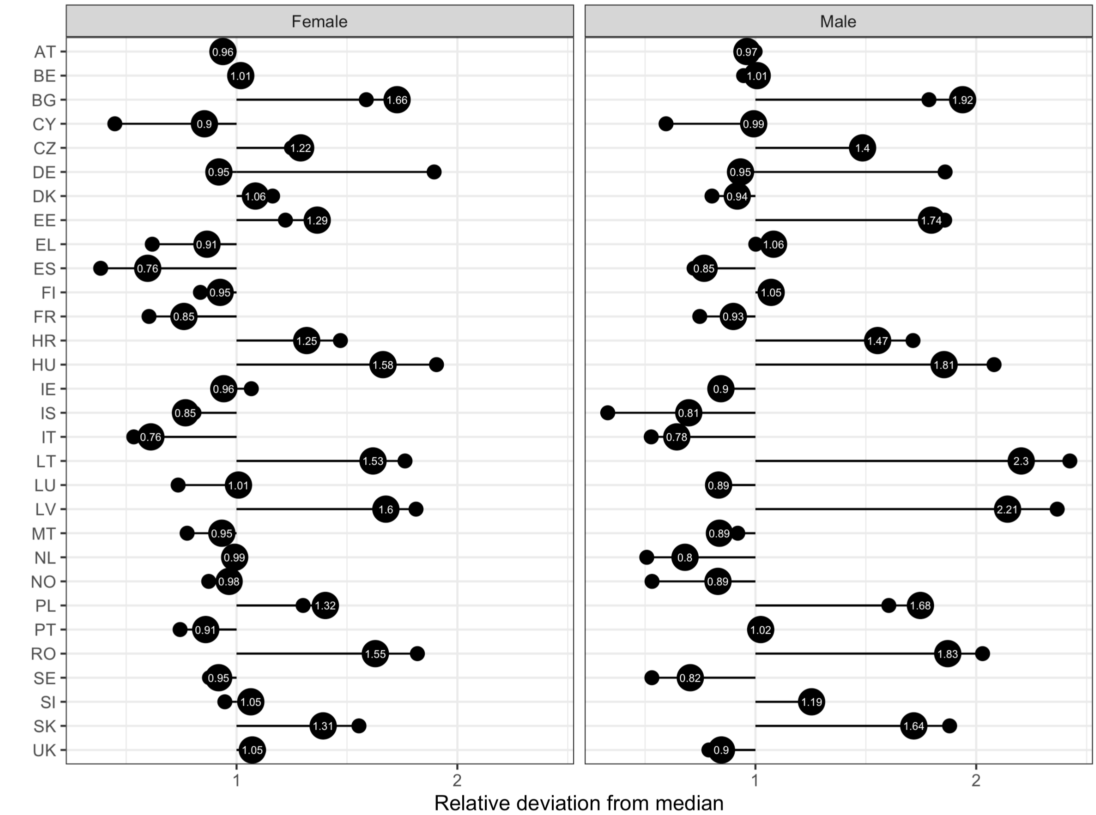

Figure 4 Relative deviation from EU median. Baseline deviation is represented by the small circle. The lagged age-standardised disease prevalence adjusted deviation is represented by the larger circle.

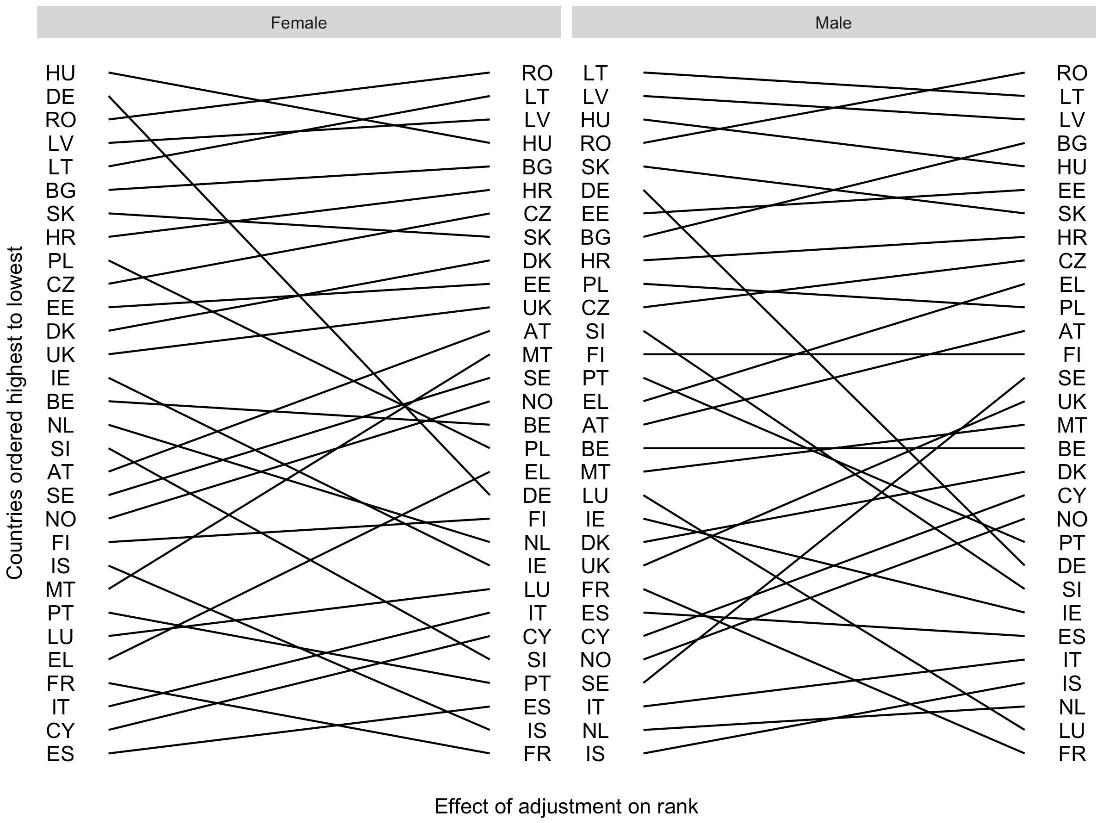

Figure 5 Effect of the lagged age-standardised disease prevalence adjustment on rank.

Table 6b. Mortality per 100 000 prevalent cases with 2-year lag and country ranks by selected disease categories

Country	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)	Circulatory disease (women)	Diabetes (women)	Respiratory disease (women)
AT	198,53	225,84	154,13	438,1	367,11	254,87	16	27	23	12	29	18
BE	178,25	66,66	162,03	390,16	158,45	302,47	11	5	24	10	9	20
BG	390,23	212,01	71,38	919,81	338,14	313,92	27	25	12	27	27	21
CY	143,2	169,71	54,05	471,84	262,78	118,21	6	20	8	14	20	3
CZ	284,08	200,5	173,53	673,48	332,05	502,78	23	24	25	21	26	27
DE	140,76	126,29	138,63	301,37	177,24	227,89	5	13	21	2	10	14
DK	185,71	218,57	295	353,35	365,34	275,94	13	26	30	7	28	19
EE	248,23	97,9	90,91	787,6	253,74	330,74	21	10	13	23	16	23
EL	235,32	83,9	58,25	697,33	154,49	160,7	18	9	10	22	8	10
ES	136,4	69,41	52,74	365,17	102,83	194,83	4	7	6	8	3	11
FI	184,9	68,18	68,81	492,55	101,53	154,97	12	6	11	17	2	9
FR	136,39	45,12	25,83	350,72	113,32	71,68	3	2	1	6	5	1
HR	319,75	243,9	132,39	814,88	325,3	341,94	25	28	19	26	25	25
HU	332,02	181,19	284,69	792,54	262,57	689,3	26	23	29	24	19	29
IE	209,9	101,59	97,83	475,9	120,61	134,2	17	11	15	15	7	6
IS	77,3	0	117,53	268,42	203,34	618,47	1	1	18	1	15	28
IT	152,97	167,63	53,46	348,18	261,72	123,73	8	19	7	5	18	4
LT	444,31	133,98	44,89	1451,63	293,19	324,19	29	16	3	29	23	22
LU	143,82	49,96	101,79	306,92	114,44	123,79	7	3	17	3	6	5
LV	427,51	318,83	58,19	1398,72	572,43	389,7	28	30	9	28	30	26
MT	247,89	273,04	52,22	479,88	254,88	225,79	20	29	5	16	17	13
NL	154,07	116,5	152,21	319,9	186,6	197,53	9	12	22	4	13	12
NO	198,48	130,19	182,7	453,69	182,12	252,96	15	14	27	13	11	17
PL	185,93	174,99	93,77	500,87	273,03	236,38	14	22	14	18	22	15
PT	124,9	142,16	29,76	411,71	188,24	144,51	2	17	2	11	14	7
RO	667,28	174,3	260,15	2049,68	317,44	770,02	30	21	28	30	24	30
SE	237,27	158,72	136,34	557,13	271,99	146,64	19	18	20	20	21	8
SI	158,9	64,12	49,28	377,65	105,5	107,68	10	4	4	9	4	2
SK	300,1	133,01	97,86	799,48	186,44	336,01	24	15	16	25	12	24
UK	269,62	82,57	177,02	533,3	97,43	251,41	22	8	26	19	1	16

Learning effects

The most prevalent conditions were high blood pressure and diabetes. The most common causes of death were ischaemic heart disease, cerebrovascular disease, lung cancer, and external causes of death. To ensure adequate representation of the countries included in the study, we selected three post-2004 Member States (Hungary, Lithuania, and Bulgaria) and two pre-2004 Member States (Germany and Finland) for further analysis.

We tested for the effect of the passage of time (2011-2017) on the age-standardised cerebrovascular mortality rate while controlling for various factors using a generalised linear model. We fit three sets of models. In the first set, we tested for the association between the avoidable mortality rate and time while controlling for sex, age-group, mortality rate in 2011, and Member State. In the second, we also controlled for the proportion of population reporting the prevalence of high blood pressure in 2014. In the final model, we also controlled for the economic variables. In all models, the baseline group are Bulgarian women.

Table 7a. Regression results using cerebrovascular mortality rate as the outcome.

Predictor	*b*	*b* *[95% CI]*	*Goodness of Fit*
(Intercept)	2660.65	[1971.23, 3350.07]	
Time	-1.32	[-1.66, -0.98]	
Germany (dummy)	1.64	[-3.85, 7.13]	
Finland (dummy)	1.69	[-4.46, 7.85]	
Hungary (dummy)	-3.60	[-7.45, 0.24]	
Lithuania (dummy)	-1.72	[-4.78, 1.33]	
Sex: Male	-1.93	[-4.89, 1.04]	
Mortality rate in 2011	1.01	[0.92, 1.09]	
(Intercept)	2659.13	[1963.49, 3354.77]	
Time	-1.32	[-1.67, -0.98]	
Germany (dummy)	2.11	[-7.39, 11.61]	
Finland (dummy)	2.36	[-10.17, 14.88]	
Hungary (dummy)	-3.45	[-8.01, 1.10]	
Lithuania (dummy)	-1.44	[-7.05, 4.17]	
Sex: Male	-2.13	[-6.62, 2.36]	
Mortality rate in 2011	1.01	[0.86, 1.17]	
Prevalence	3.77	[-58.29, 65.84]	R^2 = .992
(Intercept)	2791.24	[1073.71, 4508.76]	
Time	-1.39	[-2.25, -0.53]	
Germany (dummy)	-9.42	[-37.79, 18.95]	
Finland (dummy)	1.91	[-22.47, 26.29]	
Hungary (dummy)	-0.19	[-7.98, 7.61]	
Lithuania (dummy)	5.11	[-4.99, 15.22]	
Sex: Male	-2.13	[-6.26, 2.00]	
Mortality rate in 2011	1.01	[0.87, 1.16]	
Prevalence	3.77	[-53.29, 60.84]	
GDP per capita	-0.00	[-0.00, -0.00]	
Health spending	0.02	[0.01, 0.02]	R^2 = .993

Cerebrovascular mortality rates have decreased over time in all models. The rate of decrease was slow but significantly different from zero in all of the models. Likewise, there was a weak but significant positive association between the mortality rate and health spending in the same year.

For additional context, we performed a similar analysis of cancer mortality rates. We used the same countries, ages, and year groups as the sample. However, we did not control for disease prevalence in this case due to lack of data.

Table 7b. Regression results using cancer mortality rate as the outcome.			
Predictor	*b*	*b* *[95% CI]*	*Goodness of Fit*
(Intercept)	3367.94	[2269.63, 4466.25]	
Time	-1.67	[-2.21, -1.12]	
Germany (dummy)	-1.06	[-7.77, 5.65]	
Finland (dummy)	-6.33	[-10.74, -1.92]	
Hungary (dummy)	-2.33	[-8.57, 3.90]	
Lithuania (dummy)	-4.68	[-8.36, -1.00]	
Sex: Male	0.92	[-4.87, 6.71]	
Mortality rate in 2011	0.91	[0.83, 0.98]	R^2 = .994
(Intercept)	2474.84	[-510.29, 5459.97]	
Time	-1.22	[-2.71, 0.28]	
Germany (dummy)	11.52	[-35.89, 58.94]	
Finland (dummy)	6.03	[-31.59, 43.65]	
Hungary (dummy)	2.08	[-10.98, 15.14]	
Lithuania (dummy)	1.40	[-14.15, 16.96]	
Sex: Male	0.92	[-4.94, 6.77]	
Mortality rate in 2011	0.91	[0.83, 0.98]	
GDP per capita	-0.00	[-0.00, 0.00]	
Health spending	0.00	[-0.01, 0.02]	R^2 = .994

Cancer mortality rates have decreased over time in both models. The rate of decrease was statistically significant in the first model. However, the time coefficient was no longer significantly different from zero after controlling for economic variables.

Avoidable burden of disease

For adjustment in terms of burden of disease outcomes, we calculated three age-adjusted indicators: avoidable YLL, avoidable YLD, and avoidable DALYs per 100,000 population (Tables 8a-8f). We use the term avoidable because the calculations do not include all premature deaths, but only those considered avoidable through healthcare activities.

Table 8a. Avoidable disability adjusted life years (DALYs) per 100 000.

Country	Treatable DALYs - Women	Treatable DALYs - Men	Adjusted rank (DALYs) - Women	Adjusted rank (DALYs) - Men
AT	7052,14	12045,37	12	14
BE	7457,74	12438,89	17	16
BG	12183,52	23710,11	30	28
HR	9173,52	18155,78	22	22
CY	6653,93	12303,45	5	15
CZ	9001,19	17317,58	21	21
DK	7808,87	11684,41	20	12
EE	9481,57	21492,68	23	25
FI	6990,46	12996,09	10	18
FR	6239,17	11541,64	3	11
DE	6963,29	11804,66	9	13
EL	6707,32	13094,17	7	19
HU	11657,51	22368,48	28	26
IS	6269,93	10034,6	4	3
IE	7070,96	11099,97	13	9
IT	5624,01	9663,83	2	1
LV	11761,9	27301,83	29	29
LT	11297,24	28497,73	26	30
LU	7404,97	11020,32	16	7
MT	7027,65	11048,57	11	8
NL	7316,76	9917,33	15	2
NO	7190,43	10998,18	14	6
PL	9726,9	20765,85	25	24
PT	6680,97	12576,96	6	17
RO	11378,89	22625,57	27	27
SK	9659,48	20339,9	24	23
SI	7696,5	14755,99	18	20
ES	5568,51	10530,18	1	5
SE	6957,91	10083,01	8	4
UK	7733,72	11119	19	10
Mean	8124,57	15111,07		
Median	7360,86	12371,17		
IQR	2445,3	8732,45		
Coefficient of variation	0,23	0,36		
Gini index	0,13	0,19		
Theil index	0,03	0,06		

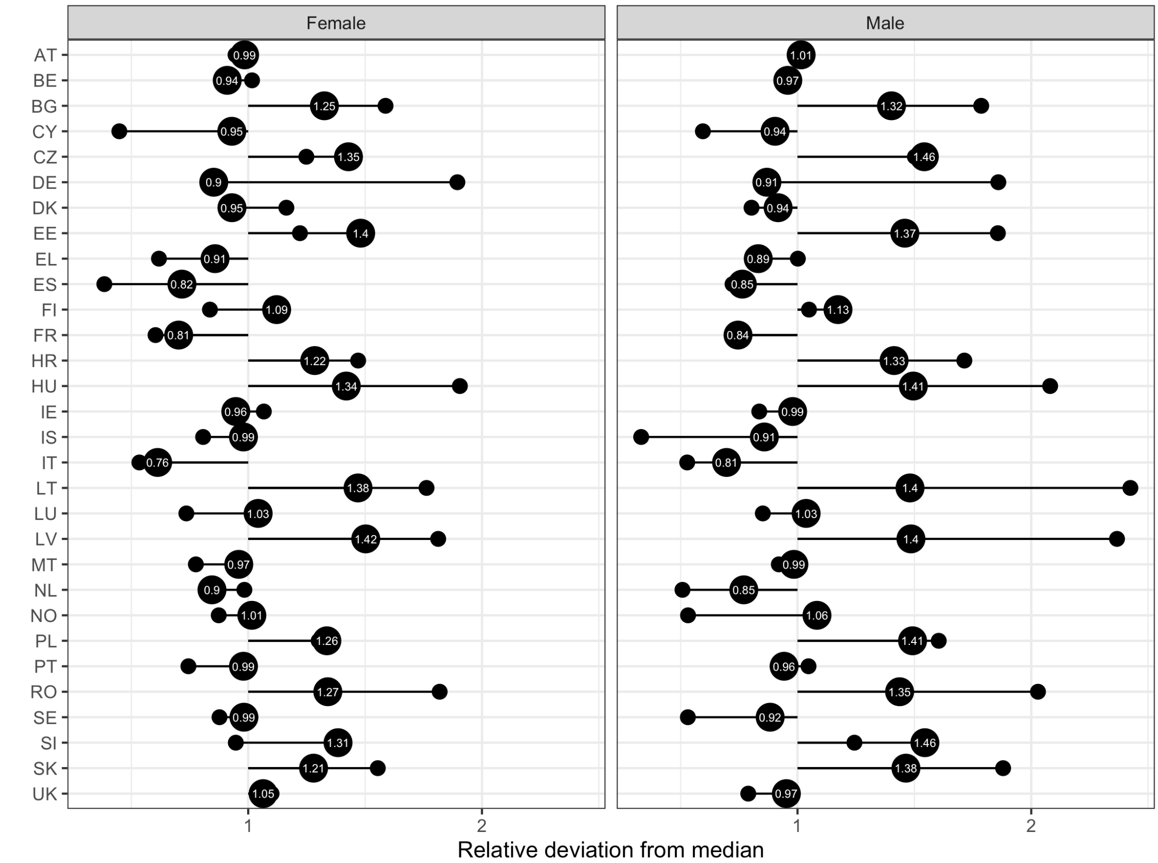

Figure 6 Relative deviation from EU median. Baseline deviation is represented by the small circle. The avoidable DALYs based deviation is represented by the larger circle.

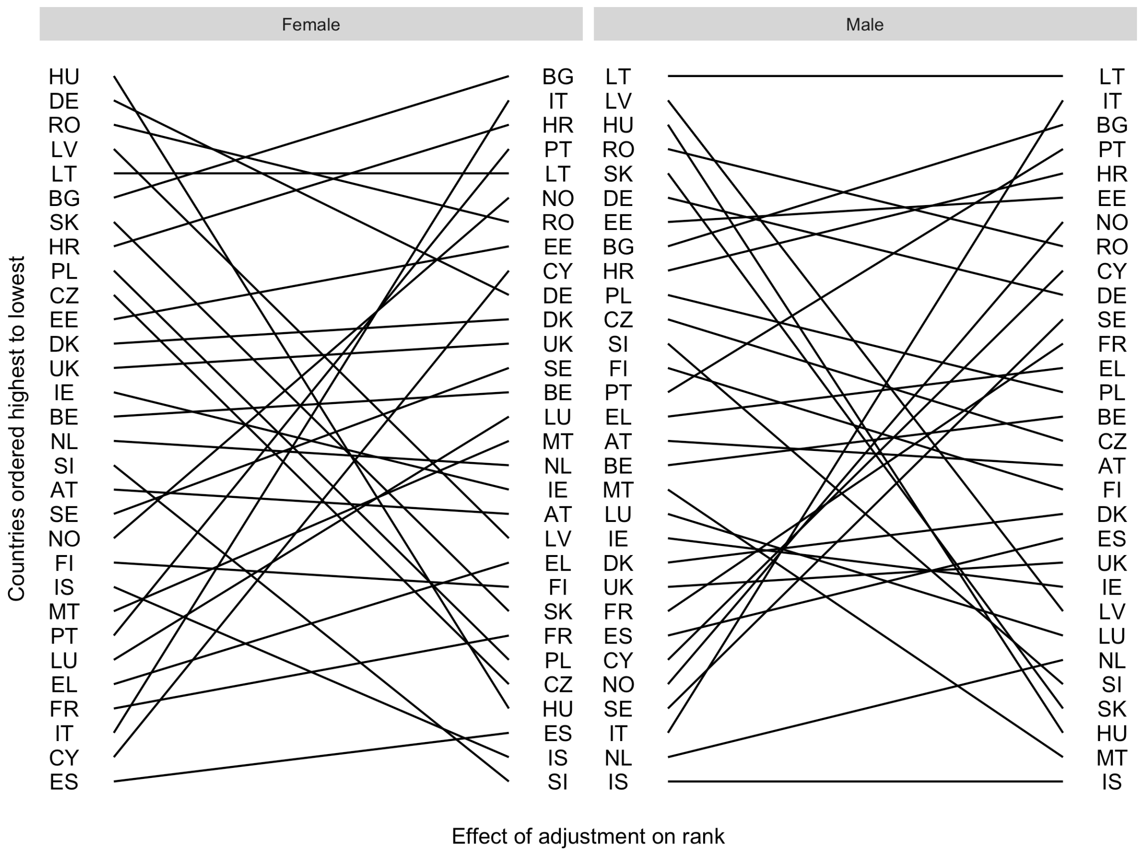

Figure 7 Effect of the avoidable DALYs based adjustment on rank.

Table 8b. DALYs per 100 000 and country ranks for selected disease categories

Country	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)
AT	1996,54	976,41	4079,2	2581,35	2407	7057,03	9	12	13	9	14	17
BE	2248,04	951,54	4258,16	3096,63	2112,51	7229,75	19	10	16	15	8	18
BG	2571,35	4313,2	5298,97	4139,09	10016,93	9554,09	26	30	26	23	30	23
CY	2386,65	2100,39	4686,49	4312,3	5004,92	8838,56	24	24	21	26	22	20
CZ	1719,31	1122,95	3811,68	2363,64	3386	6553,81	3	18	8	8	19	13
DE	2080,71	1835,45	5085,03	3361,07	4589,06	9367,45	14	22	24	19	21	22
DK	2644,17	865,39	4299,31	2700,33	1981,92	7002,16	27	6	17	12	5	16
EE	2029,66	1815,12	5636,79	3889,47	5565,43	12037,78	12	21	27	22	24	28
EL	1640,53	1024,78	4325,15	1836,53	3075,73	8083,83	1	15	18	2	18	19
ES	2072,84	655,75	3510,58	3434,23	1683,3	6424,11	13	1	3	21	1	12
FI	2147,24	1030,38	3785,66	2797,78	2588,16	6418,72	17	16	7	14	16	11
FR	1795,25	1345,14	3566,93	3180,35	3822,66	6091,15	5	20	4	17	20	6
HR	3303,96	2709,81	5643,74	5678,89	6548,13	10141,46	30	26	28	30	26	25
HU	1909,41	681,23	3679,29	2004,83	2206,91	5822,86	8	2	5	3	9	4
IE	2263,68	957,14	3850,15	2307,25	2385,59	6407,13	20	11	9	6	13	10
IS	1872,9	739,47	3011,64	2611,15	1828,06	5224,62	7	4	1	10	3	1
IT	2168,17	3387,8	6205,93	4319,04	9591,16	13391,62	18	28	30	27	29	29
LT	2099,34	3078,84	6119,06	4309,57	9036,38	15151,78	15	27	29	24	28	30
LU	2279,88	888,92	4236,17	2658,85	1982,24	6379,23	21	8	15	11	6	8
LV	1795,35	1331,58	3900,72	2135,39	2745,26	6167,92	6	19	10	5	17	7
MT	2716,58	865,37	3734,81	2785,65	1718,14	5413,53	29	5	6	13	2	2
NL	2127,14	867,13	4196,16	2038,05	2071,29	6888,84	16	7	14	4	7	14
NO	2646,95	2043,96	5035,99	4384,27	5485,43	10896,15	28	23	23	28	23	27
PL	1753	945,89	3982,09	3366,44	2298,26	6912,25	4	9	12	20	11	15
PT	2530,86	3611,28	5236,75	4658,66	7519,06	10447,85	25	29	25	29	27	26
RO	2301,04	2513,54	4844,9	4311,33	6237,97	9790,6	22	25	22	25	25	24
SE	1998,71	1020,48	4677,3	3286,28	2581,1	8888,6	10	14	20	18	15	21
SI	1654,76	734,36	3179,39	3150,94	1964,75	5414,48	2	3	2	16	4	3
SK	2024,53	991,08	3942,29	1697,26	2296,4	6089,36	11	13	11	1	10	5
UK	2320,15	1032,32	4381,25	2344,85	2379,85	6394,3	23	17	19	7	12	9

Table 8c. Avoidable years lived in disability (YLD) per 100 000.

Country	Treatable YLD - Women	Treatable YLD - Men	Adjusted rank (YLD) - Women	Adjusted rank (YLD) - Men
AT	3076,91	4097,94	15	16
BE	2922,51	3939,09	7	13
BG	3898,57	5357,36	22	20
HR	3788,72	5398,31	21	21
CY	2962,39	3793,16	8	9
CZ	4187,17	5904,92	27	29
DK	2963,84	3827,51	9	10
EE	4341,41	5573,74	29	23
FI	3383,91	4571,12	19	19
FR	2530,72	3398,49	2	2
DE	2808,1	3702,26	5	7
EL	2818,85	3608,57	6	5
HU	4160,15	5715,55	26	28
IS	3066,6	3674,42	12	6
IE	2997,77	3996,05	10	14
IT	2377,65	3284,97	1	1
LV	4407,34	5675,47	30	26
LT	4307,44	5659,46	28	25
LU	3203,06	4159,27	17	17
MT	3024,23	4010,71	11	15
NL	2793,31	3457,25	4	4
NO	3143,77	4294,96	16	18
PL	3927,26	5702,5	23	27
PT	3066,85	3895,89	13	11
RO	3938,44	5487,92	24	22
SK	3775,37	5591,57	20	24
SI	4059,64	5915,04	25	30
ES	2555,18	3442,26	3	3
SE	3070,86	3738,29	14	8
UK	3250,95	3922,41	18	12
Mean	3360,3	4493,22		
Median	3110,34	4054,32		
IQR	957,34	1800,28		
Coefficient of variation	0,18	0,2		
Gini index	0,1	0,11		
Theil index	0,02	0,02		

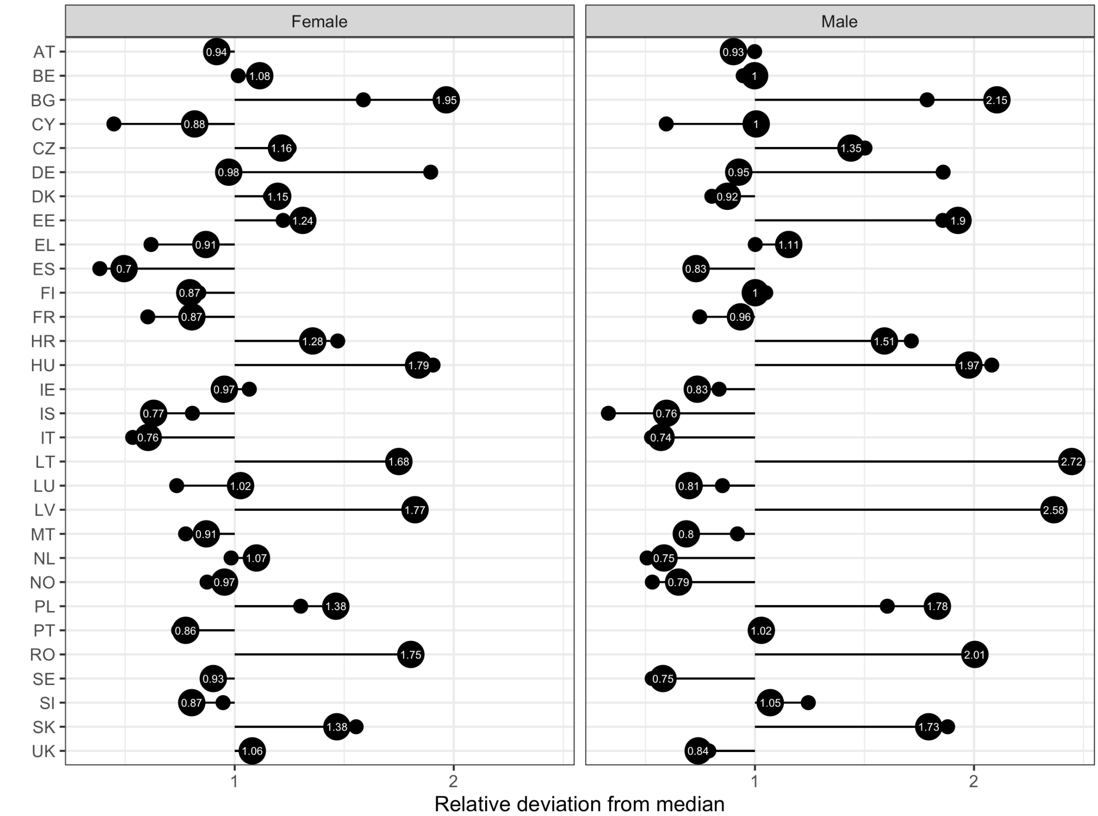

Figure 8 Relative deviation from EU median. Baseline deviation is represented by the small circle. The avoidable YLD based deviation is represented by the larger circle.

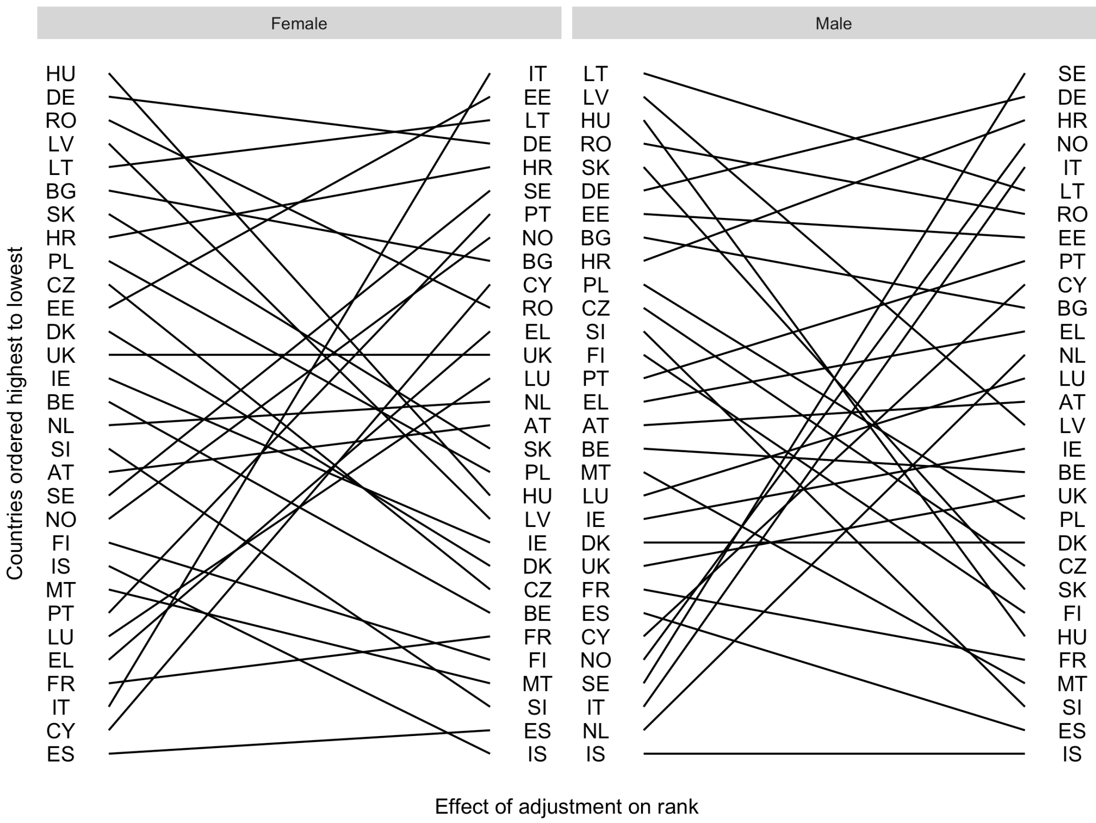

Figure 9 Effect of the avoidable YLD based adjustment on rank.

Table 8d. YLDs per 100 000 and country ranks for selected disease categories

Country	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)
AT	135,33	208,23	2733,35	89,66	250,22	3758,07	14	16	13	14	16	16
BE	156,66	185,74	2580,11	94,03	215,73	3629,32	21	9	7	17	4	13
BG	122,6	512,63	3263,34	81,48	584,15	4691,72	5	28	21	7	29	20
CY	139,46	381,41	3267,84	105,11	456,52	4836,68	15	22	22	25	24	21
CZ	145,11	184,55	2632,73	78,45	226,8	3487,9	20	6	9	5	11	9
DE	125,25	402,05	3659,88	98,56	444,74	5361,62	9	23	27	20	22	29
DK	180,91	191,32	2591,61	103,83	228,98	3494,7	28	12	8	24	12	10
EE	124,77	429,16	3787,48	90,09	456,42	5027,22	7	25	30	15	23	25
EL	144,01	235,59	3004,31	71,23	279,41	4220,47	18	18	19	1	17	19
ES	144,34	164,74	2221,65	100,31	203,31	3094,87	19	2	2	23	2	2
FI	160,03	202,84	2445,23	100,12	238,96	3363,18	22	15	5	22	14	7
FR	128,42	201,84	2488,6	88,81	242,02	3277,75	12	14	6	13	15	5
HR	126,56	437,8	3595,79	110,46	536,03	5069,06	10	26	25	27	28	27
HU	143,72	170,54	2752,34	88,09	223,7	3362,64	17	3	14	11	8	6
IE	163,58	182,37	2651,82	83,93	225,29	3686,82	25	5	10	9	9	14
IS	160,81	142,78	2074,05	105,69	185,57	2993,72	23	1	1	26	1	1
IT	115,18	536,57	3755,58	87,07	603,4	4985	4	30	29	10	30	24
LT	107,81	519,7	3679,92	82,25	533,98	5043,23	2	29	28	8	26	26
LU	186,46	180	2836,6	98,57	217,49	3843,21	29	4	17	21	6	17
LV	140,47	185,69	2698,08	74,34	226,5	3709,87	16	8	12	2	10	15
MT	200,01	195,37	2397,92	111,19	229,89	3116,17	30	13	4	28	13	4
NL	165,75	213,73	2764,29	95,6	292,44	3906,91	26	17	16	19	19	18
NO	109,35	368,87	3449,03	75,16	421,43	5205,91	3	21	24	3	21	28
PL	124,85	185,92	2756,07	94,83	221,52	3579,54	8	11	15	18	7	11
PT	103,58	509,05	3325,81	80,99	535,51	4871,41	1	27	23	6	27	22
RO	129,66	423,74	3221,97	115,72	501,98	4973,87	13	24	20	29	25	23
SE	123,24	303,53	3632,87	91,17	335,12	5488,75	6	20	26	16	20	30
SI	127,48	185,84	2241,85	116,45	217,3	3108,51	11	10	3	30	5	3
SK	163,04	239,45	2668,37	76,6	283,13	3378,57	24	19	11	4	18	8
UK	169,49	185,08	2896,38	88,39	211,9	3622,12	27	7	18	12	3	12

Table 8e. Avoidable years of life lost (YLL) per 100 000.

Country	Treatable YLL - Women	Treatable YLL - Men	Adjusted rank (YLL) - Women	Adjusted rank (YLL) - Men
AT	3817,09	7747,98	12	12
BE	4373,17	8284,07	19	15
BG	7891,44	17833,05	30	28
HR	5171,4	12493,43	23	22
CY	3559,72	8325,8	8	17
CZ	4685,16	11236,65	21	21
DK	4629,05	7600,2	20	11
EE	5011,46	15766,89	22	25
FI	3504,59	8302,1	5	16
FR	3528,21	7921,47	7	14
DE	3964,56	7878,32	15	13
EL	3688,28	9228,77	9	20
HU	7229,13	16319,42	29	26
IS	3126,5	6269,28	3	4
IE	3910,17	6909,8	13	9
IT	3072,72	6161,27	2	1
LV	7148,59	21354,91	28	29
LT	6791,99	22596,99	26	30
LU	4115,96	6733,62	16	7
MT	3693,01	6674,14	10	6
NL	4327,71	6219,4	18	3
NO	3911,93	6513,41	14	5
PL	5563,36	14771,18	24	24
PT	3460,24	8462,39	4	18
RO	7054,02	16631,23	27	27
SK	5582,57	14372,25	25	23
SI	3526,89	8704,39	6	19
ES	2846,91	6883,2	1	8
SE	3775,68	6199,53	11	2
UK	4271,53	6929,8	17	10
Mean	4574,43	10377,5		
Median	4040,26	8293,08		
IQR	1539,55	7012,7		
Coefficient of variation	0,3	0,45		
Gini index	0,16	0,23		
Theil index	0,04	0,09		

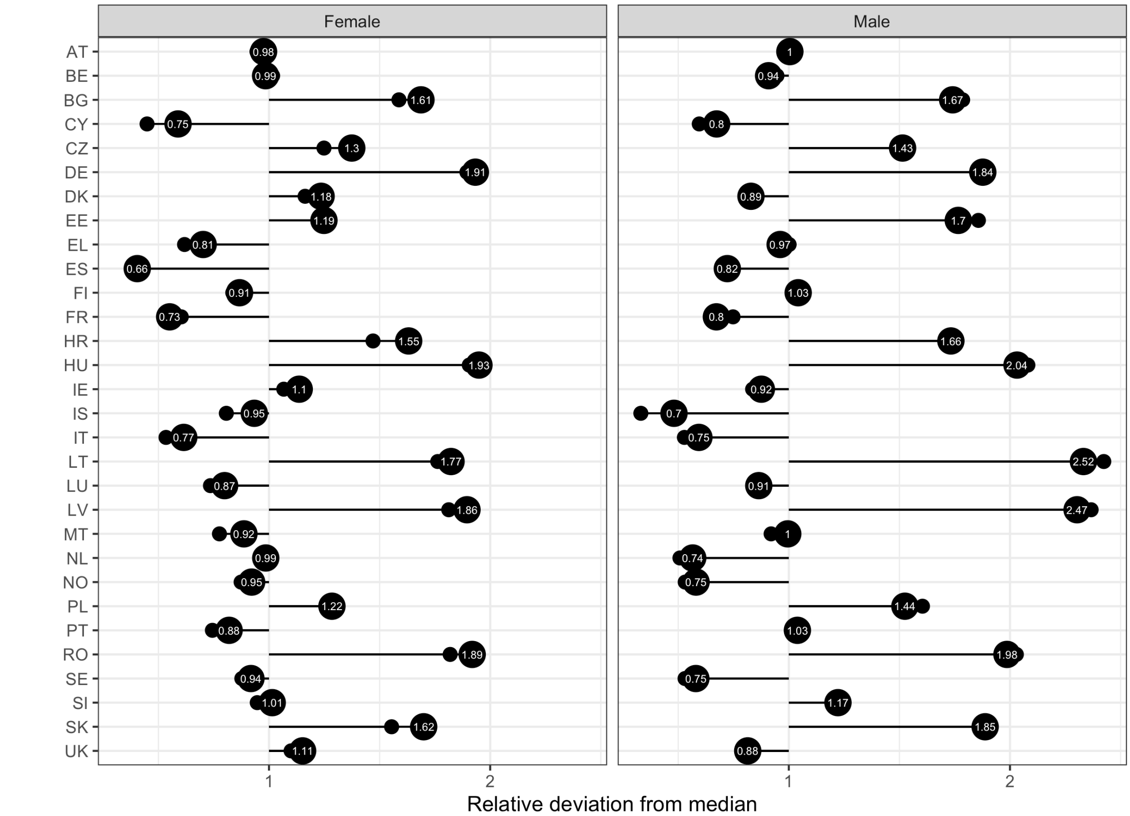

Figure 10 Relative deviation from EU median. Baseline deviation is represented by the small circle. The avoidable YLL based deviation is represented by the larger circle.

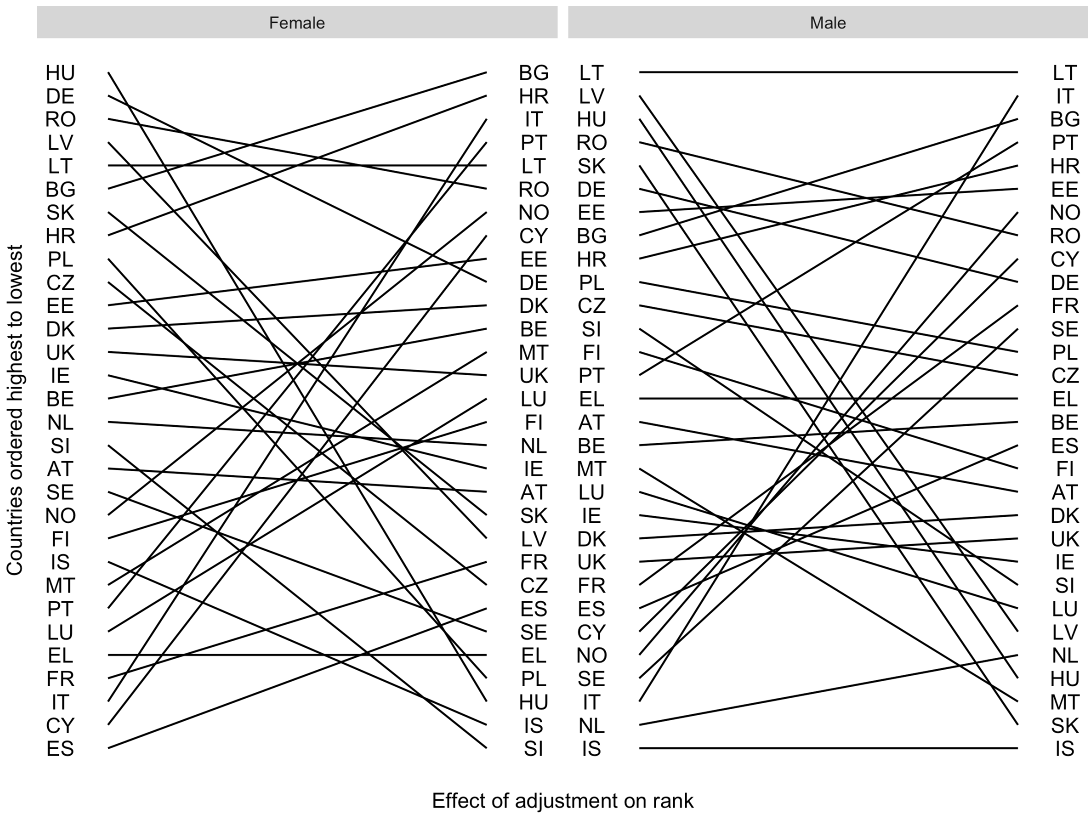

Figure 11 Effect of the avoidable YLL based adjustment on rank.

Table 8f. YLLs per 100 000 and country ranks for selected disease categories												
Country	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)
AT	1861,2	767,93	1187,96	2491,68	2156,51	3099,78	9	13	14	9	12	14
BE	2091,37	765,39	1516,41	3002,59	1896,12	3385,37	19	12	24	15	8	19
BG	2448,73	3798,38	1644,33	4057,58	9429,81	4345,66	26	30	26	23	30	23
CY	2247,17	1717,62	1206,6	4207,18	4547,05	3739,2	24	24	15	25	22	20
CZ	1574,19	937,98	1047,55	2285,19	3158,75	2881,86	3	18	8	8	19	13
DE	1955,46	1433,23	1296,47	3262,5	4144,09	3830,06	14	22	18	19	21	22
DK	2463,24	673,96	1491,84	2596,49	1752,85	3250,86	27	7	23	12	5	17
EE	1904,89	1385,91	1720,67	3799,36	5108,94	6858,6	12	21	27	22	24	28
EL	1496,51	788,9	1219,18	1765,28	2795,92	3740,9	1	15	16	2	18	21
ES	1928,49	490,45	1109,27	3333,9	1479,3	3108,27	13	1	10	21	1	15
FI	1987,21	827,34	1150,02	2697,65	2348,97	2831,7	16	16	12	14	16	12
FR	1666,81	1143,11	878,36	3091,53	3580,38	2556,86	6	19	4	17	20	9
HR	3177,39	2271,81	1779,93	5568,42	6011,9	4739,1	30	26	28	30	26	25
HU	1765,69	510,45	850,37	1916,73	1982,81	2369,73	8	2	3	3	9	5
IE	2100,09	774,58	1035,5	2223,31	2159,97	2526,52	21	14	7	6	13	8
IS	1712,08	596,15	764,49	2505,45	1641,67	2014,14	7	4	1	10	3	1
IT	2052,97	2851,18	2244,43	4231,96	8987,71	8135,24	18	28	30	27	29	29
LT	1991,52	2559,06	2241,41	4227,31	8502,33	9867,34	17	27	29	26	28	30
LU	2093,42	708,68	1313,86	2560,27	1764,35	2409	20	8	20	11	6	6
LV	1654,88	1144,96	893,16	2061,03	2517,44	2095,67	5	20	5	5	17	3
MT	2516,55	669,67	1141,49	2674,45	1487,83	2057,12	28	6	11	13	2	2
NL	1961,38	653,1	1297,44	1942,43	1778,58	2792,4	15	5	19	4	7	11
NO	2537,59	1674,62	1351,15	4309,09	5063,31	5398,78	29	23	22	28	23	27
PL	1628,14	759,65	1072,45	3271,59	2076,08	3114,73	4	11	9	20	11	16
PT	2427,27	3101,9	1524,85	4577,65	6983,08	5070,5	25	29	25	29	27	26
RO	2171,38	2089,6	1321,59	4195,61	5735,37	4441,27	23	25	21	24	25	24
SE	1875,47	716,57	934,86	3195,11	2245,76	3263,52	11	9	6	18	15	18
SI	1527,26	547,56	772,08	3034,48	1746,4	2102,32	2	3	2	16	4	4
SK	1861,48	751,39	1162,81	1620,65	2013,08	2565,81	10	10	13	1	10	10
UK	2150,65	846,9	1273,98	2256,45	2167,56	2505,8	22	17	17	7	14	7

Different age thresholds to define avoidable deaths

For adjustment in terms of alternative age thresholds, we tested several different scenarios. The first scenario was one without age thresholds (i.e. all deaths due to the specified causes of death were considered avoidable) (Table 9a and 9b). The second considered updating the age ranges to 0-79 in causes with a current range 0-74 to reflect better the current mortality conditions in the European Union (Table 9c and 9d). The third is sex-specific age ranges, 0-84 in women and 0-79 in men (Table 9e and 9f), which better reflects sex differences in life expectancy.

Table 9a. Avoidable mortality with no age limit

Country	Avoidable mortality rate (women)	Avoidable mortality rate (men)	Country rank (women)	Country rank (men)
AT	460,31	765,99	16	16
BE	391,26	673,1	7	11
BG	678,06	1103,97	23	22
HR	388,76	625,84	6	7
CY	652,15	1073,13	22	21
CZ	856,66	1413,03	29	28
DK	475,33	682,74	18	13
EE	518,64	1122,08	21	23
FI	382,36	660,26	5	9
FR	295,68	608,19	2	6
DE	417,68	756,36	11	15
EL	291,57	552,4	1	1
HU	754,67	1222,28	24	24
IS	800,75	1365	27	27
IE	498,19	742,31	20	14
IT	430,19	587,96	13	3
LV	373,9	631,28	4	8
LT	862,11	1669,72	30	30
LU	363,13	666,66	3	10
MT	837,62	1590,28	28	29
NL	480,86	809,33	19	18
NO	397,54	584,93	8	2
PL	414,43	606,82	10	5
PT	455,43	891,28	15	20
RO	418,07	770,57	12	17
SK	786,48	1290,05	26	25
SI	407,45	602,02	9	4
ES	442,21	837,84	14	19
SE	771,04	1318,03	25	26
UK	461,07	674,08	17	12
Mean	525,45	896,58		
Median	457,87	761,18		
IQR	271,56	479,03		
Coefficient of variation	0,34	0,36		
Gini index	0,18	0,19		
Theil index	0,05	0,06		

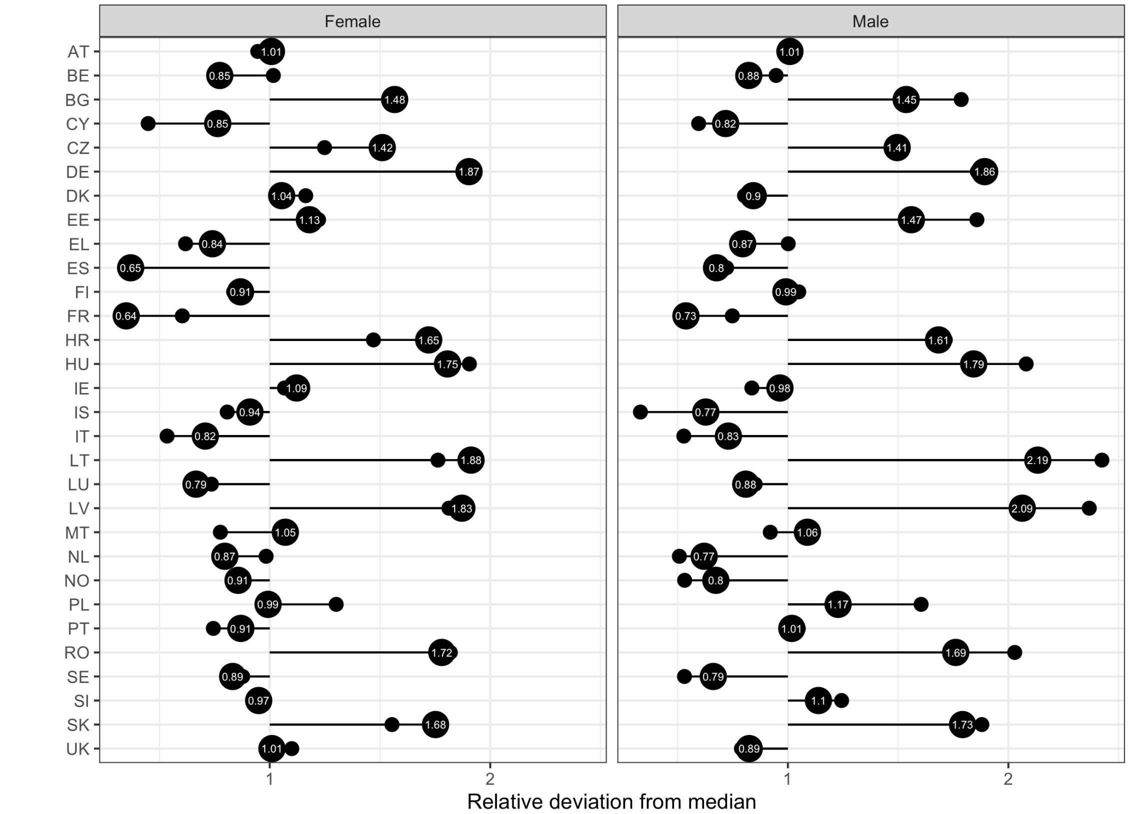

Figure 12 Relative deviation from EU median. Baseline deviation is represented by the small circle. The no age threshold deviation is represented by the larger circle.

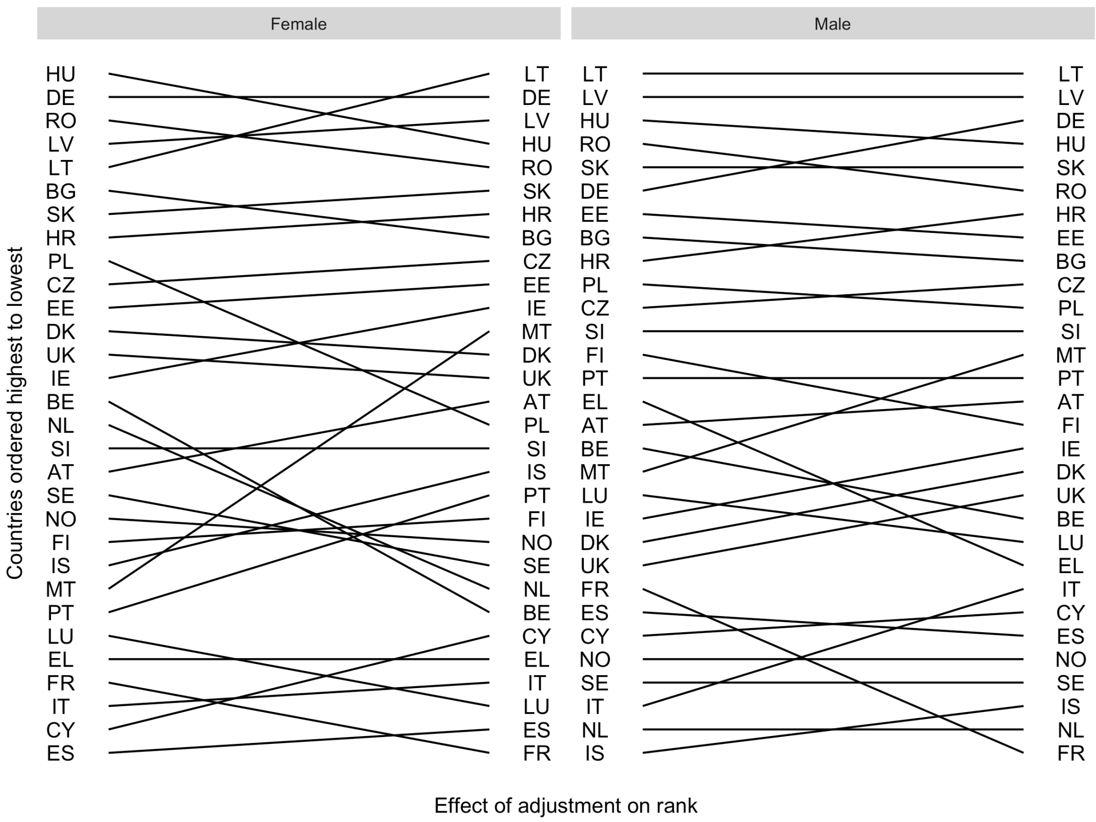

Figure 13 Effect of the no age threshold adjustment on rank.

Table 9b. Mortality and country ranks with no age limit for selected disease categories

Country	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)
AT	132,67	191,71	135,94	196,81	300,41	268,78	11	18	17	6	18	16
BE	137,33	105,39	148,54	220,38	173,7	279,03	14	4	21	13	4	18
BG	125,65	449,12	103,28	218,37	636,69	248,91	10	26	7	12	25	12
CY	94,08	143,72	150,96	168,28	229,78	227,78	1	8	23	3	10	9
CZ	138,95	363,09	150,1	237,92	523,8	311,42	15	23	22	19	23	20
DE	273,48	322,31	260,87	408,36	521,73	482,95	30	22	30	30	22	30
DK	183,6	120,8	170,94	221,09	187,34	274,32	28	6	29	14	6	17
EE	143,64	280,75	94,25	299,57	489,65	332,86	18	21	4	26	21	23
EL	113,95	186,87	81,54	230,06	262,64	167,55	3	17	1	17	14	2
ES	105,97	97,14	92,57	231,92	164,14	212,12	2	2	3	18	3	7
FI	114,01	215,05	88,63	164,76	365,01	226,59	4	19	2	2	20	8
FR	122,07	72,34	97,16	216,71	126,26	209,43	7	1	5	9	1	6
HR	174,75	424,22	155,69	318,46	569,35	334,46	26	24	26	28	24	24
HU	197,89	446,8	156,06	347,01	658,63	359,35	29	25	27	29	27	26
IE	182,49	172,76	142,94	218,29	269,05	254,96	27	15	20	11	15	15
IS	161,8	146,61	121,78	171,35	255,07	161,54	24	12	11	4	13	1
IT	124,97	145,83	103,1	218,13	217,73	195,42	9	10	6	10	8	3
LT	124,8	612,77	124,54	282,11	925,53	462,08	8	30	13	24	30	29
LU	132,95	101,18	128,99	239,02	175,42	252,22	13	3	15	20	5	13
LV	142,65	567,3	127,67	303,06	894,12	393,09	17	29	14	27	29	28
MT	119,6	248,98	112,28	212,66	343,42	253,25	6	20	8	8	19	14
NL	161,3	107,06	129,19	222,33	154,82	207,78	23	5	16	15	2	5
NO	147,4	127,88	139,15	176,35	194,78	235,69	19	7	19	5	7	11
PL	150,4	184,62	120,4	277,3	299,3	314,67	20	16	10	23	17	21
PT	116,95	146,53	154,59	229,71	223,27	317,6	5	11	25	16	9	22
RO	139,52	509,63	137,33	263,28	689,95	336,82	16	28	18	21	28	25
SE	132,83	156,52	118,09	148,92	249,28	203,82	12	13	9	1	12	4
SI	155,01	163,48	123,73	272,11	269,32	296,42	21	14	12	22	16	19
SK	159,54	452,07	159,43	297,4	649,62	371,01	22	27	28	25	26	27
UK	162,37	144,77	153,93	204,87	236,74	232,47	25	9	24	7	11	10

Table 9c. Avoidable mortality with higher age limit (0-79)

Country	Avoidable mortality rate (women)	Avoidable mortality rate (men)	Country rank (women)	Country rank (men)
AT	203,38	414,21	13	16
BE	204,68	387,51	14	13
BG	333,09	689,9	24	23
HR	155,57	329,28	3	7
CY	268,16	589,71	22	20
CZ	395	758,21	29	25
DK	243,58	366,69	19	10
EE	245,77	702,17	20	24
FI	168,31	401,78	5	14
FR	136,91	340,5	1	8
DE	188,63	425,15	8	18
EL	151,54	329,01	2	6
HU	320,5	686,09	23	22
IS	399,48	844,08	30	28
IE	227,43	378,82	17	12
IT	197,57	288,08	12	1
LV	158,38	311,47	4	5
LT	365,99	1039,4	26	30
LU	180,02	375,76	6	11
MT	384,78	1018,91	27	29
NL	191,25	411,48	9	15
NO	204,79	305,49	15	2
PL	195,92	308,71	11	4
PT	251,99	593,97	21	21
RO	182,57	424,1	7	17
SK	391,07	817,86	28	27
SI	195,49	308,52	10	3
ES	208,99	481,61	16	19
SE	335,92	763,83	25	26
UK	229,87	362,96	18	9
Mean	243,89	515,18		
Median	206,89	412,85		
IQR	118,13	342,83		
Coefficient of variation	0,33	0,42		
Gini index	0,18	0,23		
Theil index	0,05	0,08		

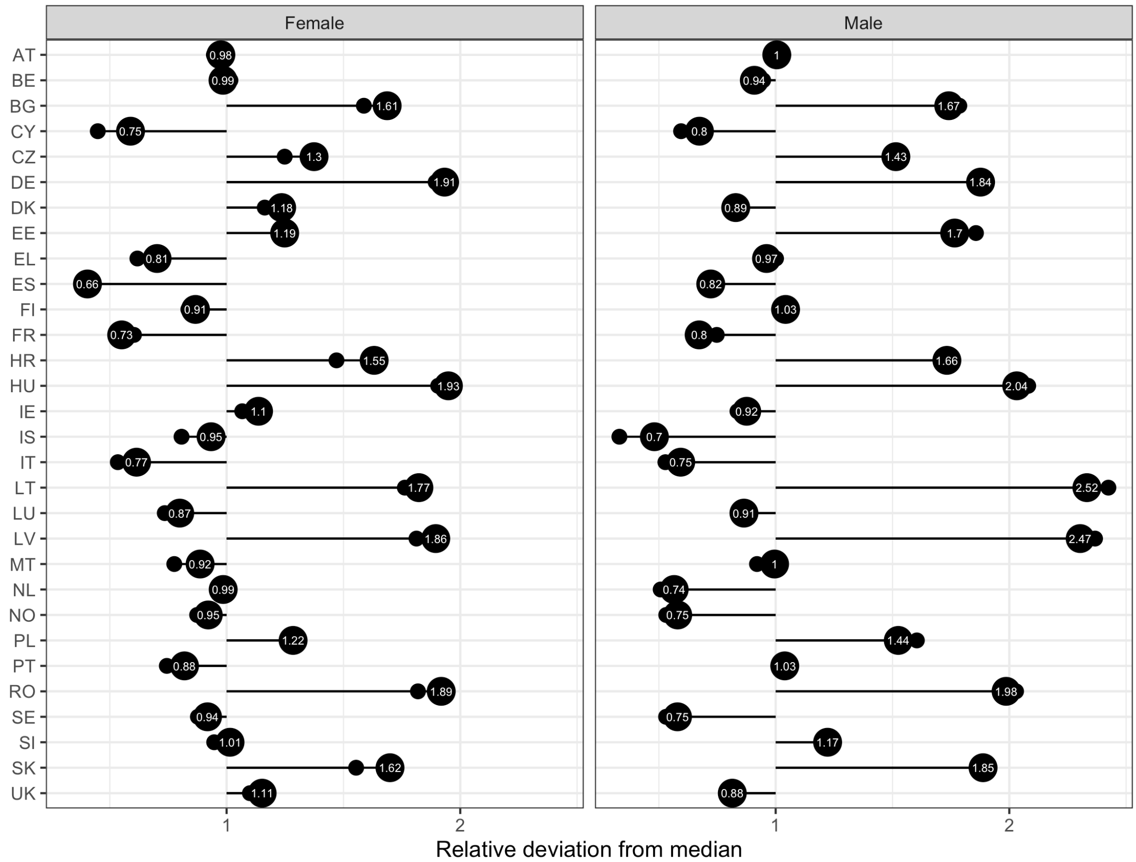

Figure 14 Relative deviation from EU median. Baseline deviation is represented by the small circle. The higher age threshold deviation is represented by the larger circle.

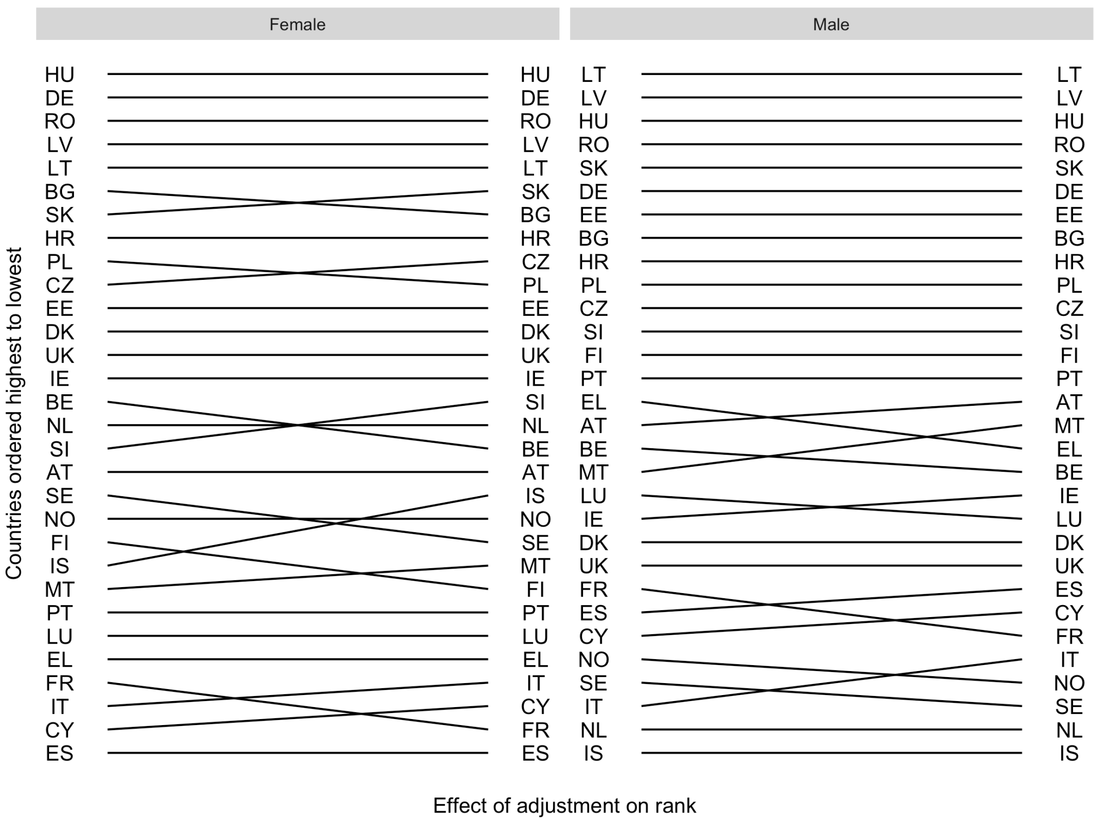

Figure 15 Effect of the higher age threshold adjustment on rank.

Table 9d. Mortality and country ranks with higher limit (0-79) for selected disease categories

Country	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)
AT	90,72	48,61	64,05	132,17	120,26	161,78	10	14	15	7	15	16
BE	94,8	35,6	74,29	149,5	77,85	160,16	13	7	22	14	6	15
BG	96,43	167,9	68,77	174,57	326,93	188,4	14	27	19	20	27	20
CY	63,26	41,46	50,85	118,54	104,08	106,66	1	10	6	5	12	5
CZ	97,14	95,1	75,92	173,91	218,41	197,38	15	23	23	19	22	21
DE	186,67	87,84	120,48	274,53	214,18	269,5	30	22	30	30	21	28
DK	126,86	35,64	81,08	146,78	76,78	143,13	28	8	24	12	4	13
EE	100,14	77,92	67,71	208,59	233,48	260,1	17	21	18	23	23	26
EL	75,98	52,94	39,38	162,92	133,43	105,43	4	17	2	18	17	4
ES	70,38	28,15	38,38	158,08	74,29	108,13	2	3	1	16	3	6
FI	76,79	54,14	57,69	105,4	156,16	163,59	5	18	10	2	19	18
FR	83,73	21,31	46,5	150,4	54,86	123,75	8	1	5	15	1	9
HR	119,72	128,63	72,15	228,66	257,4	200,03	26	24	20	28	24	22
HU	149,85	152,65	96,98	267,91	318,27	257,9	29	26	29	29	26	25
IE	122,07	46,93	58,43	138,45	114,57	125,8	27	13	11	9	14	11
IS	108,64	36,78	52,15	117,86	89,71	80,51	21	9	7	4	9	1
IT	83,57	35,26	39,55	141,05	77,52	92,9	7	6	3	10	5	2
LT	92,14	182,79	91,05	216,6	439,13	383,67	12	28	27	26	29	30
LU	87,93	25,69	66,4	148,78	83,56	143,42	9	2	17	13	8	14
LV	103,28	192,14	89,36	223,73	466,22	328,96	19	30	26	27	30	29
MT	75,13	75,51	40,61	138,11	140,45	132,92	3	20	4	8	18	12
NL	114,47	33,5	56,82	142,33	64,13	99,04	24	4	9	11	2	3
NO	100,11	34,32	61,49	111,85	78,06	118,8	16	5	14	3	7	8
PL	114,78	71,16	66,05	206,98	166,62	220,36	25	19	16	22	20	23
PT	77,82	44,79	59,96	158,39	102,5	163,21	6	12	12	17	11	17
RO	108,86	185,68	96,53	215,67	339,92	262,27	22	29	28	24	28	27
SE	90,81	43,32	61,36	95,71	97,89	114,91	11	11	13	1	10	7
SI	101,97	52,55	54,47	180,74	126,45	174,42	18	16	8	21	16	19
SK	110,74	141,97	83,21	215,83	298,46	249,54	23	25	25	25	25	24
UK	107,86	49,25	72,76	129,26	109,51	124,19	20	15	21	6	13	10

Table 9e. Avoidable mortality with sex-specific age limits

Country	Avoidable mortality rate (women)	Avoidable mortality rate (men)	Country rank (women)	Country rank (men)
AT	272,98	414,21	14	16
BE	259,73	387,51	11	13
BG	456,36	689,9	23	23
HR	229,77	329,28	4	7
CY	374,82	589,71	22	20
CZ	528,39	758,21	30	25
DK	320,22	366,69	19	10
EE	325,31	702,17	21	24
FI	233,12	401,78	5	14
FR	181,7	340,5	1	8
DE	251,27	425,15	8	18
EL	190,64	329,01	2	6
HU	457,93	686,09	24	22
IS	528,13	844,08	29	28
IE	304,4	378,82	18	12
IT	270,93	288,08	13	1
LV	216,59	311,47	3	5
LT	505,69	1039,4	26	30
LU	235,15	375,76	6	11
MT	522,77	1018,91	27	29
NL	273,76	411,48	15	15
NO	262,65	305,49	12	2
PL	257,64	308,71	10	4
PT	320,93	593,97	20	21
RO	248,28	424,1	7	17
SK	526,88	817,86	28	27
SI	254,05	308,52	9	3
ES	282,76	481,61	16	19
SE	475,52	763,83	25	26
UK	300,39	362,96	17	9
Mean	328,96	515,18		
Median	278,26	412,85		
IQR	184,01	342,83		
Coefficient of variation	0,34	0,42		
Gini index	0,18	0,23		
Theil index	0,05	0,08		

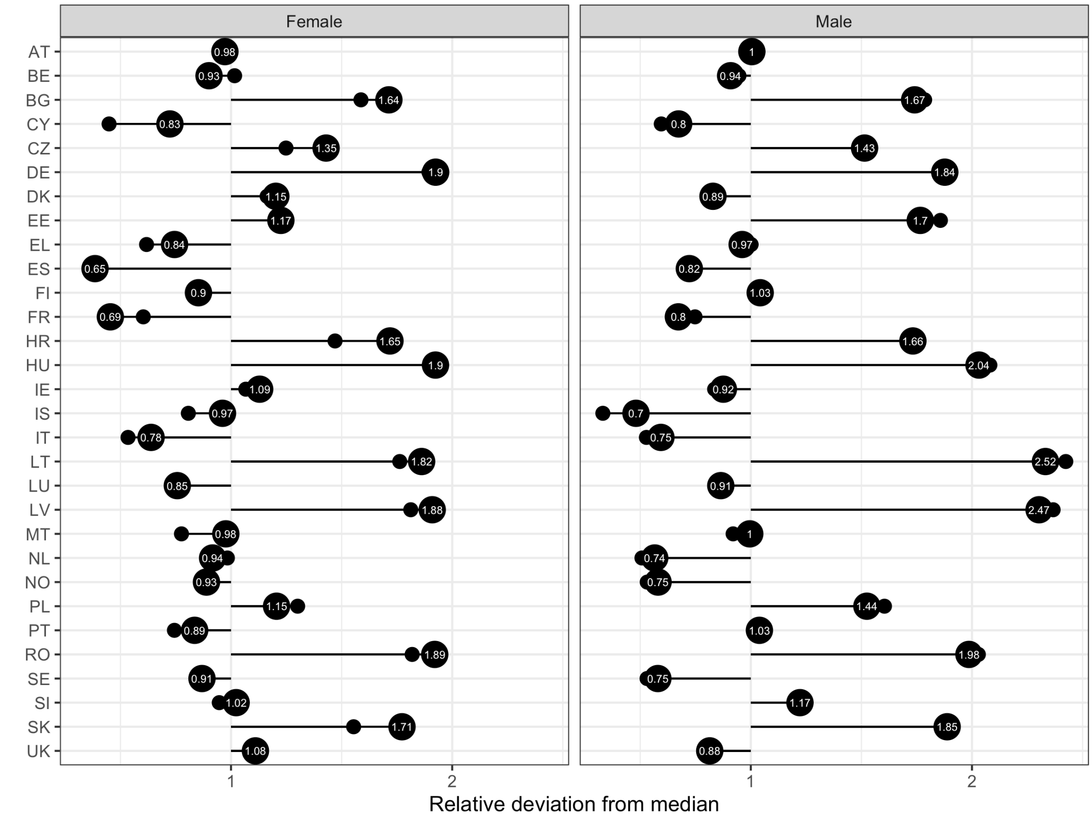

Figure 16 Relative deviation from EU median. Baseline deviation is represented by the small circle. The sex-specific age threshold deviation is represented by the larger circle.

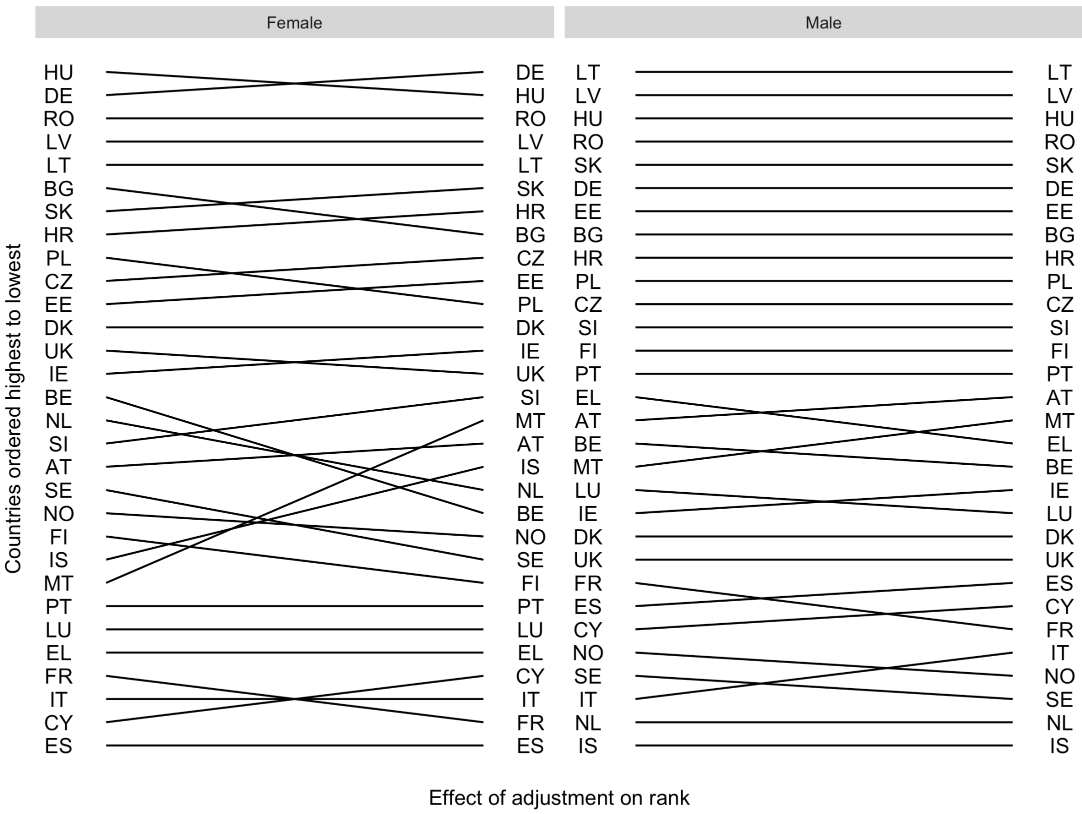

Figure 17 Effect of the sex-specific age threshold adjustment on rank.

Table 9f. Mortality and country ranks with sex-specific age limits for selected disease categories

Country	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)
AT	107,34	82,02	83,63	132,17	120,26	161,78	9	15	18	7	15	16
BE	111,72	53,83	94,18	149,5	77,85	160,16	14	5	20	14	6	15
BG	110,95	262,21	83,2	174,57	326,93	188,4	13	27	15	20	27	20
CY	76,58	70,06	83,13	118,54	104,08	106,66	1	11	14	5	12	5
CZ	114,72	161,6	98,5	173,91	218,41	197,38	15	23	23	19	22	21
DE	221,79	146,38	160,23	274,53	214,18	269,5	30	22	30	30	21	28
DK	153,09	57,08	110,05	146,78	76,78	143,13	28	7	27	12	4	13
EE	118,35	128,69	78,27	208,59	233,48	260,1	16	21	11	23	23	26
EL	91,24	89,28	52,61	162,92	133,43	105,43	3	17	2	18	17	4
ES	84,77	45,12	51,81	158,08	74,29	108,13	2	3	1	16	3	6
FI	93,04	90,57	67,66	105,4	156,16	163,59	4	18	6	2	19	18
FR	98,85	33,02	58,78	150,4	54,86	123,75	7	1	5	15	1	9
HR	142,35	217,55	98,02	228,66	257,4	200,03	26	24	22	28	24	22
HU	171,17	239,14	117,82	267,91	318,27	257,9	29	26	29	29	26	25
IE	148,76	76,46	79,18	138,45	114,57	125,8	27	14	12	9	14	11
IS	136,69	61,96	72,28	117,86	89,71	80,51	25	9	8	4	9	1
IT	100,79	59,93	55,87	141,05	77,52	92,9	8	8	3	10	5	2
LT	107,68	294,55	103,46	216,6	439,13	383,67	10	29	25	26	29	30
LU	108,17	43,48	83,5	148,78	83,56	143,42	11	2	16	13	8	14
LV	120,64	299,66	102,47	223,73	466,22	328,96	17	30	24	27	30	29
MT	96,82	119,74	57,2	138,11	140,45	132,92	6	20	4	8	18	12
NL	134,15	53,05	75,45	142,33	64,13	99,04	24	4	9	11	2	3
NO	121,19	55,12	81,33	111,85	78,06	118,8	18	6	13	3	7	8
PL	131,4	106,01	83,52	206,98	166,62	220,36	23	19	17	22	20	23
PT	93,18	70,72	84,38	158,39	102,5	163,21	5	12	19	17	11	17
RO	124,29	289,42	113,16	215,67	339,92	262,27	19	28	28	24	28	27
SE	109,09	68,19	76,77	95,71	97,89	114,91	12	10	10	1	10	7
SI	125,73	85,4	71,62	180,74	126,45	174,42	20	16	7	21	16	19
SK	130,94	235,34	109,24	215,83	298,46	249,54	22	25	26	25	25	24
UK	130,6	74,55	95,24	129,26	109,51	124,19	21	13	21	6	13	10

Combining the YLL adjustment with no age cut-offs

As an addition, we explored an adjustment that combined no age cut-offs with using the years of life lost estimate instead of mortality rates.

Table 10a. Avoidable years of life lost (YLL) without age cut-off

Country	Avoidable YLL (women)	Avoidable YLL (men9)	Country rank (women)	Country rank (men)
AT	7100,16	12697,27	9	13
BE	7439,99	13146,65	15	16
BG	14878,92	26796,99	30	28
HR	11084,56	20610,43	24	22
CY	6573,12	14364,15	6	20
CZ	9641,89	18176,08	22	21
DK	8308,17	12699,86	20	14
EE	8996,11	22434,91	21	25
FI	6465,47	13038,3	5	15
FR	5830,01	11825,41	3	9
DE	7354,3	12539,39	13	12
EL	7872,24	13929,18	19	19
HU	12640,94	24127,48	26	26
IS	5812,83	10890,57	2	2
IE	7337,01	11832,12	12	10
IT	5936,57	10898,39	4	3
LV	12992,12	29962,06	28	29
LT	12889,35	31429,61	27	30
LU	7692,43	11304,65	18	6
MT	7368,24	12025,18	14	11
NL	7565,13	11000,47	17	4
NO	7179,92	11169,25	11	5
PL	9825,14	21173,22	23	23
PT	6837,18	13323,3	7	17
RO	13324,74	24447,9	29	27
SK	11295,22	22362,17	25	24
SI	6874,49	13889,66	8	18
ES	5392,85	11369,05	1	8
SE	7152,49	10813,51	10	1
UK	7505,66	11357,03	16	7
Mean	8572,24	16187,81		
Median	7472,82	13092,47		
IQR	2848,42	9549,38		
Coefficient of variation	0,3	0,38		
Gini index	0,16	0,2		
Theil index	0,04	0,07		

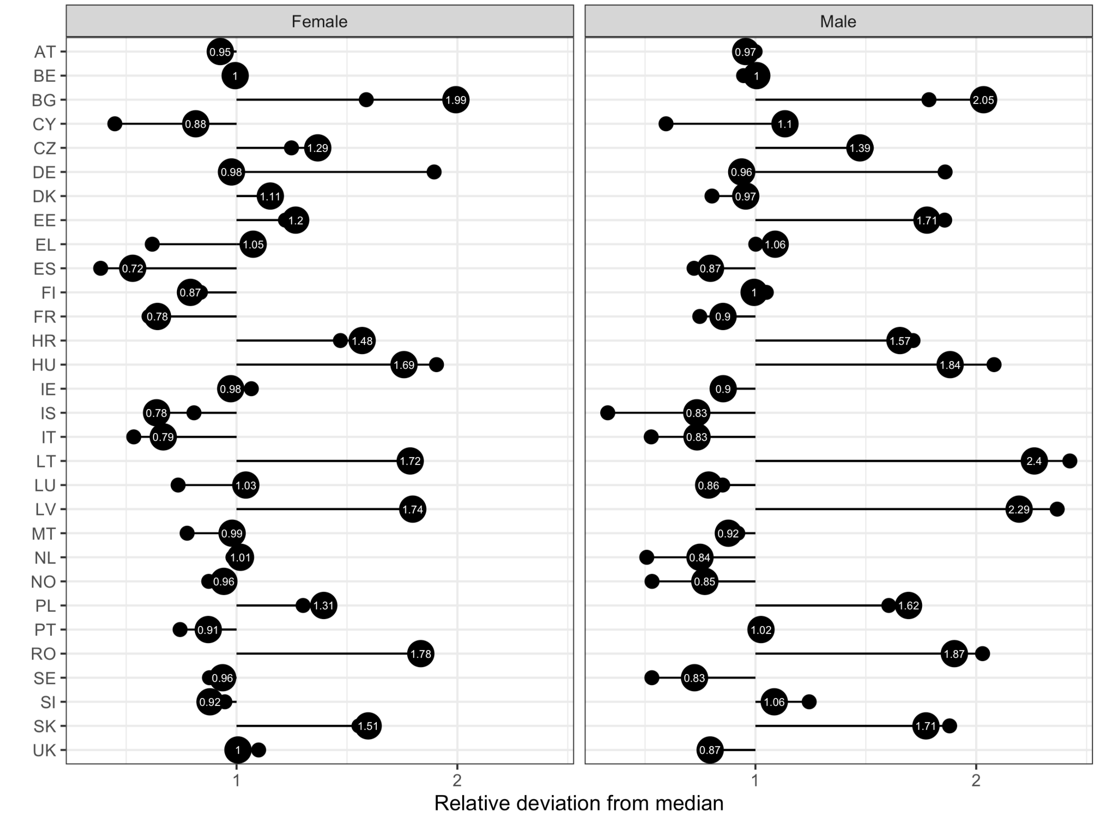

Figure 18 Relative deviation from EU median. Baseline deviation is represented by the small circle. The avoidable YLL and no age threshold deviation is represented by the larger circle.

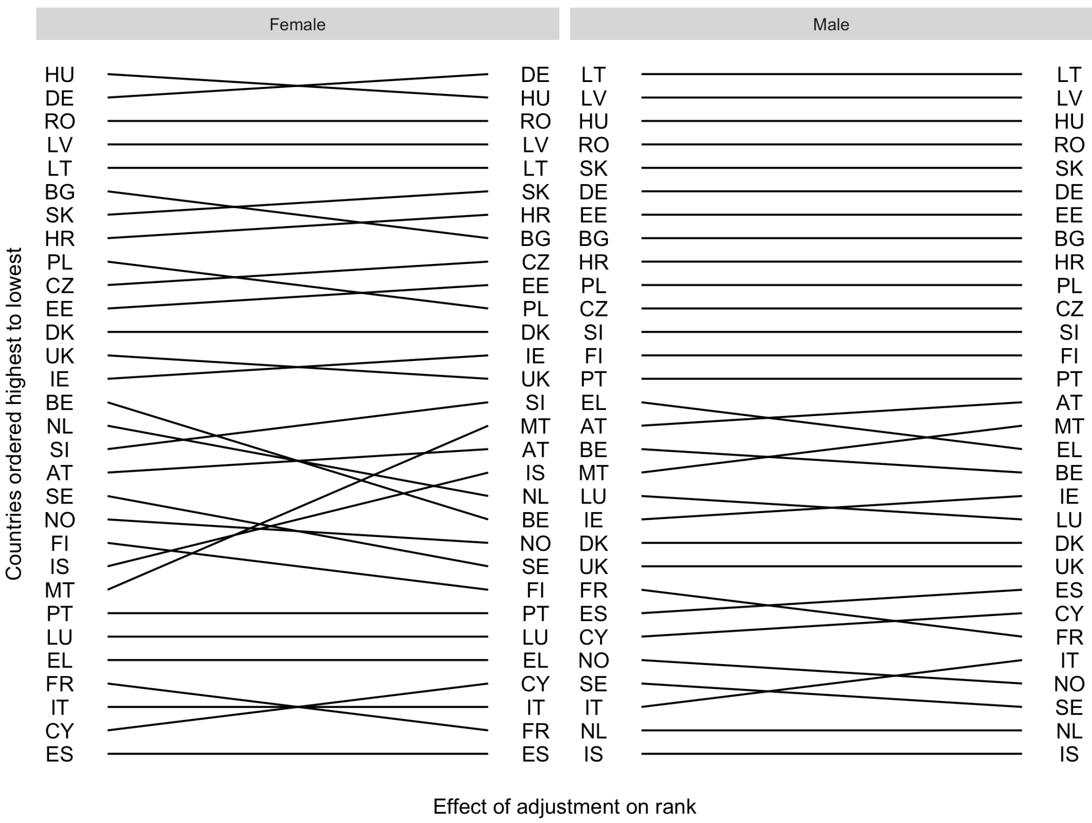

Figure 19 Effect of the avoidable YLL and no age threshold adjustment on rank.

Table 10b. YLLs per 100 000 without age cut-off and country ranks for selected disease categories

Country	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)	Cancers (women)	Circulatory disease (women)	Other (women)	Cancers (men)	Circulatory disease (men)	Other (men)
AT	2464,86	2613,99	2021,31	3427,78	4839,33	4430,16	9	15	14	8	15	14
BE	2791,46	2197,4	2451,13	4256,88	4038,02	4851,75	19	7	26	17	7	18
BG	2991,33	9640,79	2246,8	4929,09	16395,18	5472,72	24	30	23	22	30	23
CY	3067,54	5808,61	2208,41	5714,48	9463,93	5432,03	25	24	22	29	23	22
CZ	2020,73	2441,41	2110,98	3314,55	5999,34	5050,26	1	10	18	6	19	20
DE	2638,28	4937,53	2066,08	4408,57	8676,75	5090,76	15	23	17	19	21	21
DK	3484,11	2125	2699,07	3824,88	3943,18	4931,8	29	6	29	13	5	19
EE	2500,62	4336,21	2159,28	5131,37	9532,72	7770,81	10	21	21	23	24	28
EL	2049,01	2723,71	1692,74	2564,9	5795,51	4677,9	2	18	6	2	18	17
ES	2536,65	1494,56	1798,8	4437,49	3102,55	4285,36	12	1	8	20	1	13
FI	2639,16	2668,06	2047,08	3668,9	4808,65	4061,84	16	17	15	10	14	11
FR	2304,64	3861,64	1705,95	4213,25	6164,46	3551,47	6	20	7	15	20	5
HR	3979,1	6001,43	2660,41	7003,85	10894,09	6229,54	30	25	27	30	25	26
HU	2440,26	1911,2	1461,38	2843,93	4698,75	3347,89	8	3	1	3	13	2
IE	2980,76	2481,59	1874,66	3370,53	4614,67	3846,92	23	12	9	7	11	10
IS	2356,49	2075,74	1504,35	3753,76	3825,53	3319,1	7	5	2	12	4	1
IT	2655,44	7612,96	2723,71	5534,2	15418,61	9009,25	17	27	30	26	29	29
LT	2518,54	7704,4	2666,41	5407,54	15156,09	10865,98	11	28	28	24	28	30
LU	2928,42	2462,58	2301,43	3681,54	3991,3	3631,81	21	11	25	11	6	6
LV	2267,25	3468,93	1632,06	3059,93	5581,78	3383,48	5	19	4	5	17	3
MT	3393,53	2026,65	2144,95	4069	3417,13	3514,34	28	4	20	14	2	4
NL	2708,2	2219,08	2252,64	2921,33	4054,84	4193,08	18	8	24	4	8	12
NO	3222,19	4659,32	1943,63	5708,21	8970,86	6494,15	27	22	11	28	22	27
PL	2241,76	2532,62	2062,79	4333,5	4340,83	4648,97	4	13	16	18	10	16
PT	2976,32	8359,31	1989,1	5521,2	12954,25	5972,44	22	29	13	25	27	25
RO	2874,91	6485,58	1934,74	5552,16	11292,73	5517,29	20	26	10	27	26	24
SE	2575,21	2664,16	1635,12	4469,63	4872,71	4547,31	13	16	5	21	16	15
SI	2060,95	1739,35	1592,55	4247,71	3475,08	3646,26	3	2	3	16	3	8
SK	2591,97	2580,78	1979,74	2443,3	4651,38	3718,82	14	14	12	1	12	9
UK	3069,6	2317,36	2118,69	3433,42	4281,39	3642,23	26	9	19	9	9	7

Rank differences per adjustment

In this section, we report on the impact of the various adjustments of the avoidable mortality indicator on the rank of the countries studied. For each country and for each adjustment, we provide the absolute difference from the unadjusted rank. We also calculated the mean absolute difference (MAD) for each adjustment and for each country. The results are stratified by sex (Tables 11b and 11c).

Overall, the adjustments created an average change in country ranks of between 0.7 and 8.9 in women, and 0.5 and 8.8 in men. Modifying age thresholds had the smallest effect on country ranks (average change of 1-3 places), while adjustments using avoidable burden of disease concepts had quite large effects (average change of 8-9 places) .

We can also note that the average effect of all adjustments varies per country (last column in 11b and 11c, and Figure 20) and ranges from very small (e.g., Icelandic men) to a substantial change in rank (e.g., Italian men). The reasons behind the differences in country rank robustness are not obvious. We speculate that they may be related to the differences in data quality – particularly the quality of morbidity data, or to the differences in the relative importance old-age mortality and mortality due to cardiovascular disease.

Table 11a reports on the results of the Spearman rank correlation analysis of the ranks obtained through various adjustments and the rank obtained by the unadjusted indicator (Table 11a). It is apparent that using various burden estimates as indicators has a profound effect on the country ranks with only marginal correlation with the unadjusted ranks. On the other hand, varying age limits has only a limited effect on the ranking compared to unadjusted ranks with very high correlation coefficient values.

Table 11a. Results of the correlation analysis.

Adjustment	Correlation coefficient – women	Correlation coefficient - men
Unadjusted value	1	1
Prevalence	0,77	0,8
Lagged prevalence	0,79	0,78
Treatable DALYs	0,12	0,14
Treatable YLDs	0,2	0,1
Treatable YLLs	0,11	0,14
No age limits	0,9	0,95
Higher age	0,99	0,99
Sex-specific age	0,97	0,99
Treatable YLLs with sex-specific age cut-off	0,15	0,17

Table 11b. Country ranks using different adjustments - Women.

Country	Standard	Prevalence adjusted	Lagged prevalence	Avoidable DALYs	Avoidable YLDs	Avoidable YLLs	No age limits	Higher age	Sex-specific age	Avoidable YLLs – Women under 85	Avoidable YLLs – no age limit	**MAD**
AT	13	5	6	-1	2	-1	3	0	1	-4	-4	**2,7**
BE	16	-1	-1	1	-9	3	-9	-2	-5	0	-1	**3,2**
BG	25	2	1	5	-3	5	-2	-1	-2	5	5	**3,1**
CY	2	8	4	20	19	21	4	1	2	22	22	**12,3**
CZ	21	3	3	-16	-13	-13	1	1	1	-14	-15	**8**
DE	29	-17	-17	-8	-2	-8	0	0	1	-7	-7	**6,7**
DK	19	3	3	1	-10	1	-1	0	0	1	1	**2,1**
EE	20	1	1	3	9	2	1	0	1	1	1	**2**
EL	5	8	8	5	14	0	0	0	0	0	0	**3,5**
ES	1	3	2	2	1	6	1	0	0	3	2	**2**
FI	10	1	1	-1	-5	5	1	-2	-2	3	3	**2,4**
FR	4	-2	-3	3	2	5	-3	-2	-2	6	15	**4,3**
HR	23	2	2	5	3	6	1	0	1	5	3	**2,8**
HU	30	-4	-3	-26	-18	-27	-3	0	-1	-27	-28	**13,7**
IE	17	-11	-8	-4	-7	-4	3	0	1	-3	-5	**4,6**
IS	9	-8	-7	-7	-8	-7	4	3	4	-7	-5	**6**
IT	3	4	4	26	27	25	1	1	0	24	25	**13,7**
LT	26	3	3	0	2	0	4	0	0	0	1	**1,3**
LU	6	-1	2	10	11	10	-3	0	0	11	12	**6**
LV	27	1	1	-16	-16	-17	1	0	0	-12	-13	**7,7**
MT	8	11	10	7	-4	10	11	1	7	10	9	**8**
NL	15	-7	-5	-1	1	-1	-7	0	-3	-3	-4	**3,2**
NO	11	5	5	14	12	13	-1	0	-1	12	12	**7,5**
PL	22	-8	-8	-16	-9	-18	-7	-1	-2	-16	-15	**10**
PT	7	-4	-3	20	17	20	5	0	0	22	22	**11,3**
RO	28	2	2	-4	-8	-3	-2	0	0	-3	-3	**2,7**
SE	12	5	5	6	13	-6	-3	-2	-3	-4	-4	**5,1**
SI	14	-5	-9	-13	-11	-13	0	2	2	-13	-13	**8,1**
SK	24	-1	-1	-16	-10	-13	1	1	1	-13	-14	**7,1**
UK	18	2	2	1	0	-1	-1	0	-1	1	-2	**1,1**
MAD	**-**	**4,6**	**4,3**	**8,6**	**8,9**	**8,8**	**2,8**	**0,7**	**1,5**	**8,4**	**8,9**	

Table 11c. Country ranks using different adjustments - Men.

Country	Unadjusted	Prevalence adjusted	Lagged prevalence	Avoidable DALYs	Avoidable YLDs	Avoidable YLLs	No age limits	Higher age	Sex-specific age	Avoidable YLLs – Men under 85	Avoidable YLLs – no age limit	**MAD**
AT	15	4	4	-1	1	-3	1	1	1	-3	-2	**2,1**
BE	14	1	0	2	-1	1	-3	-1	-1	1	2	**1,3**
BG	23	4	4	5	-3	5	-1	0	0	5	5	**3,2**
CY	6	5	6	16	15	16	1	1	1	16	16	**9,3**
CZ	20	2	2	-5	-11	-3	1	0	0	-2	0	**2,6**
DE	25	-17	-16	-4	4	-4	3	0	0	-4	-4	**5,6**
DK	10	3	3	2	0	1	3	0	0	3	4	**1,9**
EE	24	1	1	1	-1	1	-1	0	0	1	1	**0,8**
EL	16	5	5	2	3	0	-7	-2	-2	0	-1	**2,7**
ES	7	-2	-1	4	-5	7	-1	1	1	4	2	**2,8**
FI	18	-1	0	-5	-11	-5	-3	0	0	-4	-6	**3,5**
FR	8	-6	-7	11	-3	12	-7	-2	-2	12	11	**7,3**
HR	22	2	1	4	6	4	2	0	0	4	4	**2,7**
HU	28	-2	-2	-25	-22	-24	-1	0	0	-25	-26	**12,7**
IE	11	-4	-4	-2	3	-2	3	1	1	-1	-1	**2,2**
IS	1	0	3	0	0	0	2	0	0	0	2	**0,7**
IT	3	3	2	26	23	26	5	2	2	26	26	**14,1**
LT	30	-2	-1	0	-5	0	0	0	0	0	0	**0,8**
LU	12	-9	-10	-5	5	-5	-2	-1	-1	-6	-6	**5**
LV	29	0	-1	-21	-14	-23	0	0	0	-20	-18	**9,7**
MT	13	5	2	-11	-9	-10	5	2	2	-9	-9	**6,4**
NL	2	2	1	4	16	3	0	0	0	3	3	**3,2**
NO	5	5	6	19	22	19	0	-1	-1	18	18	**10,9**
PL	21	-1	-1	-4	-10	-3	-1	0	0	-4	-4	**2,8**
PT	17	-8	-7	10	5	10	0	0	0	10	10	**6**
RO	27	3	3	-4	-3	-4	-2	0	0	-3	-3	**2,5**
SE	4	12	13	16	26	15	0	-1	-1	15	14	**11,3**
SI	19	-7	-11	-14	-16	-11	0	0	0	-12	-11	**8,2**
SK	26	-3	-2	-22	-18	-24	0	0	0	-24	-25	**11,8**
UK	9	5	7	1	3	1	3	0	0	-1	-2	**2,3**
MAD	**-**	**4,1**	**4,2**	**8,2**	**8,8**	**8,1**	**1,9**	**0,5**	**0,5**	**7,9**	**7,9**	

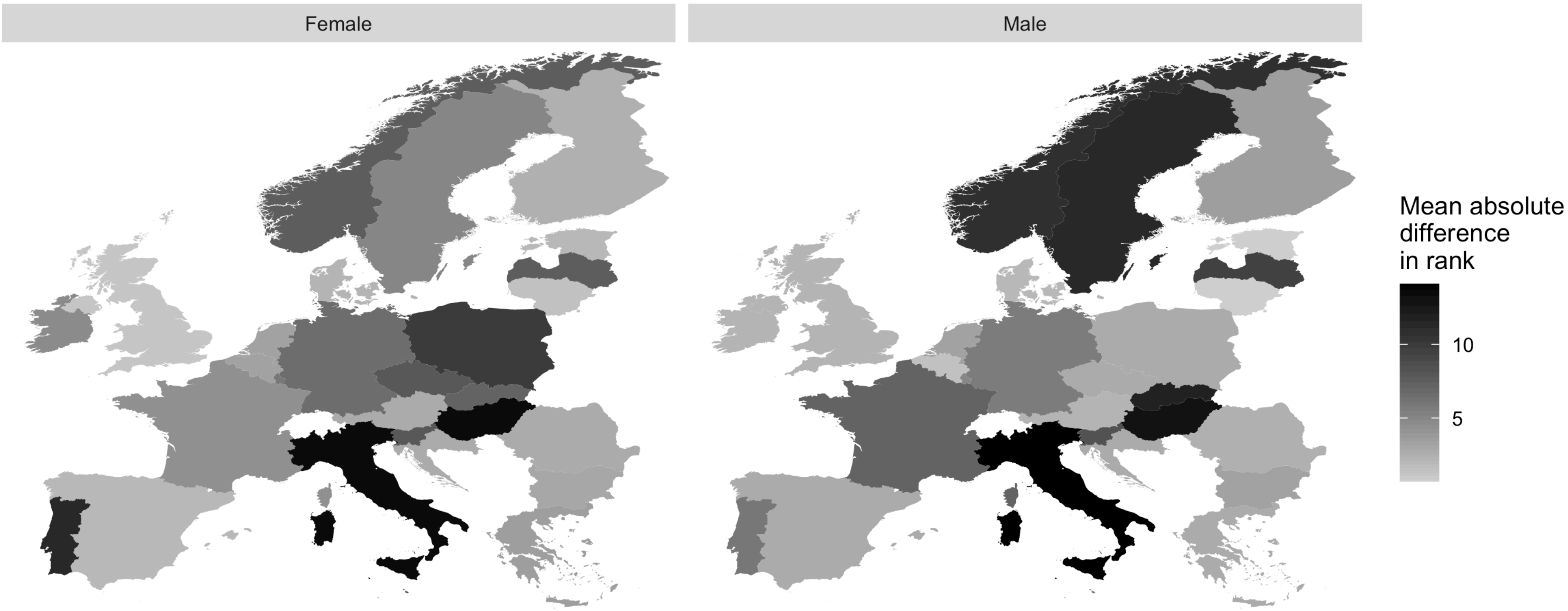

Figure 19 Mean absolute difference in rank over all adjustments per country (stratified by sex).

Country ranks based on healthcare expenditures

We also compared the country ranks based on the various adjusted treatable mortality estimates with country rankings based on the overall health expenditure per capita, government expenditure on health per capita, and out of pocket spending per capita (Table 12).

Note that out of pocket spending per capita data was available only for Austria, Cyprus, Czechia, Greece, France, Hungary, Iceland, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Norway and Romania. This part of the correlation analysis thus only includes these countries.

Table 12. Correlation analysis of country ranks based on adjusted treatable mortality indicator and healthcare expenditure per capita

Treatable mortality indicator	Total expenditure	Government expenditure	Out of pocket expenditure	Total expenditure	Government expenditure	Out of pocket expenditure
	Women			Men		
Unadjusted value	-0,41	-0,28	-0,09	-0,66	-0,58	-0,11
Prevalence	-0,53	-0,44	-0,02	-0,72	-0,67	-0,01
Lagged prevalence	-0,48	-0,38	-0,03	-0,71	-0,65	0,08
Treatable DALYs	-0,08	-0,06	-0,19	-0,2	-0,19	-0,06
Treatable YLDs	-0,13	-0,1	-0,14	0,01	0,02	-0,07
Treatable YLLs	-0,11	-0,09	-0,25	-0,21	-0,2	-0,12
No age limits	-0,48	-0,37	0,15	-0,63	-0,53	-0,02
Higher age	-0,43	-0,3	-0,08	-0,68	-0,6	-0,11
Sex-specific age	-0,45	-0,33	-0,03	-0,68	-0,6	-0,11
Treatable YLLs with sex-specific age cut-off	-0,16	-0,14	-0,23	-0,23	-0,22	-0,11
Treatable YLLs with no age cut-off	-0,13	-0,11	-0,3	-0,24	-0,22	-0,05

We can see that most variants of the treatable mortality indicator have the expected negative correlation between rank based on spending (higher spending equals higher rank) and rank based on treatable mortality (higher mortality rate equals higher rank).

The correlations between spending and mortality ranks are stronger in men, for total expenditure, and are for most types of expenditure strongest in prevalence adjusted treatable mortality. It is notable that burden of diseased based adjustments very weakly correlate with all types of expenditure.

CHAPTER 5. AVOIDABLE MORTALITY IN A SYSTEMS PERSPECTIVE

Common approaches to avoidable mortality attempt to measure mortality due to all potentially treatable diseases. A central assumption is that the availability of interventions that may prevent or delay death in patients (e.g., coronary angioplasty in ischaemic heart disease) leads to important reductions in the relevant cause-specific mortality rates at the population level. This in turn means that differences in avoidable mortality rates between countries may be interpreted as differences in healthcare system performance over a broad range of healthcare services.

However, previous research[15] has shown that this causal chain is more involved than often assumed. The additional complexity may lie in implementation delays, limited access to healthcare in some population groups, limited, differential, or delayed effectiveness of interventions, or other failures in the causal chain that connects a healthcare or public health intervention with its lifesaving effects. One important consequence of the causal distance between intervention and population level effects is that avoidable mortality largely remains agnostic about the quality of specific functions of healthcare systems, conflating the quality of health promotion and education, primary prevention, early detection, effective treatment, rehabilitation, and follow up. This limits the utility of avoidable mortality for international comparisons of complex healthcare systems and for the generation of precise policy advice on required healthcare reforms.

The aim of this chapter is to propose an outline of a framework for health system performance assessment that utilises a systems perspective on avoidable mortality. We propose a generic patient pathway in health systems in high-income settings and identify potential breakpoints, which may result in patient death. We identify causes of death that are closely related to each of the potential breakpoint and are thus able to act as proxy measures for the functioning of health systems at various points of the generic patient pathway. Finally, we extract the relevant data from Eurostat and benchmark the functioning of EU health systems according to the framework.

Methods

Generic patient pathway and health system breakpoints

A recent publication[16] developed a logic model that visualised the patient pathway for cancer patients. We modified that pathway, so it can reflect other disease groups as well. We propose a simple general model in Figure 20.

[15] Hoffmann, R., Plug, I., Khoshaba, B., McKee, M., & Mackenbach, J. P. (2013). Amenable mortality revisited: The AMIEHS study. Gaceta Sanitaria, 27(3), 199–206. https://doi.org/10.1016/j.gaceta.2012.08.004

[16] Morris, M., Landon, S., Reguilon, I., Butler, J., McKee, M., & Nolte, E. (2020). Understanding the link between health systems and cancer survival: A novel methodological approach using a system-level conceptual model. Journal of Cancer Policy, 25, 100233. https://doi.org/10.1016/j.jcpo.2020.100233

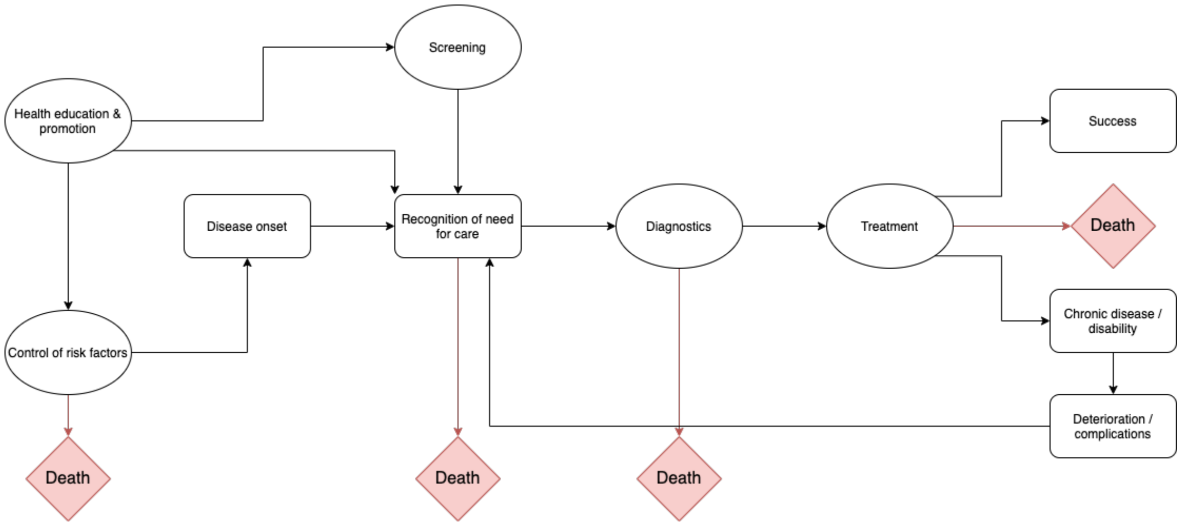

Figure 20. Generic patient pathway and selected breakpoints that may lead to patient death. Circular items represent health system functions, rounded boxes represent disease states.

Under this proposed pathway, there are three breakpoints in the healthcare system that may directly lead to patient death after the onset of disease. First, a patient may fail to detect the signs and symptoms of their disease, thus failing to seek timely healthcare. This may occur either at initial disease onset or in the context of a deterioration of a chronic disease. Second, a patient may recognise a need for care, but fail to receive a timely and accurate diagnosis. Third, a patient may receive an accurate and timely diagnosis, but may not have timely access treatment, or the treatment available is not effective.

There are also upstream services that work before the onset of disease that represent potential breakpoints whose failure may indirectly contribute to patient death. First, a failure in health promotion and education may delay the recognition of disease through poor health literacy, a failure for individuals to act to control risk factors, or a failure of patients to engage with systematic screening programmes that facilitate early disease detection. Second, a failure by policymakers to act to control societal risk factors (e.g., air pollution) or to support individuals in controlling individual risk factors (e.g., smoking) may directly contribute to the emergence of disease or a deterioration of existing chronic disease. Finally, a failure to establish inclusive and effective population screening may delay the recognition of a disease state and a definitive diagnosis.

Selection of causes of death associated with health system breakpoints

In this framework, a cause of death is an effective proxy measure for a health system function if a death due to the cause may not be effectively prevented or substantially delayed by any of the functions downstream of the service. For example, deaths due to lung cancer are most effectively prevented by the "control of risk factors" function. Preventing lung cancer deaths after the "recognition of disease state" point in the pathway is less effective, since 5-year survival in European lung cancer patients is below 25%[17]. This may change as improved population screening and treatment modalities become available.

In addition to these theoretical considerations, the selected causes of death should show substantial variation between EU Member States to be useful for benchmarking procedures. This requires data on these causes of death to be routinely collected and be made available for international comparative research.

[17] European Union. (2020). European Cancer Information System. https://ecis.jrc.ec.europa.eu/. Accessed 3 September 2020.

Based on these criteria, we identified a preliminary list of causes of death for each of the potential points of failure in a health system (Table 13a). We present this list merely to illustrate the concept and not as a definitive selection, which should be performed after a rigorous consultation of the available evidence and expert opinion.

Table 13a. Causes of death corresponding to the potential points of failure in high-income health systems

Point of failure	*Cause of death*	*Rationale*
Control of risk factors	Lung cancer	Deaths due to this disease would be very rare in the absence of smoking. The diagnosis and treatment of the disease play a less important role in preventing deaths as treatment remains less effective compared to other common cancers. The outcome is expected to be responsive to various tobacco control policy measures, for example pricing and availability changes, and health literacy campaigns.
Screening and diagnosis	Colorectal cancer & breast cancer	The causes of these diseases are multifactorial and not amenable to simple preventive strategies. Survival rates in localised CRC and breast cancer reach almost 100% and fall precipitously with delayed detection. Effective population-level screening modalities are widely available and need to be well-integrated with specialised diagnostic services (e.g., pathology) for effective intervention. The outcome is expected to be responsive to policies that enhance participation in and effectiveness of population-level screening, for example improving the invitation system (population coverage and follow-up) and executing the screening (guidelines).
Emergency care	Acute myocardial infarction	The causes of this disease are multifactorial and not amenable to simple preventive strategies. The ability to recognise the onset of this disease is high among populations in high-income settings. Survival in both diseases thus depends on the existence of effective acute care, which includes the organisation of emergency care and its ability to interface with specialised treatment facilities in regional hospitals or tertiary care centres. The outcome is expected to be responsive to policies that improve accessibility and functioning of emergency care, for example improved networks of emergency care providers.
Chronic disease care	Diabetes and intentional self-harm	The causes of these diseases are multifactorial and not amenable to simple preventive strategies. The diagnostic procedure is well-established and widely accessible. While delayed diagnosis may result in a large burden of morbidity, it may not result immediately in outright death. Thus, early deaths due to these diseases are commonly the consequence of a failure to deliver integrated care, which requires effective interfacing between self-care, primary care providers, and other healthcare professionals at different levels of care provision. The outcome is expected to be responsive to policies that improve complex care, for example provider payment schemes that incentivise integrated care and mHealth applications that support self-management.

Results

We used Eurostat death count and population size data to generate age-standardised death rates for selected causes of death. We then ranked the included countries according to cause-specific mortality that reflects each of the health system functions presented in Table 12a. Tables 12b and 12c summarise the results for women and men, respectively.

Overall, we may note that the ranks produced with this approach vary importantly between disease groups within countries. This may indicate that national systems exhibit important variation in their performance of particular functions. For example: Danish men and women experience relatively low rates of death due to acute myocardial infarction, which may indicate excellent acute cardiovascular care, but experience relatively high rates of death due to lung cancer (especially women), which may indicate poorer control of risk factors.

Table 13b. Age-standardised mortality rate (per 100 000) and rank for selected causes of death – women.

Country	Acute myocardial infarction – mortality rate	Breast and colorectal cancer – mortality rate	Diabetes and self-harm – mortality rate	Lung cancer – mortality rate	Acute myocardial infarction – country rank	Breast and colorectal cancer – country rank	Diabetes and self-harm – country rank	Lung cancer – country rank
AT	38,12	53,01	39,86	32,47	17	10	25	17
BE	28,3	58,36	22,55	33,65	10	18	15	18
BG	47,73	57,43	24,45	17,5	24	15	18	7
CY	34,29	38,52	67,67	13,84	16	1	30	2
CZ	43,76	56,95	41,71	30,14	22	13	28	15
DE	79,2	117,36	57,41	64,74	28	30	29	30
DK	22,43	68,74	25,2	62,93	3	26	20	29
EE	23,89	59,79	18,31	22,15	5	20	9	10
EL	32,4	49,23	13,79	21,67	13	4	3	9
ES	21,91	46,82	22,19	16,62	2	3	12	6
FI	48,11	45,1	13,91	25,14	25	2	4	13
FR	14,08	53,38	20,34	25,61	1	11	11	14
HR	61,24	79,46	40,71	31,01	27	29	26	16
HU	46,96	77,26	34,26	58,21	23	28	23	28
IE	49,93	67,44	16,55	51,67	26	25	6	26
IS	38,22	66,74	13,16	53,88	18	24	2	27
IT	24,75	52,89	27,88	24,48	6	9	21	12
LT	27,16	51,19	18,11	14,2	7	5	8	4
LU	22,49	52,02	22,45	36,06	4	7	13	20
LV	41,72	61,19	30,58	14,55	19	22	22	5
MT	92,22	57,52	39,01	12,14	30	16	24	1
NL	27,36	62,19	24,59	50,14	8	23	19	24
NO	43,23	59,59	17,56	42,5	21	19	7	23
PL	27,77	57,29	24,25	38,09	9	14	16	22
PT	29,87	51,82	40,73	13,95	11	6	27	3
RO	81,48	56,27	14,68	20,91	29	12	5	8
SE	42,12	52,79	22,54	36,68	20	8	14	21
SI	33,29	60,22	19,32	35,32	14	21	10	19
SK	33,95	71,87	24,35	22,43	15	27	17	11
UK	31,7	57,63	12,72	51,33	12	17	1	25

Table 13c. Age-standardised mortality rate (per 100 000) and rank for selected causes of death – men.

Country	Acute myocardial infarction – mortality rate	Colorectal cancer – mortality rate	Diabetes and suicide – mortality rate	Lung cancer – mortality rate	Acute myocardial infarction – country rank	Colorectal cancer – country rank	Diabetes and self-harm – country rank	Lung cancer – country rank
AT	83,81	35,51	71,5	69,58	20	8	27	7
BE	58,69	33,51	41,58	101,21	7	4	10	23
BG	107,78	50,35	38,67	81,88	26	19	9	10
CY	80,36	23,38	85,32	65,61	17	1	29	5
CZ	87,91	54,33	73,06	87,09	22	25	28	14
DE	162,85	75,16	97,22	154,53	30	28	30	30
DK	47,04	45,05	54,1	85,68	2	16	20	13
EE	59,6	54,31	45,7	117,26	8	24	16	27
EL	79,06	30,44	25,22	111,63	15	3	2	25
ES	49,5	48,83	35,53	88,66	4	18	5	15
FI	93,85	29,24	35,57	60,24	24	2	6	2
FR	32,55	34,99	44,96	82,58	1	7	14	11
HR	136,95	77,1	64,92	115,23	27	29	23	26
HU	95,63	82,24	67,5	140,26	25	30	24	29
IE	84,56	42,05	41,7	75,76	21	14	11	8
IS	70,03	37,13	35,84	60,88	13	11	7	3
IT	51,19	35,93	43,12	84,47	5	9	13	12
LT	62,62	51,47	70,06	100,8	10	21	25	22
LU	56,22	39,92	53,83	93,45	6	12	19	18
LV	92,7	51,99	63,51	107,35	23	22	21	24
MT	140,23	36,44	70,58	89,12	28	10	26	16
NL	49,15	41,87	36,78	93,21	3	13	8	17
NO	79,17	43,31	33,92	63,62	16	15	3	4
PL	63,94	53,01	53,31	118,72	12	23	18	28
PT	60,23	50,39	63,59	67,21	9	20	22	6
RO	155,15	45,32	34,24	98,01	29	17	4	21
SE	80,9	34,35	42,72	42,71	18	5	12	1
SI	75,88	55,52	51,72	93,72	14	26	17	19
SK	83,77	73,14	45,01	94,34	19	27	15	20
UK	63,28	34,77	23,5	76,51	11	6	1	9

Next steps in developing the approach

The above results and expert consultation suggest that the systems perspective on avoidable mortality is a promising extension of the methodology that may provide more precise insights into the relative performance of health systems and guide the generation of policy advice on required healthcare reforms.

The next steps in developing the approach need to accomplish the following tasks:

- Formulate a more complete version of the generic patient pathway (Figure 2) in high-income settings.
- Identify a more complete set of causes of death corresponding to the potential points of failure in high-income health systems (Table 13a).
- Validate the indicator on historical and current data.

The first task involves performing a systematic literature review combined with expert informant interviews of a variety of specific disease patient pathways in high-income settings. Once common pathways and notable exceptions are mapped, an analysis of the comprehensive pathway will allow for the identification of all potential points of failure in a generic high-income health system.

The second task also involves performing a systematic literature review combined with expert informant interviews and quantitative analysis of mortality and morbidity data to identify causes of death that are reliably causally dependent on the points of failure identified in the previous paragraph. The total number of diseases included is not as important as the strength of the causal link that can be established. It may be that some points of failure are better detected by the presence of incident or prevalent cases of a disease instead of deaths due to the disease, in which case we would recommend to expand the concept to include both avoidable mortality *and* morbidity in a systems perspective. This task may therefore also indicate what particular morbidity data would be most valuable for future collection efforts.

The third task involves testing whether the selected causes of death (or morbidity) in fact respond to healthcare reforms that had a well-established effect on the specific points of failure in the health system and estimate the expected lag between the policy change and the outcome measure. It would also be very helpful to establish a comprehensive database of healthcare reforms and associated policies that have been found to be reliably associated with changes in the selected outcome measures.

CHAPTER 6. RECOMMENDATIONS FOR THE FUTURE DEVELOPMENT OF THE TREATABLE MORTALITY INDICATOR

Expert consultation

The three experts that agreed to participate in the previous consultation were contacted again with a request to review an early version of chapters 4-6 of this report and provide comments. Two responded in time (JM and NR) and provided their views on the methodological limitations of the study, key conclusions, and recommendations.

The feasibility of the adjustments to avoidable mortality

The core requirements for the adjusted indicator to be of practical use in health system performance assessment in the European Union are:

- complete geographic coverage
- availability of up-to-date data (e.g., no older than 2-3 years), and
- computational simplicity and ease of interpretation.

We can consider each in turn to evaluate the proposed adjustments.

While the issues of geographic coverage and data availability are closely related, we have not found important differences between the countries of interest in terms of data available in the publicly[18] available datasets. Mostly, data were either available for the majority of the included countries or missing for most of them.

Any adjustments that rely on the availability of good quality and timely morbidity data are currently not feasible. Both external experts consulted share this view. There is a significant paucity of publicly accessible, timely, and objectively measured morbidity data across all disease groups. This includes neoplastic and infectious diseases, despite the rigorous surveillance systems in place for both. Given that there are ongoing efforts within DG Eurostat to setup a systematic collection of morbidity data, this situation may change in the future.

Adjusting treatable mortality in terms of the age-ranges included and estimating the treatable burdens of disease are possible given the currently available data. While the first set of adjustments has only a small impact on country rankings, the second adjustment profoundly changes them. There is also country-specific variation in the impact of the changes. The country-specific effects of adjusting age-ranges may be the consequence of poor data at very high ages, but are more likely an accurate representation of mortality at older ages. On the other hand, the large impact of using the treatable burden of disease measures are more challenging to explain. Therefore, considering deaths from all ages in the treatable mortality indicator may represent a helpful conceptual simplification and include relevant improvements in the health status at older ages. Old-age mortality has been shown to be an increasingly important demographic feature in high-income settings[19] and is therefore an important part of future international comparisons in health system performance.

Despite their ready availability, interpreting the disability-based treatable burden of disease estimates (YLD and DALYs) may be challenging due to the fact that for some causes of death and geographies the case fatality rate is estimated assuming spatial smoothness (e.g., similar values in neighbouring countries) to overcome missing data. Such an approach would invalidate any benchmarks based on the indicator if the purpose of the exercise is to compare the ability of neighbouring health systems to prevent death, since

[18] There may be differences between data collected by national statistics offices and the data shared with international health databases. The focus of this study was on the availability of data in the latter only.

[19] Meslé, F., & Vallin, J. (2006). Diverging Trends in Female Old-Age Mortality: The United States and the Netherlands versus France and Japan. *Population and Development Review*, *32*(1), 123–145. https://doi.org/10.1111/j.1728-4457.2006.00108.x

the assumption of spatial smoothness may clearly be violated. This is less concerning for YLL estimates, which rely on mortality data only.

Limitations of the feasibility study

One of the major limitations of the current analysis includes the scarcity and lack of recent data, as well as lack of disaggregated prevalence data for the majority of causes of death in the current list of preventable and treatable causes of death. Essentially, it was not possible to fully explore adjustments based on refined prevalence data due to lack of relevant information. Furthermore, the self-reported prevalence data on which we currently rely for all prevalence-based adjustment may have seriously affected the reported country ranks. Previous research comparing self-reported morbidity between the national census and a cross-country health information survey found moderate concordance between the two on morbidity-related questions and a tendency of the health information survey to underestimate the prevalence of persons with chronic disease[20].

We had not compared the various country ranks generated in this study with other established rankings of health system performance or more detailed health system comparisons, for example the European Observatory on Health Systems and Policies reports[21]. Such an exercise could have further contextualised the findings and helped explain why the ranks changed between adjustments the way they did. However, such a comparison would require additional substantial time and resources and is out of scope of an initial feasibility study.

In addition, experts highlighted that the 'learning effects' adjustment has potentially important conceptual flaws that may interfere to some extent with the quality of care construct. We nevertheless reported on this adjustment for completeness, but a more rigorous assessment of potential learning effects would require a more substantial theoretical basis for the selection of causes of death, economic indicators, and model structures (especially appropriate lags between variables).

Finally, the inclusion of causes of death in this study was primarily based on data availability and does not fully comply with the joint OECD/Eurostat list of preventable and treatable causes of death. In fact, there were only eighteen instances of precise alignment between the ICD-10 categories in the available cause of death data and the categories defined by the preventable and treatable lists (out of 66 and 100 categories, respectively).

Recommendations for future development and use of the avoidable mortality indicator

Collecting reliable and timely morbidity data will remain a challenge in the near future. The situation may be partially remedied by exploring additional national sources of health data, which are not be currently accessible to the public. However, accessing these sources of health data (e.g., insurance claims data, electronic health records) is a highly time-consuming process if it is to include all thirty countries included in this study. It may also not be possible in all places due to variation in local legislation and capacity. Alternatively, one may consider relying on morbidity estimates published in the scientific literature. However, these estimates are not comprehensive and may therefore afford us only insight into specific countries and for specific disease groups. Further, the methods used may differ between the studies, making comparability over time and space unlikely. With these challenges in mind, the most practicable approach over the short-term is to focus efforts and resources into collecting morbidity data for a smaller subset of diseases and making them available. This requires a shorter list of avoidable causes of death compared to the current OECD/Eurostat list.

[20] Van der Heyden, J., De Bacquer, D., Tafforeau, J., & Van Herck, K. (2014). Reliability and validity of a global question on self-reported chronic morbidity. Journal of Public Health, 22(4), 371–380. https://doi.org/10.1007/s10389-014-0624-9

[21] https://www.hspm.org/

An appealing alternative is to focus on analysing mortality due to a subset of diseases that may be particularly informative regarding the specific functions of health systems, including risk factor control, population screening, and emergency, and chronic care of common diseases. Such an approach may be informed by utilising the concept of "sentinel causes" described by Vergara-Duarte et al.[22] in combination with knowledge of disease categories most relevant for the current stage in the health transition and an understanding of the fact that deaths from these causes results due to a failure of the health system at specific stages of the patient pathway (cf. Morris et al.[23]). We have explored such an approach to health system performance assessment in Chapter 5 of this report. We show that this approach is feasible given the data available today and that it could provide interesting insight into the comparative performance of health systems of countries included in the study. However, the approach requires further elaboration based on expert input, particularly in selecting appropriate causes of death. This would require further support from the European Commission.

In the short term, the inclusion of measures of years of life lost and relaxing of age-restrictions constitute a potential methodological advancement within the existing framework of avoidable mortality. In the longer term, this report provides a novel and eventually useful methodological framework regarding a systems perspective for linking specific causes to specific health care outcomes. The novel approach requires the further development of a new list of preventable and/or treatable causes of death should be considered in order to better link the specific causes of death with the specific points in the health care system. Also, specific disease groups that represent key functions of a health system and their respective role to the potential points of failure of care provision should be sought and adequately explored.

[22] Vergara-Duarte, M., Borrell, C., Perez, G., Martin-Sanchez, J. C., Cleries, R., Buxo, M., . . . Benach, J. (2018). Sentinel Amenable Mortality: A New Way to Assess the Quality of Healthcare by Examining Causes of Premature Death for Which Highly Efficacious Medical Interventions Are Available. Biomed Research International, 2018, 5456074. doi:10.1155/2018/5456074

[23] Morris, M., Landon, S., Reguilon, I., Butler, J., McKee, M., & Nolte, E. (2020). Understanding the link between health systems and cancer survival: A novel methodological approach using a system-level conceptual model. Journal of Cancer Policy, 25, 100233. https://doi.org/10.1016/j.jcpo.2020.100233

ANNEX 1. ANNOTATED REVIEW OF AVOIDABLE MORTALITY STUDIES 2010-2020

Author	Title	Country/region	Time period	Topic/aim of study	Number of causes	Data source
Mustard et al. 2010	Avoidable Mortality for Causes Amenable to Medical Care, by Occupation in Canada, 1991-2001	Canada	1991-2001	Examine differences in the incidence of avoidable mortality for causes amenable to medical care among occupationally active adults in Canada aged 30-69 by occupation and skill level as well as for persons who were not occupationally active.	Basis: Nolte & McKee (2008). 29 conditions with IHD treated separately. Age limit 0-74 with variation between causes.	Canadian Census Mortality and Cancer Follow-up Study
Stirbu et al. 2010	Educational inequalities in avoidable mortality in Europe	16 European populations (Finland, Sweden, Norway, Denmark, Belgium, Switzerland, Italy, Spain, Slovenia, Hungary, the Czech Republic, Poland, Lithuania, and Estonia)	Variable, mostly 1990-2000	Estimate the magnitude of educational inequalities in avoidable mortality in different European countries.	Basis: Rutstein (1976). 13 conditions. Age limit 30-64.	Mortality data for several Central and Eastern European countries and Estonia come from cross-sectional unlinked mortality studies, in which information on socioeconomic position is derived separately from death certificates and census records. Data for other European countries come from longitudinal follow-up studies, in which socioeconomic position as determined during a census has been linked to mortality.

Baburin et al. 2011	Avoidable mortality in Estonia: Exploring the differences in life expectancy between Estonians and non-Estonians in 2005-2007	Estonia	2005-2007	Evaluate the contribution of avoidable causes of death to the difference in life expectancy between Estonians and non-Estonians in Estonia.	Basis: Nolte and McKee (2004) and Page et al. (2006). 53 causes (19 preventable and 34 treatable). Age limit 0-74.	Statistics Estonia (census data).
Chau et al. 2011	Avoidable mortality pattern in a Chinese population-Hong Kong, China	Hong-Kong, Paris, Inner London and Manhattan	2004-2006	Examine the avoidable mortality pattern in Hong Kong and the influence of age and gender. Compare the avoidable mortality pattern in Hong Kong with those in Paris, Inner London and Manhattan.	Basis: Weisz et al. (2008). 22 conditions with IHD treated separately. Age limit 1–74.	Census and Statistics Department of Hong Kong and other respective official statistics agencies.
Desai et al. 2011	Measuring NHS performance 1990-2009 using amenable mortality: interpret with care	United Kingdom	1990-2009	Examine whether and to what extent the changes of the NHS in each part of the UK, including the increase in spending in England, are reflected in health outcomes, using the concept of amenable mortality.	Basis: Nolte & McKee (2008). 33 conditions plus IHD treated separately. Age limit 0-74 with variation between causes.	World Health Organization’s (WHO) mortality database.
Grabauskas et al. 2011	Trends in Avoidable Mortality in Lithuania During 2001-2008 and Their Impact on Life Expectancy	Lithuania	2001-2008	Assess the level of avoidable mortality as well as its changes over time in Lithuania during 2001–2008 and to define the impact of avoidable mortality on life expectancy.	Basis: Holland (1988). 12 conditions (9 treatable, 3 preventable). Age limit 5-64 with variation between causes.	Lithuanian Department of Statistics, WHO European “Health for All” database
Nolte et al. 2011	Variations in amenable mortality-Trends in 16 high-income nations	13 countries of Western Europe, Australia, New Zealand and Japan	1997-2007	Examines trends in amenable mortality in sixteen high-income countries.	Basis: Nolte and McKee (2004). 33 conditions plus IHD treated separately. Age limit 0-74 with variation between causes.	WHO mortality database, US CDC

Ollandezos et al. 2011	Trends of mortality in Greece 1980-2007: a focus on avoidable mortality	Greece	1980-2007	Examine avoidable mortality in Greece between 1980 and 2007.	Basis: Newey et al. (2004). 37 conditions (33 treatable and 3 preventable) with IHD treated separately. Age limit 0-74 with variation between causes.	National Statistic Service of Greece.
Schoenbaum et al. 2011	Mortality amenable to health care in the United States: the roles of demographics and health systems performance	United States	2004-2005	Examine the variation of mortality amenable to health care across the US and assesses the extent to which variations in state rates are associated with two key socio-demographic characteristics, poverty and race, and then, control- ling for those characteristics, with a variety of health-systems indicators.	Basis: Nolte and McKee (2004). 33 conditions plus IHD treated separately. Age limit 0-74 with variation between causes.	CDC Multiple Cause-of-Death data.
Fantini et al. 2012	Amenable mortality as a performance indicator of Italian health-care services	Italy	2006-2008	Analyze the regional variability in health-care services using amenable mortality as a performance indicator.	Basis: Nolte and McKee (2004). 33 conditions plus IHD treated separately. Age limit 0-74 with variation between causes.	Italian National Institute of Statistics (ISTAT).
Lumme et al. 2012	Socioeconomic equity in amenable mortality in Finland 1992-2008	Finland	1992-2008	Assess equity of health care by examining the extent of and trends in socioeconomic inequities in amenable mortality. Evaluate equity in more detail by categorizing conditions that cause amenable deaths according to the place of intervention to which conditions are responsive.	Basis: Nolte and McKee (2008) and Page et al. (2006). 41 causes (primary health care: primary prevention, early detection and treatment, improved treatment and medical care, and specialised health care). Age limit 1-74 with variation between causes	Statistics Finland (Causes of Death Register and the annual individual-level employment statistics database; data linkage).

Nagy et al. 2012	Mortality amenable to health care and its relation to socio-economic status in Hungary, 2004–08	Hungary	1996-2008	Assesses the trends of amenable mortality over time and, its spatial inequalities with respect to deprivation, in Hungary	Basis: Nolte and McKee (2004). 33 conditions plus IHD treated separately. Age limit 0-74 with variation between causes.	Hungarian Central Statistical Office.
Nolte et al. 2012	In Amenable Mortality-Deaths Avoidable Through Health Care-Progress In The US Lags That Of Three European Countries	United States, France, Germany, and the United Kingdom	1999-2007	Compare trends in amenable mortality in US, France, Germany and the UK	Basis: Nolte and McKee (2004). 33 conditions plus IHD treated separately. Age limit 0-74 with variation between causes.	World Health Organization mortality database.
Plug et al. 2012	Socioeconomic inequalities in mortality from conditions amenable to medical interventions: do they reflect inequalities in access or quality of health care?	14 European countries (Sweden, Finland, Denmark, Norway, Belgium, Switzerland, Italy, Spain, Poland, Czech Republic, Hungary, Slovenia, Estonia, and Lithuania)	Variable, mostly 1990-2000	Study whether inequalities in mortality from conditions amenable to medical intervention vary between countries in patterns which differ from those observed for other (non-amenable) causes of death.	Basis: Rutstein (1976). 13 conditions. Age limit 30-64.	Mortality data for several Central and Eastern European countries and Estonia come from cross-sectional unlinked mortality studies, in which information on socioeconomic position is derived separately from death certificates and census records. Data for the Basque country and Lithuania are derived from a cross-sectional census linked study. Data for other European countries come from longitudinal follow-up studies, in which socioeconomic position as

						determined during a census has been linked to mortality.
Amiresmaili et al. 2013	Study of the Avoidable Mortality in Iran: Kerman Province	Kerman province, Iran	2004-2010	Describe amenable mortality in Kerman province.	Basis: Holland (1997). 31 conditions. Age limit 0-74.	Kerman University of Medical Science
Chen et al. 2013	Temporal trend analysis of avoidable mortality in Taiwan, 1971-2008: overall progress, with areas for further medical or public health investment	Taiwan	1971-2008	Document temporal trends in avoidable mortality.	Basis: Holland (1997). 15 conditions. Age limit 0-64 with variation between causes.	Taiwan National Death Certification Registry
Heijink et al. 2013	Spending more money, saving more lives? The relationship between avoidable mortality and healthcare spending in 14 countries	14 western countries (Australia, France, New Zealand, UK, Austria, Germany, Norway, US, Denmark, Japan, Spain, Finland, Netherlands, and Sweden)	1996-2006	Study the relationship between healthcare spending and avoidable mortality.	Basis: Nolte & McKee (2004). 37 conditions plus IHD treated separately. Age limit 0-74 with variation between causes.	WHO Mortality Database
Kossarova et al. 2013	Avoidable mortality: a measure of health system performance in the Czech Republic and Slovakia between 1971 and 2008	Czechia and Slovakia	1971-2008	Assess the performance of the Czech and Slovak health care systems before (1971–1989) and after (1990–2008) the fall of the Communist regime.	Basis: Holland (1997); 16 conditions; Age limit 0-64 with variation between causes.	Statistical Office of the Slovak Republic and Czech Statistical Office
Lavergne et al. 2013	What, if anything, does amenable mortality tell us about regional health system performance?	British Columbia, Canada	2002-2009	Assess whether amenable mortality is a potentially useful indicator of regional health system performance in Canada.	Basis: Nolte & McKee (2004). 46 conditions. Age limit 0-74 with variation between causes.	BC Vital Statistics

McCallum et al. 2013	Socioeconomic differences in mortality amenable to health care among Finnish adults 1992-2003: 12 year follow up using individual level linked population register data	Finland	1992-2003	Analyse changes in the socioeconomic distribution of mortality amenable to primary prevention, early detection and improved treatment and medical care between 1992 and 2003 in Finland.	Basis: Nolte & McKee (2004). List no longer available.	Statistics Finland (individual data linkage of annual tax statistics and causes of death register)
Omranikhoo et al. 2013	Avoidable Mortality Differences between Rural and Urban Residents During 2004-2011: A Case Study in Iran	Iran	2004-2011	Measure health system performance by following the trend of healthcare indicator and also inter-sectoral health policy between urban and rural residents during 2004–2011 in one of southern provinces in Iran.	Basis: Nolte & McKee (2004). 39 conditions (34 treatable, 4 health policy, IHD treated separately). Age limit 0-74 with variation between causes.	Ministry of Health and Medical Education
Quercioli et al. 2013	The effect of healthcare delivery privatisation on avoidable mortality: longitudinal cross-regional results from Italy, 1993-2003	Italy	1993-2003	Examine whether the share of private delivery of healthcare in Italy affected each region’s progress in one indicator of health system performance: avoidable mortality.	Basis: Nolte & McKee (2004). 39 conditions. Age limit 0-74 with variation between causes.	Italian Bureau of Statistics (ISTAT), Health for All - Italy database, and Italian Ministry of Health
Stracci et al. 2013	Effect of healthcare on mortality: trends in avoidable mortality in Umbria, Italy, 1994-2009	Umbria, Italy	1994-2009	Examine recent trends in avoidable and non-avoidable mortality in Umbria.	Basis: Korda & Butler (2006). 34 conditions. Age limit 0-74 with variation between causes.	Cause of Death Nominative Registry (ReNCaM) of the Umbria region
Sundmacher 2013	Trends and levels of avoidable mortality among districts: "Healthy" benchmarking in Germany	Germany	2000-2008	Illustrate relative levels and time trends in avoidable mortality among the 413 German local districts for men and women separately.	Basis: Nolte & McKee (2004). 38 conditions. Age limit 0-70 with variation between causes.	German Federal Statistical Office

Hoffmann et al. 2014	Social differences in avoidable mortality between small areas of 15 European cities: an ecological study	15 European cities (Amsterdam, Barcelona, Bratislava, Brussels, Budapest, Helsinki, Košice, Lisbon, London, Madrid, Prague, Rotterdam, Stockholm, Turin, and Zurich)	2001	Analyse (1) whether levels of mortality from avoidable causes of death are higher in deprived small areas and (2) whether the magnitude of these social inequalities in mortality differs between European cities, regions and gender.	Basis: Hoffmann et al. (2013). Additional file no longer available.	Not public
Kunitz et al. 2014	Historical Trends and Regional Differences in All-Cause and Amenable Mortality Among American Indians and Alaska Natives Since 1950	American Indians and Alaska Natives, United States	1949–1953 (American Indians), 1999–2009 (Among American Indians/Alaska Natives)	Describe the different regions in which AI/AN persons live in terms of amenable mortality and the ways in which those different contexts appear to have influenced mortality in the 1950s and the changes since then.	Not reported	US Public Health Service and AI/AN Mortality Database
Manderbacka et al. 2014	Multiple social disadvantage does it have an effect on amenable mortality: a brief report	Finland	1992-2008	Elaborate income inequalities in amenable mortality in Finland among the working age population aged 25 to 59 years.	Basis: Nolte & McKee (2004). 40 conditions. Age limits 1-74 with variation between conditions.	Individual data linkage between Causes of Death Statistics of Statistics Finland and employment register
Manderbacka et al. 2014	Amenable mortality by household income and living arrangements: a linked register-based study of Finnish men and women in 2000-2007	Finland	2000-2007	Examining the effect of income and living arrangements on mortality amenable to healthcare in Finland in 2000–2007.	Basis: Nolte & McKee (2004). 40 conditions. Age limits 0-74 with variation between conditions.	Individual data linkage between Causes of Death Statistics of Statistics Finland and other administrative registers
Nolasco et al. 2014	Trends in socioeconomic inequalities in	3 Spanish cities (Alicante,	1996–99, 2000–2003 and 2004–2007	Analyse the temporal evolution of amenable mortality between 1996	Basis: Nolte and McKee (2004); 33 conditions plus IHD treated	Comunitat Valenciana Death Register Office

	amenable mortality in urban areas of Spanish cities, 1996-2007	Castellón, and Valencia)		and 2007 and its association with socioeconomic status in small areas (census tracts) of the three largest cities, province capitals, of the Comunitat Valenciana (Spain): Alicante, Castellón, and Valencia.	separately; Age limit 0-74 with variation between causes.	
Perez et al. 2014	Approaches, strengths, and limitations of avoidable mortality	Spain	1980-2007	Highlight difficulties in relating the evolution of amenable and avoidable mortality to health-care system and/or inter-sectoral services and policy interventions.	Basis: Simonato et al. (1998), Tobias & Jackson (2001) and James et al. (2006). List not reported.	National Institute of Statistics (Spain)
Botero et al. 2015	Avoidable mortality in the states adjacent to the Mexico-United States border; 1999-2001 and 2009-2011	Mexican and US border regions (Baja California, Coahuila, Chihuahua, Nuevo León, Sonora, Tamaulipas, and Arizona, California, New Mexico, Texas)	1999-2001 and 2009-2011	Measure the effect of avoidable mortality in life expectancy changes in the U.S.-Mexico Border States between 1999-2001 and 2009-2011.	Basis: Nolte and McKee (2004); 33 conditions plus IHD treated separately; Age limit 0-74 with variation between causes.	National Institute of Statistics and Geography (Mexico), National Center for Health Statistics and United States Census Bureau (US)
Gavurova & Vagasova 2015	The significance of amenable mortality quantification for financing the health system in Slovakia.	Slovakia	2002 and 2013	Examine the level and trend of amenable mortality because it directly responses to quality of health care and thus, with effectiveness of health care system.	Basis: Nolte & McKee (2008). 27 conditions. Age limit 0-74 with variation between causes.	World Health Organization (WHO) database, National Health Information Center (Slovakia), Statistical Database of the United Nations Economic Commission for Europe
Gusmano et al. 2015	Shanghai rising: health improvements as measured by	Shanghai, China	1999-2010	Study the evolution of Shanghai's healthcare	Basis: Nolte & McKee (2004). 21 conditions. Age limit 1-74.	Shanghai Municipal Center for Disease Control and

	avoidable mortality since 2000			system by analyzing "Avoidable Mortality".		Prevention, Bureau of Vital Statistics of the New York City Department of Health and Mental Hygiene and data on population are from the U.S. Bureau of the Census, Office of National Statistics (London), Institut National de la Santé et de la Recherche Médicale (INSERM) and Institut National de la Statistique et des Etudes Economiques (INSEE)
Kinge et al. 2015	Income related inequalities in avoidable mortality in Norway: A population-based study using data from 1994-2011	Norway	1994-2011	Compare the trend in income-related inequality in avoidable mortality with the trend in income inequality, measured by the Gini coefficient for income.	Basis: ONS (2012), Nolte & McKee (2004) and Page et al. (2006). 44 causes. Age limit 0-74 with varation between causes.	Statistics Norway (individual linkage of Cause of Death Registry and Norwegian Income Register)
Nolasco et al. 2015	Trends in socioeconomic inequalities in preventable mortality in urban areas of 33 Spanish cities, 1996-2007 (MEDEA project)	33 Spanish cities	1996-2007	Describe trends in preventable mortality and analyse its relationship to socioeconomic inequalities in small areas of 33 large cities between 1996–2001 and 2002–2007.	Basis: Nolte and McKee (2004); 33 conditions plus IHD treated separately; Age limit 0-74 with variation between causes.	Spanish National Statistics Institute
Omariba 2015	Immigration, ethnicity, and avoidable mortality in Canada, 1991-2006	Canada	1991-2006	Establish whether immigrants overall and selected foreign-born ethnic groups (Western Europeans, South Asians,	Basis: CIHI (2012). 12 groups of conditions. Age limit 0-74 with variation between causes.	Canadian Census Mortality and Cancer Follow-up Study

				Chinese, and Filipinos) have an advantage over nonimmigrants in avoidable mortality.		
Park et al. 2015	Avoidable mortality among First Nations adults in Canada: A cohort analysis	Canada	1991-2006	Examine avoidable mortality among First Nations adults.	Basis: CIHI (2012). 12 groups of conditions. Age limit 0-74 with variation between causes.	Canadian Census Mortality and Cancer Follow-up Study
Soltes & Gavurova 2015	QUANTIFICATION AND COMPARISON OF AVOIDABLE MORTALITY - CAUSAL RELATIONS AND MODIFICATION OF CONCEPTS	Slovakia	2002-2013	Evaluate avoidable mortality development at conceptual and evaluative level.	Basis: Nolte and McKee(2008), Tobias and Yeh (2009), Plug et al. (2011)	WHO mortality database and Statistical office of the Slovak Republic
Feng et al. 2016	Analysis of health service amenable and non-amenable mortality before and since China's expansion of health coverage in 2009	China	2006-2012	Explore the early impacts of the expansion of universal coverage on public health.	Basis: Nolte and McKee (2004); 34 conditions plus IHD treated separately; Age limit 0-74 with variation between causes	Chinese Center for Disease Control and Prevention
Lehikoinen et al. 2016	Comparative observational study of mortality amenable by health policy and care between rural and urban Finland: no excess segregation of mortality in the capital despite its increasing residential differentiation	Finland	1992–2008	Assess whether the capital city has an excess of geographical inequality in mortality — unrelated to socioeconomic differences — compared to other types of geographic areas.	Basis: Nolte & McKee (2004), Page et al. (2006). List not directly reported.	Statistics Finland (individual linkage)
Surenjav et al. 2016	Trends in amenable mortality rate in the Mongolian	Mongolia	2007-2014	Assess the trend and magnitude of avoidable mortality in Mongolia with the purpose of providing	Basis: Nolte and McKee (2004); 32 conditions plus IHD treated separately; Age limit 0-	Health Statistics Office of the Ministry of Health of Mongolia

	population, 2007-2014			evidence for decisions on resource allocation.	74 with variation between causes.	
Anita et al. 2017	Trends and socioeconomic inequalities in amenable mortality in Switzerland with international comparisons	Switzerland	1996-2010	Examine: (1) time trends in amenable mortality in Switzerland, (2) Swiss results in an international context, and (3) Swiss-specific association between sociodemographic characteristics and amenable mortality.	Basis: Nolte and McKee (2004); 34 conditions plus IHD treated separately; Age limit 0-74 with variation between causes.	Swiss Federal Statistical Office and the Swiss National Cohort (SNC)
Gianino et al. 2017	Declining amenable mortality: a reflection of health care systems?	22 European OECD countries	2000-2014	Examine whether specific health care system types are associated with different time trend declines in amenable mortality from 2000 to 2014.	Basis: Nolte and McKee (2004); 33 conditions plus IHD treated separately; Age limit 0-74 with variation between causes.	World Health Organization (WHO) Mortality Database and the 2012 Revision of the World Population Prospects (WPP)
Gianino et al. 2017	Declining Amenable Mortality: Time Trend (2000-2013) and Geographic Area Analysis	32 OECD countries	2000–2013	Update the amenable mortality rates in 32 OECD countries at 2013 or the last available year, to describe the annual variations in mortality amenable to health care during 2000–2013, to determine whether these changes were constant over time, and to evaluate the pattern across geographic areas.	Basis: Nolte and McKee (2004); 33 conditions plus IHD treated separately; Age limit 0-74 with variation between causes.	World Health Organization (WHO) Mortality Database and the 2012 Revision of the World Population Prospects (WPP)
Hone et al. 2017	Large Reductions In Amenable Mortality Associated With Brazil	Brazil	2000-2012	Investigate whether the expansion of the family health strategy reduced amenable mortality rates in Brazil.	Basis: Nolte & McKee (2004). List not reported.	Brazilian Ministry of Health (DATASUS), Atlas Brazil and the Brazilian Institute of Geography and Statistics

Hone et al. 2017	Association between expansion of primary healthcare and racial inequalities in mortality amenable to primary care in Brazil: A national longitudinal analysis	Brazil	2000-2013	Evaluate whether expansion of the family health strategy was associated with differential reductions in mortality amenable to PHC between racial groups.	Basis: Alfradique (2009). 45 conditions. Age limit 0-70.	Brazilian Ministry of Health (DATASUS) and the Brazilian Institute of Geography and Statistics
Jarcuska et al. 2017	MORTALITY AMENABLE TO HEALTH CARE IN EUROPEAN UNION COUNTRIES AND ITS LIMITATIONS	28 EU Member States	2002-2013	Analyse differences in amenable mortality across European Union countries and to determine the associations between amenable mortality and life expectancy at birth	Basis: Plug et al. (2011). 16 conditions. Age limit 0-74.	World Health Organization (WHO) database
Khan et al. 2017	Socioeconomic gradients in all-cause, premature and avoidable mortality among immigrants and long-term residents using linked death records in Ontario, Canada	Ontario, Canada	2002-2012	Examine all-cause, premature and avoidable mortality rates of immigrants and long-term residents across income levels.	Basis: Nolte & McKee (2004), James et al. (2006). 49 conditions (42 treatable, 6 preventable, IHD separate). Age limit 0-47 with variation between causes.	Institute for Clinical Evaluative Sciences (ICES) (individual linkage of Ontario Registrar General-Death files (ORG-D), Ontario Registered Persons database (RPDB), Canadian census and the Immigration, Refugees and Citizenship Canada (IRCC) Permanent Resident database)
Mackenbach et al. 2017	Trends In Inequalities In Mortality Amenable To Health Care In 17 European Countries	17 European countries	1980–2010	Study trends in inequalities in mortality from conditions amenable to health care intervention in a range of European countries since the 1980s.	Basis: Mackenbach et al. (1990), Nolte & McKee (2004) and Tobias & Jackson (2001). 23 conditions. Age limit 35-79.	Not public

Weber & Clerc 2017	Deaths amenable to health care: Converging trends in the EU?	28 EU Member States	1994–2013	Calculate annual amenable mortality rates for 28 EU countries and the EU for the period 1994–2013 based on the recently published list of deaths amenable to health care by Eurostat.	Eurostat (2013). 29 conditions. Age limit 0-74.	Eurostat's data collection on causes of death
Aburto et al. 2018	Trends in avoidable mortality over the life course in Mexico, 1990-2015: a cross-sectional demographic analysis	Mexico	1990-2015	Analyse average lifespan and quantify the effect of avoidable/amenable mortality on the difference between state-specific mortality and a low-mortality benchmark in Mexico during 1990–2015.	Aburto et al. (2016). List not reported in the paper.	Mexican Statistical Office (INEGI) and Mexican Population Council (CONAPO)
Karanikolos et al. 2018	Amenable mortality in the EU-has the crisis changed its course?	28 EU Member States	2000-2015	Analyse amenable mortality trends from 2000 onwards in the countries of the EU in order to understand the possible impacts of the global financial crisis by means of Joinpoint regression analysis.	Basis: Nolte & McKee (2004). 32 conditions. Age limit 0-74 with variation between causes.	WHO detailed mortality database
Lumme et al. 2018	Trends of socioeconomic equality in mortality amenable to healthcare and health policy in 1992–2013 in Finland: a population-based register study	Finland	1992-2013	Study trends in socioeconomic equality in mortality amenable to healthcare and health policy interventions.	Basis: Nolte & McKee (2004), Page et al. (2006). List not directly reported.	Statistics Finland (individual linkage of Causes of Death to population Censuses and the annual Employment statis-tics of Statistics Finland)
Nolasco et al. 2018	Economic Crisis and Amenable Mortality in Spain	Spain	2002-2013	Describe the evolution of overall mortality and amenable mortality in Spain between 2002–	Basis: Nolte & McKee (2004). 34 conditions with separate treatment of IHD. Age limit 0-74	Spanish National Statistics Institute

				2007 (before the economic crisis) and 2008–2013 (during the economic crisis), nationally and by province, as well as to analyse trends in the risks of death and their association with indicators of the impact of the crisis.	with variation between causes.	
Vergara-Duarte et al. 2018	Sentinel Amenable Mortality: A New Way to Assess the Quality of Healthcare by Examining Causes of Premature Death for Which Highly Efficacious Medical Interventions Are Available	United States and Spain	1984-2004	Introduce a new approach to amenable mortality by identifying "sentinel amenable mortality".	Basis: own. 27 conditions. Age limit 0-74 with variation between causes.	Spanish National Institute of Statistics and Centers for Disease Prevention and Control and the US Census Bureau
Wall-Wieler et al. 2018	Avoidable mortality among parents whose children were placed in care in Sweden: a population-based study	Sweden	1990-2012	Investigate whether parents whose children were placed in care had higher rates of avoidable mortality.	Basis: ONS (2012). 43 conditions (14 preventable, 18 amenable, rest both). Age limit 0-74 with variation between causes.	individual linkage of Swedish National Board of Health and Welfare (the Medical Birth Register, the Cause of Death Register, the Hospital Discharge Register, the National Child Welfare Register), the National Council for Crime Prevention (the National Register of Criminal Convictions) and Statistics Sweden (the Multi-

						Generation Register, the Register for the Total Population and the Longitudinal Integrated Database for Health Insurance and Labor Market Studies (LISA by Swedish acronym), and the Swedish Parent Register)
Currie et al. 2019	Evaluating effects of recent changes in NHS resource allocation policy on inequalities in amenable mortality in England, 2007-2014: time-series analysis	England	2007-2014	Explore whether changes in overall funding and the distribution of those funds in England between 2007 and 2014 are having an impact on the gap in rates of amenable mortality.	Basis: Nolte & McKee (2004), ONS (2016). 32 conditions. Age limit 0-74 with variation between causes.	NHS Digital
Ericsson et al. 2019	Life-course socioeconomic differences and social mobility in preventable and non-preventable mortality: a study of Swedish twins	Sweden	Birth cohort study	Examine socioeconomic differences in mortality and causes of death in Sweden in a genetically informative design using twins.	Basis: Plug et al. (2011). 39 conditions. Age limit 0-70.	Screening Across the Lifespan Twin study (SALT) and Swedish Adoption/Twin Study of Aging (SATSA)
Gavurova & Toth 2019	Preventable Mortality in Regions of Slovakia Quantification of Regional Disparities and Investigation of the Impact of Environmental Factors	Slovakia	2015	Quantify regional disparities in the development of preventable mortality and to examine the extent of the impact of selected environmental factors on changes in the development of its values.	Basis: ONS (2013). Not directly reported in the paper.	National Health Information Centre of the Slovak Republic, Water Research Institute of the Slovak Republic, and Statistical Office of the Slovak Republic

Gavurova et al. 2019	THE IMPACT OF HEALTHCARE AVAILABILITY ON THE AMENABLE MORTALITY: COUNTRY STUDY	Slovakia	1998-2015	Provide information on the relationship between the accessibility of healthcare and avoidable mortality.	Basis: ONS (2013). 29 conditions. Age limit 0-74.	National Health Information Centre of the Slovak republic.
Gavurova et al. 2019	Investigation of Relationship Between Spatial Distribution of Medical Equipment and Preventable Mortality	Slovakia	2008-2017	Investigate the relationship between the spatial distribution of the selected medical equipment and the preventable mortality rate in the regions of the Slovak Republic.	Basis: Eurostat (2018). Preventable mortality. 27 groups.	National Health Information Center of the Slovak Republic and the Statistical Office of the Slovak Republic.
Neethling et al. 2019	Trends and inequities in amenable mortality between 1997 and 2012 in South Africa	South Africa	1997-2012	Establish an amenable cause of death list appropriate for SA and to determine the levels, trends, geographical distribution, population group differences and international comparisons of mortality amenable to healthcare.	Basis: Nolte & McKee (2004), Tobias & Yeh (2009). 45 conditions. Most conditions without age limits.	Second South African National Burden of Disease (NBD) study.
Saltarelli et al. 2019	Deaths preventable by actions of the Unified Health System in the population of the Brazilian Southeast Region	Southeast region, Brazil	2000-2013	Analyze the mortality trend in the population aged 5-69 years residing in the Southeast and Federal Units (UF), using the "Brazilian List of Preventable Deaths Causes".	Basis: Malta (2011). 5 groups of conditions: reducible by vaccine-preventable actions; reducible by health promotion actions, adequate prevention, control and care for diseases of infectious causes; reducible by appropriate health promotion, prevention, control and care for noncommunicable diseases; reducible by	Mortality Information System (SIM), Brazilian Institute of Geography and Statistics (IBGE), and the National Household Sample Survey (PNAD).

					adequate action of prevention, control and care for the causes of maternal death; reducible by intersectoral actions and actions of health promotion, prevention and adequate care for external causes. Age limit 5-74.	
Subedi et al. 2019	Does geography matter in mortality? An analysis of potentially avoidable mortality by remoteness index in Canada	Canada	2011-2015	Examine major causes of both preventable and treatable mortality by relative remoteness of Canadian communities.	Basis: CIHI (2012). 81 conditions (split into preventable and treatable). Age limit 0-74.	Statistics Canada (Canadian Vital Statistics – Death Database (CVSD) and census data).
Walsh & Grey 2019	The contribution of avoidable mortality to the life expectancy gap in Maori and Pacific populations in New Zealand-a decomposition analysis	New Zealand	2013-2015	Determine the contribution of avoidable causes of death to the life expectancy diff erentials in both Māori and Pacific compared with non-Māori/non-Pacific ethnic groups in New Zealand.	Basis: Ministry of Health (2016). 50 conditions (preventable, treatable, or both). Age limit 0-74 with variation between causes.	New Zealand Mortality Collection.
Wuhlichen 2019	Avoidable Mortality in the German Baltic Sea Region Since Reunification: Convergence or Persistent Disparities?	2 German Lander (Mecklenburg–Vorpommern and Schleswig–Holstein)	1990-2011	Explore the development of the adaptation process in mortality for MV compared to SH since reunification, taking particular account of amenable and preventable mortality.	Basis: Nolte & McKee (2004), Page et al. (2006). 65 conditions (41 treatable, 24 preventable). Age limit 0-74 with variation between causes.	Research data centre of the statistical offices of the federal states and the the statistical offices of MV and SH/Hamburg
Zygmunt et al. 2019	Avoidable Mortality Rates Decrease but Inequity Gaps Widen for Marginalized Neighborhoods: A	Ontario, Canada	1993-2014	Examine trends in AM rates by level of neighborhood marginalization.	Basis: CIHI (2012). 81 conditions (split into preventable and treatable). Age limit 0-74.	Institute for Clinical Evaluative Sciences (ICES) (individual linkage of Ontario Registrar General-

	Population-Based Analysis in Ontario, Canada from 1993 to 2014					Death files (ORG-D), Ontario Health Insurance Plan (OHIP) database, Registered Persons Database (RPDB)).
Zygmunt et al. 2019	Neighbourhood-level marginalization and avoidable mortality in Ontario, Canada: a population-based study	Ontario, Canada	1993-2014	Examine the impact ofneighbourhood marginalization on avoidable mortality (AM) from preventable and treatable causes of death.	Basis: CIHI (2012). 81 conditions (split into preventable and treatable). Age limit 0-74.	Institute for Clinical Evaluative Sciences (ICES) (individual linkage of Ontario Registrar General-Death files (ORG-D), Ontario Health Insurance Plan (OHIP) database, Registered Persons Database (RPDB)), Discharge abstract database (DAD), National Ambulatory Care Reporting System (NACRS).

ANNEX 2. DATA AND CODE

All of the code used to generate the results in this report can be found online at (https://github.com/rhrzic/TreatableMortality). This is a temporary repository and will be moved into permanent storage after the report is approved.

ANNEX 3. CALCULATING AVOIDABLE YEARS OF LIFE LOST

Data required

The required data is freely available from the IHME website for all included countries. Due to IHME estimation methods, full data is available 1990-2017.

Calculation procedure

Age- and sex-specific rates of years of life lost for the selected diseases (Table S1) are extracted from IHME.

Table S1. Included disease categories

Disease group	*ICD-10 mapping*
HIV/AIDS	B20-B24.9
Sexually transmitted infections (except HIV/AIDS)	A50-A58, A60-A60.9, A63-A63.8, B63, I98.0, K67.0-K67.2, M03.1, M73.0-M73.1
Tuberculosis	A15-A19.9, B90-B90.9, K67.3, K93.0, M49.0, N74.1, P37.0, U84.3
Enteric infections	A00-A00.9, A01.0-A09.9, A80-A80.9, R19.7
Malaria	B50-B53.8
Haemophilus and pneumococcal meningitis	A39-A39.9, A87-A87.9, G00.0-G00.8, G03-G03.8
Diphtheria	A36-A36.9
Whooping cough	A37-A37.9
Tetanus	A33-A35.0
Measles	B05-B05.9
Varicella	B01-B02.9, P35.8
Viral hepatitis	B15-B17.9, B19-B19.9, B94.2, P35.3
Upper respiratory infections	J00-J02.8, J03-J03.8, J04-J04.2, J05-J05.1, J06.0-J06.8, J36-J36.0
Maternal disorders	N96, N98-N98.9, O00-O07.9, O09-O16.9, O20-O26.9, O28-O36.9, O40-O48.1, O60-O77.9, O80-O92.7, O96-O98.6, O98.8-O99.9
Neonatal disorders	P00-P04.2, P04.5-P05.9, P07-P15.9, P19-P22.9, P24-P29.9, P36-P36.9, P38-P39.9, P50-P61.9, P70-P70.1, P70.3-P72.9, P74-P78.9, P80-P81.9, P83-P84, P90-P94.9, P96, P96.3-P96.4, P96.8
Cancer of lip and oral cavity	C00-C08.9, D10.0-D10.5, D11-D11.9
Cancer of pharynx	C11-C11.9, D10.6, C09-C10.9, C12-C13.9, D10.7
Oesophageal cancer	C15-C15.9, D00.1, D13.0
Stomach cancer	C16-C16.9, D00.2, D13.1, D37.1
Colon and rectum cancer	C18-C21.9, D01.0-D01.3, D12-D12.9, D37.3-D37.5
Liver cancer	C22-C22.9, D13.4
Tracheal, bronchus, and lung cancer	C33-C34.9, D02.1-D02.3, D14.2-D14.3, D38.1
Melanoma	C43-C43.9, D03-D03.9, D22-D23.9, D48.5
Breast cancer	C50-C50.9, D05-D05.9, D24-D24.9, D48.6, D49.3
Cervical cancer	C53-C53.9, D06-D06.9, D26.0
Uterine cancer	C54-C54.9, D07.0-D07.2, D26.1-D26.9
Testicular cancer	C62-C62.9, D29.2-D29.8, D40.1-D40.8
Bladder cancer	C67-C67.9, D09.0, D30.3, D41.4-D41.8, D49.4
Thyroid cancer	C73-C73.9, D09.3, D09.8, D34-D34.9, D44.0
Hodgkin lymphoma	C81-C81.9
ALL	C91.0
Other neoplasms	D32-D33.9, D35.3-D35.4, D42-D43.9, D45-D47.9, D49.6, K62.0-K62.1, K63.5, N60-N60.9, N84.0-N84.1, N87-N87.9
Ischaemic heart disease	I20-I25.9
Stroke	G45-G46.8, I60-I63.9, I65-I66.9, I67.0-I67.3, I67.5-I67.6, I68.1-I68.2, I69.0-I69.3
Hypertensive heart disease	I11-I11.9
Aortic aneurysm	I71-I71.9
Rheumatic heart disease	I01-I01.9, I02.0, I05-I09.9
Chronic obstructive pulmonary disease	J41-J44.9
Asthma	J45-J46.9
Peptic ulcer disease	K25-K28.9, K31, K31.1-K31.6, K31.8
Appendicitis	K35-K37.9, K38.3-K38.9
Abdominal hernias	K40-K42.9, K44-K46.9
Gallbladder and biliary disease	K80-K83.9
Pancreatitis	K85-K86.9
Epilepsy	G40-G41.9

Alcohol use disorders	F10-F10.9, G31.2, G72.1, P04.3, Q86.0, R78.0, X45-X45.9, X65-X65.9, Y15-Y15.9
Drug use disorders	F11-F16.9, F18-F19.9, P04.4, P96.1, R78.1-R78.5
Diabetes mellitus	E10-E10.1, E10.3-E11.1, E11.3-E11.9, P70.2
Chronic kidney disease	D63.1, E10.2, E11.2, I12-I13.9, N02-N08.8, N15.0, N18-N18.9, Q61-Q62.8
Neural tube disorders	Q00-Q01.9, Q05-Q05.9
Congenital heart anomalies	Q20-Q28.9
Urolithiasis	N20-N23.0
Transport injuries	V00-V86.9, V87.2-V87.3, V88.2-V88.3, V90-V98.8
Unintentional injuries	L55-L55.9, L56.3, L56.8-L56.9, L58-L58.9, W00-W46.2, W49-W62.9, W64-W70.9, W73-W75.9, W77-W81.9, W83-W94.9, W97.9, W99-X06.9, X08-X39.9, X46-X48.9, X50-X54.9, X57-X58.9, Y40-Y84.9, Y88-Y88.3
Self-harm	X60-X64.9, X66-X84.9, Y87.0
Interpersonal violence	X85-Y08.9, Y87.1

After the extraction, the calculation proceeds in 3 steps:

1. the desired age cut-offs are selected;
2. rows with appropriate age categories are included;
3. the overall YLL summary rate for each sex is calculated by age-standardisation using the European Standard Population.

TBA

Publications Office

doi:TBA