Original Article

Years of Life Lost to Death

A Comprehensive Analysis of Mortality in Germany Conducted as Part of the BURDEN 2020 Project

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Summary

Background: Knowing which diseases and causes of death account for most of the years of life lost (YLL) can help to better target appropriate prevention and intervention measures. The YLL in Germany for specific causes of death were estimated as part of the BURDEN 2020 project at the Robert Koch Institute.

Methods: Data from cause-of-death statistics were used for the analysis. ICD codes were grouped into causes of death categories at different levels of disaggregation. The YLL were estimated by combining each cause of death with the remaining life expectancy at the age of death. Deaths and YLL were compared by sex, age category, and regional distribution.

Results: Approximately 11.6 million years were estimated to be lost in Germany in 2017, of which 42.8% were lost by women and 57.2% by men. The largest number of YLL were due to (malignant) neoplasms (35.2%), followed by cardiovascular diseases (27.6%), gastrointestinal diseases (5.8%), and neurological diseases (5.7%). Deaths at younger ages had a greater impact on population health if expressed in YLL: the death share of persons under age 65 was 14.7%, but the years of life lost in this age group amounted to 38.3% of all YLL. The most common causes of death in this group include accidents, self-injury and violence, malignant neoplasms, and alcohol-related diseases.

Conclusion: A large proportion of YLL is borne by young and middle-aged persons. These findings emphasize the need to introduce preventive strategies early in life to reduce the YLL at younger ages, as well as to prevent risk factors for diseases in older ages.

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B urden of disease analyses are being conducted across the world in order to map the health status of populations comprehensively and comparably according to a standardized concept (1, 2). One important element of such analyses is disability-adjusted life years, a population-based composite measure that combines mortality and morbidity to create an indicator for the health of the population concerned (3). The focus is not on the number of cases of disease and death; rather, the actual impact on health is described in a combined unit of measurement, namely the years of healthy life lost to illness and death. This permits direct comparison of various diseases and injuries and enables prioritization of preventive and interventional measures. Metrics of disease burden are therefore important indicators of population health that are increasingly being incorporated into national and international health information systems.

The Global Burden of Disease Study (GBD) offers a good overview of the disease burden worldwide (4), but preliminary analyses of the figures for Germany show that the calculations have not always been based on the best data available (5–7). For this reason, independent burden of disease studies are being carried out in various countries (8–10). The project "BURDEN 2020: Burden of disease in Germany at the national and regional Level" has the long-term goal of creating a reliable and transparent information source for policy makers based on reproducible data and methods (11).

The aim of the analyses presented here was to calculate the mortality component of disease burden in Germany. In conventional accounts the ranking of the principal causes of death is based on the number of deaths (12, 13). The calculation of years of life lost to death (YLL), however, focuses on the analysis of lost life years rather than the number of deaths.

The consequences of death for population health only become fully visible in terms of YLL, because comparatively rare diseases that lead to death at a young age can result in relatively high numbers of YLL (14–16). Therefore, the metric YLL can help to answer the question of which diseases should be focused on to minimize the loss of life span and further increase life expectancy. This permits differentiated prioritization of diseases and injuries, particularly with regard to the recognition of age- and sex-specific needs for prevention and care.

FIGURE 1
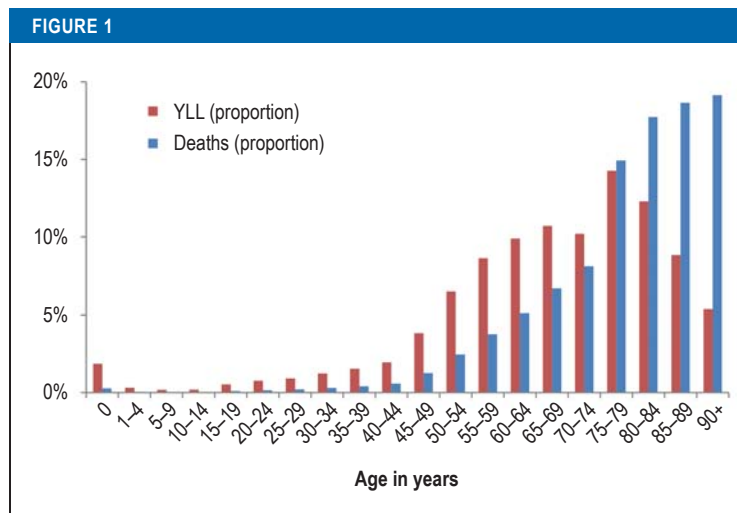
Years of life lost (YLL) and deaths (expressed as proportions) by age group
Source: BURDEN 2020 project, cause of death statistics 2017 (our own calculations)

Methods

The data source for our analyses were the German cause of death statistics for the year 2017 (17), which classify all deaths by sex, age, place of residence (community), and cause of death, with the underlying condition coded according to the International Classification of Diseases and Related Health Problems (ICD-10, WHO, 2016).

Handling of non-informative ICD-10 codes

Overall, 25.8% of the cases in the cause of death statistics for 2017 had "non-informative" ICD-10 codes, i.e., the coding yielded insufficient information regarding the underlying cause of death (13). Non-informative codes may describe sequelae of the underlying illness, symptoms of disease, or unspecific causes of death, or may contain implausible age or sex assignments. Classification into informative and non-informative ICD-10 codes and correction of coding were based on the GBD (4, 18–20). For cases of death with a non-informative ICD code, assumptions were made regarding the actual causes of death and so-called target codes were defined.

The uncertainty in the estimation of YLL that arose from the redistribution of non-informative ICD-10 codes into informative codes is represented by an uncertainty interval (UI) *(eBox 1)*. Both case numbers and lost life span are therefore reported as ranges. Redistribution and the uncertainty concept are described in detail elsewhere (12).

Figures for deaths and YLL before and after redistributing non-informative ICD-10 codes were compared *(eTable 1)*. For specific causes of death the YLL were classified according to age, sex, and spatial planning region *(eBox 2 and eTable 2)*.

Classification of causes of death

As in the GBD, the ICD-10 codes from the cause of death statistics were classified into cause of death groups.

At the uppermost level, three groups were distinguished:
- A) Communicable, maternal, neonatal, and nutritional diseases (in short: communicable diseases)
- B) Non-communicable diseases
- C) Accidents and Injuries.

At level 2, the non-communicable diseases, for example, are subdivided into neoplasms, cardiovascular diseases, etc.

Further subdivision takes place at level 3. For instance, specific neoplasms are distinguished (lung cancer, breast cancer, and so on) (21) *(eTable 3)*.

Results

A total of 932 272 deaths were registered in Germany in 2017. In 691 467 cases, the ICD-10 codes for cause of death were informative and did not need redistribution *(eTable 1)*. Women made up just over half of the deaths recorded (women: 474 508 deaths, 50.9%; men: 457 761 deaths, 49.1%); three stillbirths were excluded. Group A (communicable diseases) contained on average 4% of cases (36 929; UI: 36 707–37 123). Group B accounted for 91.2% of all deaths (850 534; UI: 850 228–850 875), group C for 4.8% (44 805; UI: 44 585–45 002). The conversion of non-informative ICD-10 codes to informative codes had a particularly pronounced effect on the size of the communicable diseases group, which increased from 10 091 deaths (1.5%) to 36 929 deaths (4.0%) *(eTable 1)*.

Altogether, approximately 11 628 000 years of life were lost to death in 2017: 4 981 000 YLL (42.8%) in women and 6 647 000 YLL (57.2%) in men. The age-specific distribution of the deaths and the YLL shows that proportionally the highest number of deaths was found in the age group 90+ years (19.1%; *Figure 1*). The highest proportion of YLL was found in the age group 75–79 years (14.3%). Although the absolute number of fatalities rises with increasing age, deaths at a lower age, measured in YLL, exert a greater impact on population health because life expectancy decreases with increasing age. While only 14.7% of deaths occurred in persons under 65 years of age, these cases made up 38.3% of the YLL. In relative numbers (per 100 000 people in the population), the highest burden of disease is in the oldest age group *(eFigure 1)*. In a sensitivity analysis, the YLL were calculated with sex-specific life expectancies *(eFigure 2)*. The number of YLL was then correspondingly lower in men, but developed comparably with increasing age.

At level 2, the disease groups responsible for the highest proportions of total YLL were (malignant) neoplasms (35.2%) and cardiovascular diseases (27.6%). Significant contributions were also made by other groups, foremost digestive diseases (5.8%) and neurological disorders (5.7%). Infectious diseases played a relatively small part. However, the redistribution of non-informative to informative ICD-10 codes resulted in particularly high increases in the case numbers for respiratory infections (+ 1130%),

FIGURE 2
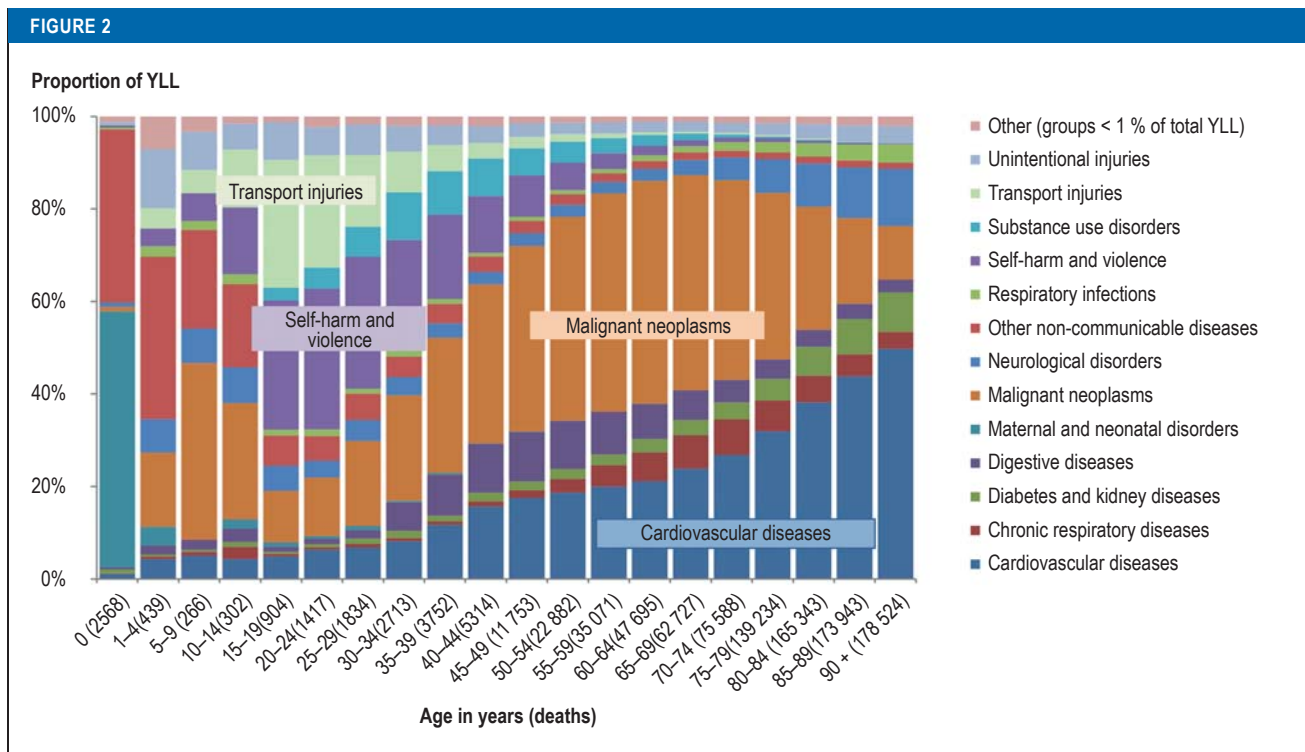
Distribution of years of life lost (YLL) among cause of death categories by age group (level 2; see *eTable 5*)
Source: BURDEN 2020 project, cause of death statistics 2017 (our own calculations; see e*Table 5*)

HIV/AIDS and sexually transmitted infections (+ 230%), and diabetes and kidney diseases (+ 80%). In the case of the respiratory infections, the rise was explained mainly by high number of unspecific pulmonary infections *(eTable 1)* (12).

Looking at the distribution of the YLL at level 2 *eTable 1)*, different disease patterns are evident in different age groups *(Figure 2)*. In 15- to 29-year-olds, the highest proportions of YLL were accounted for by self-harm and violence (27.9–30.4%) and transport injuries (15.5–27.7%). As for (malignant) neoplasms, they played a significant part in children, less so in the 15- to 29-year-olds (11.1–18.4%), but their contribution grew markedly with increasing age. In the age group 60–64 years, almost half (48.2%) of the YLL were due to (malignant) neoplasms. In the uppermost age group (90+ years), in contrast, cardiovascular diseases were to blame for 49.8% of the YLL. The second place in this category (12.4%) was occupied by the group of neurological disorders, including, for example, dementia.

At level 3, ischemic heart disease was the most important cause of death for both women and men in terms of both number of deaths and YLL (top 20 in *Figure 3*). Places 2 and 3 were occupied by lung cancer and stroke, respectively, for YLL and by stroke and Alzheimer's disease with other dementias for number of deaths. The two rankings differed considerably from one another, particularly in women *(eFigure 3, eTable 4)*. Breast cancer was ranked second for YLL and fifth for number of deaths, fol-

lowed in third place for YLL by lung cancer, which ranked seventh for number of deaths. Bowel cancer (place 7 versus 9) and pancreatic cancer (place 8 versus 14) were further examples of malignancies that ranked higher for YLL than for number of deaths. On the other hand, cardiovascular diseases such as stroke (place 4 versus 2), and hypertensive heart disease (place 9 versus 4), which tend to lead to death later in the life span, ranked lower for YLL than for number of deaths. This was also true for Alzheimer's disease and other dementias (place 5 versus 3).

For men, the four highest-ranking diagnoses were identical for YLL and number of deaths (ischemic heart disease, lung cancer, stroke, and chronic obstructive pulmonary disease [COPD]). Some other diagnoses, however, ranked much higher for YLL than for number of deaths: chronic liver disease (place 5 versus 8), self-harm (place 6 versus 14), pancreatic cancer (place 9 versus 11), alcohol use disorders (place 10 versus 20). Diseases such as prostate cancer, Alzheimer's disease and other dementias, diabetes mellitus, and lower respiratory infections (particularly pulmonary infections) ranked lower for YLL than for number of deaths.

The five causes of death accounting for the most YLL varied considerably depending on the age group. While the low numbers of deaths in childhood and adolescence were dominated by congenital and neonatal disorders and trauma, age-associated diseases became the major causes from middle age onwards

FIGURE 3

The top 20 causes of death in terms of years of life lost (YLL) and numbers of deaths (level 3)*

Rank	Cause of death	YLL	UI
1	Ischemic heart disease	1 710 791	(1 697 948–1 721 272)
2	Lung cancer	945 651	(937 383–953 606)
3	Stroke	628 518	(622 067–633 506)
4	Chronic obstructive pulmonary disease	524 237	(520 999–527 792)
5	Colon cancer	457 692	(453 468–462 557)
6	Chronic liver disease	418 522	(413 186–423 501)
7	Dementia	392 045	(385 648–396 716)
8	Breast cancer	362 538	(358 700–366 134)
9	Self-harm	350 986	(346 687–355 683)
10	Pancreatic cancer	326 491	(323 011–329 954)
11	Diabetes mellitus	271 310	(268 758–273 640)
12	Lower respiratory infections	219 500	(216 472–222 014)
13	Hypertensive heart disease	217 412	(211 542–221 626)
14	Alcohol use disorders	209 627	(206 333–214 067)
15	Chronic kidney disease	208 191	(204 094–211 222)
16	Falls	204 703	(201 025–207 932)
17	Prostate cancer	194 526	(192 199–197 092)
18	Stomach cancer	178 297	(175 620–180 752)
19	Atrial fibrillation and flutter	162 839	(160 127–164 974)
20	Brain and central nervous system cancer	161 293	(158 448–164 462)
25	Non-rheumatic valvular heart disease	118 797	(116 369–121 011)
33	Parkinson's disease	101 293	(100 875–101 716)

Rank	Cause of death	Deaths	UI
1	Ischemic heart disease	169 349	(168 885–169 898)
2	Stroke	65 218	(64 938–65 525)
3	Dementia	56 100	(55 943–56 278)
4	Lung cancer	55 032	(54 710–55 302)
5	Chronic obstructive pulmonary disease	43 538	(43 279–43 787)
6	Colon cancer	34 156	(33 856–34 421)
7	Hypertensive heart disease	32 227	(31 904–32 567)
8	Chronic kidney disease	27 741	(27 538–28 017)
9	Diabetes mellitus	25 720	(25 566–25 883)
10	Lower respiratory infections	24 611	(24 423–24 808)
11	Breast cancer	22 792	(22 576–22 993)
12	Atrial fibrillation and flutter	22 238	(22 136–22 355)
13	Pancreatic cancer	21 963	(21 760–22 133)
14	Falls	21 502	(21 312–21 687)
15	Chronic liver disease	19 531	(19 345–19 690)
16	Prostate cancer	17 848	(17 671–18 007)
17	Non-rheumatic valvular heart disease	14 495	(14 341–14 645)
18	Stomach cancer	11 905	(11 761–12 042)
19	Self-harm	11 770	(11 663–11 911)
20	Parkinson's disease	11 170	(11 141–11 201)
27	Alcohol use disorders	7587	(7491–7687)
28	Brain and central nervous system cancer	7169	(7070–7270)

*See eFigure 3 for women and eFigure 4 for men
Source: BURDEN 2020 project, cause of death statistics 2017 (our own calculations); UI, uncertainty interval

FIGURE 4

The five principal causes of death (level 3) in each age group, expressed in terms of years of life lost (YLL)*
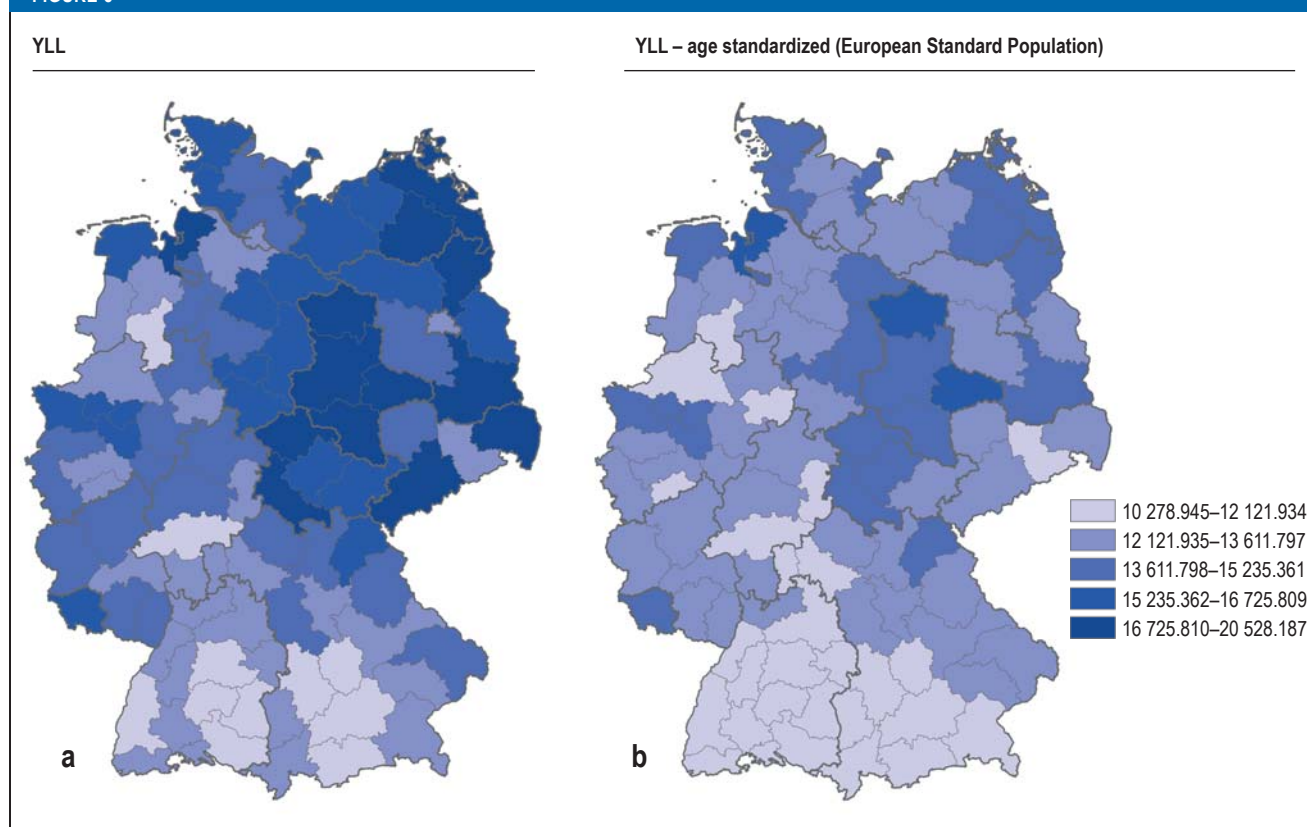
Age in years

#	0	1–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85–89	90+
1			1220																	
2			1146	1339		2182														
3		1930	4419	2183	1702		3570													
4						2995	5124	13 130	14 569	17 309										
5	11 534																			
6	2918	3162	1560																	
7		1837																		
8					1665															
9		1589		2381	15 156	19 577	14 679	11 296	8716											
10	66 491	9312	2555	2408	2341	2263	2893													
11				2871	16139	25 326	28 149	32 381	31 012	26 044	37 901	43 407								
12	119 468																			
13	1543																		44 403	34 282
14								6612	12 233	19 915	38 354	63 980	71 903	64 935	54 363					
15													45 164	53 602	60 512	56 381				
16																			48.643	50 158
17																	73 957	94 787	92 463	70 486
18														64 250	80 967	82 450	95 200	69 695		
19																65 885	115 827	116 447	88 400	55 333
20								5860			32 055	77 140	139 587	167 097	167 145	134 712	122 680	59 594		
21									10 447	14 547	29 139	41 695	42 947							
22										18 823	46 485	84 610	124 779	150 476	175 902	174 252	277 434	274 750	219 214	147 531

Legend: <5000 | 5000 to <25 000 | 25 000 to <50 000 | 50 000 to < 100 000 | ≥ 100 000

*See eFigure 5 for men and eFigure 6 for women
1) Leukemia; 2) epilepsy; 3) brain cancer; 4) alcohol use disorders; 5) sudden infant death; 6) endocrine disorders; 7) drowning; 8) transport injuries (other); 9) road injuries; 10) congenital disorders; 11) self-harm; 12) neonatal disorders;
13) chronic kidney disease; 14) chronic liver disease; 15) colon cancer; 16) hypertensive heart disease; 17) dementias; 18) chronic obstructive pulmonary disease (COPD); 19) stroke; 20) lung cancer; 21) breast cancer; 22) ischemic heart disease

YLL   YLL – age standardized (European Standard Population)

	10 278.945–12 121.934
	12 121.935–13 611.797
	13 611.798–15 235.361
	15 235.362–16 725.809
	16 725.810–20 528.187

Years of life lost (YLL), by spatial planning region
a) per 100 000 inhabitants, b) per 100 000 inhabitants, age standardized
Source: BURDEN 2020 project, Federal Statistical Office (our own calculations; see e *Table 6*); maps generated with ArcGIS (ESRI Inc.)

(Figure 4). Especially men showed high YLL figures for road injuries and self-harm in the period from childhood to early adulthood *(eFigure 5)*. Although the numbers of deaths were low, each fatality caused a particularly high number of YLL. From middle age onwards, elevated burdens of disease were caused by breast cancer in women *(eFigure 6)* and by lung cancer and chronic liver disease (above all cirrhosis). Starting in the fifth decade of life, ischemic heart disease, COPD, lung cancer, and stomach cancer caused high YLL. At advanced age stroke and dementias became increasingly important for both sexes, accompanied in women over 80 years of age by chronic kidney failure and hypertensive heart disease.

The region with the highest absolute number of YLL (463 911) in 2017 was Berlin. The highest rate, however, was found in the Anhalt-Bitterfeld-Wittenberg spatial planning region, with 20 528 YLL per 100 000 inhabitants. Munich had the lowest YLL rate, with 10 279 per 100 000 inhabitants. Even after age standardization, clear north–south and east–west gradients could be discerned. The highest YLL figures were calculated for Bremerhaven, Anhalt-Bitterfeld-Wittenberg, and Altmark, the lowest for Stuttgart, Oberland, and Munich *(Figure 5)*.

Discussion
The declared goal of public health and surveillance is to analyze the health of the population and contribute to improvement by showing where action is needed (22, 23). Causes of death yield important information with regard to the potential for prevention at population level, so detailed knowledge of the patterns of mortality is indispensable. If life expectancy is to increase any further, however, data are needed not only on the number of deaths, but also on how much of the life span is lost to individual diseases.

In the framework of the BURDEN 2020 project, wide-reaching analyses of the YLL in Germany were conducted. One of the central findings is that even with the ongoing aging of the population, a significant proportion of the YLL is accounted for by young and intermediate age bands. While only 14.7% of the deaths occurred in persons under 65 years old, 38.3% of the YLL were in this age group.

Altogether, this leads to the major causes of death being ranked in a different order for YLL than for numbers of deaths. While ischemic heart disease is the most important cause of death in both respects, breast cancer and lung cancer in women rank higher for YLL than for numbers of fatalities. In men, on the other

hand, chronic liver disease, alcohol use disorders, and self-harm come to the fore. The findings show the need for the provision of prevention programs early in life, for the benefit of both young and old. Accidents, injuries, and self-harm, together with alcohol-associated causes of death, are responsible for an appreciable burden of disease in the young. The need for early prevention measures is also evident with regard to causes of death typically affecting the elderly, such as stroke, in order to prevent accumulation of risks over the life course and raise both life expectancy and the quality of life at an advanced age.

The analyses presented here do have limitations. Assumptions had to be made regarding the probable cause of death in the case of non-informative ICD-10 codes, introducing uncertainty. For this reason we calculated uncertainty intervals (*Figure 3, eBox 1, eTable 1, eTables 4–5, eFigures 3–4*). Since the German cause of death statistics contain no further information about the fatality (e.g., multicausal data), no individual correction of non-informative codes was possible on this basis. Furthermore, for all deaths with informative ICD-10 codes it was assumed that the cause was correctly coded, which was not necessarily the case.

Compared with the results of the GBD for Germany, the BURDEN 2020 project showed minor discrepancies with regard to the ranking of causes of death for YLL. The added value of the BURDEN 2020 calculations lies in the use of national life tables. The YLL are calculated on the basis of empirically attainable residual life expectancies, so the data portray a genuine potential for prevention. Additionally, region-by-region evaluation is now possible for all causes of death, in contrast to the GBD.

The differences in results between BURDEN 2020 and the GBD are partly due to their use of different procedures for the redistribution of non-informative codes (12). In addition, the GBD uses modeling, e.g., for extrapolation of data. Another important difference is that BURDEN 2020 uses different life expectancies than the GBD. There are currently various ways of selecting life expectancy *(eBox 2)*, which has a crucial effect on YLL figures (24).

For each age group in every country surveyed, the GBD used the highest life expectancy *(eBox 2)* found anywhere in the world (4). For example, the residual life expectancy for 70- to 74-year-olds is assumed to be 20.3 years, against the assumption of 15.8 years in our study on the basis of deaths in Germany. Other burden of disease studies in other nations have also given preference to their country-specific life expectancies in order to achieve realistic results based on empirical findings with regard to fatalities (25, 26).

In common with the GBD (4) and other burden of disease studies (27), we used the same life expectancy for both sexes. A similarly high life expectancy was thus viewed as attainable, and men and women were compared directly with one another. Research data indicate that the biological component of the difference in life expectancy is small, probably amounting to less than a year. The

rest of the difference in life expectancy is due to differences in health-related behavior and in the use of medical care services (28, 29) *(eBox 2)*. The result is that more YLL are documented for men, who on average die earlier, than for women.

Summary

This analysis from the BURDEN 2020 study provides detailed findings regarding the years of life lost as a result of all ICD-coded deaths from disease and injury. The methods used were adjusted to the situation in Germany. This permitted, for the first time, the calculation of YLL at regional level, greatly expanding the utility of future burden of disease analyses (30). We thus now have a new evidence base that will form a cornerstone of future monitoring and is being made available for reference as part of an interactive visualization tool. Furthermore, the indicators have been integrated into the diabetes surveillance and the future non-communicable disease (NCD) surveillance programs of the Robert Koch Institute (31). Time series and prognostic models should now be built onto this method to enable the depiction of long-term trends, the sketching of scenarios for future developments, and to accompany measures to enhance population health.

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► **Supplementary material**

eReferences, eTables, eFigures, eBoxes:
www.aerzteblatt-international.de/m2021.0148

Years of Life Lost to Death

A Comprehensive Analysis of Mortality in Germany Conducted as Part of the BURDEN 2020 Project

by Annelene Wengler, Alexander Rommel, Dietrich Plaß, Heike Gruhl, Janko Leddin, Thomas Ziese, and Elena von der Lippe; on behalf of the BURDEN 2020 Study Group

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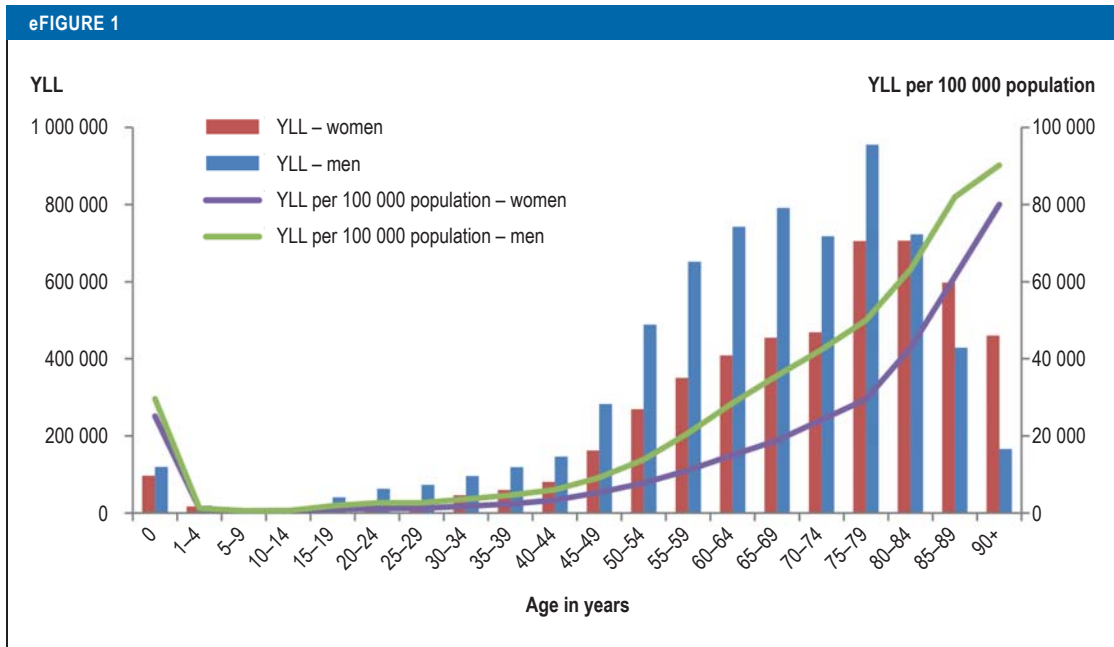
eFIGURE 1

Years of life lost (YLL) (absolute number) and YLL rates (per 100 000) by age and sex
Source: BURDEN 2020 project, cause of death statistics 2017 (our own calculations)

eFIGURE 2
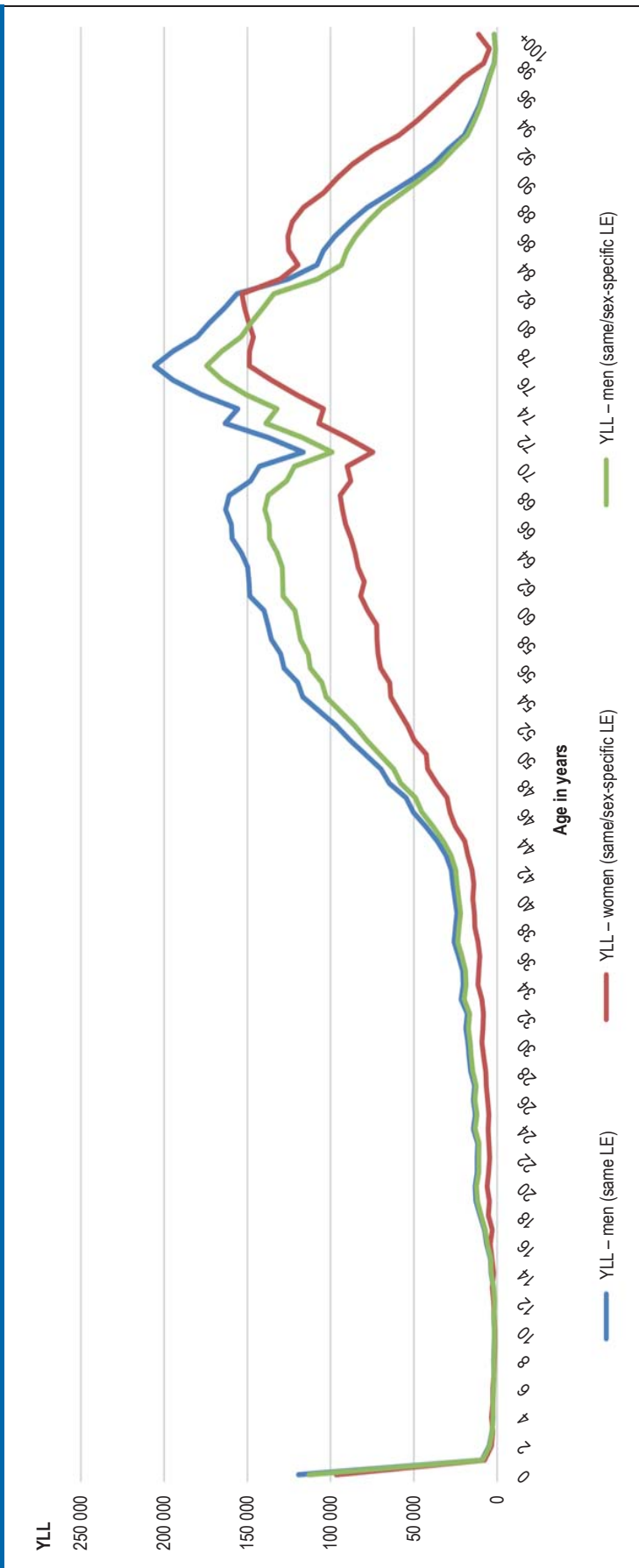
Years of life lost (YLL) with the same life expectancy (LE) for women and men and with sex-specific life expectancies

Source: Federal Statistical Office, life tables 2016/2018 and deaths 2017 (our own calculations)

[Authors' note: Both for women and for men, there were fewer deaths at the age of 71 in 2017 than at the ages above and below 71 (see also Table 12613–003 in GENESIS-ONLINE with the deaths by age and sex for 2017); this explains the dip in the curves at this point. Because the LE of women is higher than that of men at all ages, if the LE is the same for both sexes this LE is used. For this reason there is only one curve for women in the graph.]

eBOX 1

Explanation of the uncertainty interval method

For each non-informative ICD-10 code in the cause of death statistics, various informative ICD-10 codes that could be considered candidates for the actual cause of death are available as target codes. For example, an unspecified stroke may be classified as an ischemic stroke, an intracerebral hemorrhage, or a subarachnoid hemorrhage. These three causes of death are distributed differently in the population; their distribution varies by age and sex. Accordingly, unspecified stroke is redistributed with specific probabilities. Since ischemic stroke occurs much more frequently than intracerebral or subarachnoid hemorrhage as cause of death at population level, it is more often assumed to be the underlying cause of death. The process of redistribution (to informative ICD-10 codes) is repeated 1000 times for each person with a non-informative ICD-10 code [for detail, see (12)]. This is intended to represent the variation of the different possible actual causes of death. The uncertainty intervals are usually relatively small, for two reasons: First, only some of the cases (around 26%) have non-informative ICD-10 codes and in the remaining cases the ICD-10 code remains identical over the 1000 repetitions. Second, due to the target code selection and the underlying distribution, for some causes of deaths the redistribution does not result in any great variation. For instance, unspecified diabetes is converted to diabetes mellitus type 1 or type 2. In either cases, diabetes mellitus is the cause of death.

In summary, the uncertainty interval represents the range of case numbers or YLL that presumably contains the actual value. The uncertainty interval thus shows that various possible informative ICD-10 codes are available for a non-informative ICD-10 code.

eBOX 2

Explanation of method for calculation of years of life lost to death

From the statistical viewpoint, every person who dies still has, at the time of death, a remaining average life expectancy (residual life expectancy). There are various ways of determining this residual life expectancy (7, 24, 25). For the purposes of this study, the 2016/2018 life tables of all 16 federal states of Germany were compared (e1). For each age group, the highest state-specific life expectancy was used to calculate the years of life lost (YLL) for all persons who died at that age *(eTable 2)*. For example, the residual life expectancy of 70- to 74-year-old women is highest in the federal state of Baden-Württemberg, at 15.8 years, and it is assumed that this life expectancy could also be achieved in other federal states. The state-specific maximum is therefore defined as the statistically attainable life expectancy for all German citizens.

Since the project also involved presentation of the results at the level of the 96 spatial planning regions of Germany, the highest life expectancy among these regions could also theoretically be determined. Currently, the official statistics do not include these figures. However, the first publications on life expectancy at birth in the 402 districts of Germany (e2) and calculations of life expectancy by spatial planning region in broader age groups (e3) give grounds for optimism that in future these data will become available in the detail required for our purposes (individual age, sex, and spatial planning region).

The same life expectancy is assumed for men and for women, to render them comparable and make it possible to map the prevention potential in an adequate manner. The principle of a maximal life expectancy corresponds to the Global Burden of Disease Study, in which the maximal age-specific life expectancy at national level is used at international level (7). Here, this approach is adjusted to the German context by using the life expectancies in the federal states. In demographic research it is assumed that the purely biological difference in life expectancy is small (less than 1 year; see [28, 29]). The major part of the difference in life expectancy is therefore amenable to (external) influence and can be attributed, for instance, to health-related behavior or uptake of care. One of the aims of burden of disease studies is to determine the potential for prevention. Thus, high YLL figures indicate a high potential for improvement of the health situation. The disease-specific YLL in a given age group are determined by the number of cases and the life expectancy for this group:

$$YLL_{i,g,r,e} = \sum_{i=0}^{n} d_{i,g,r,e} * l_i$$

i = age from 0 to n
$d_{i,g,r,e}$ = number of deaths from disease e for age i, sex g, and region r
l_i = life expectancy at age i (in years)

eTABLE 1

Number of deaths and number of years lost (YLL) by cause of death (levels 1 and 2), with and without redistribution of non-informative ICD-10 codes

	Without redistribution of non-informative ICD-10 codes		With redistribution of non-informative ICD-10 codes			
	Deaths	YLL	Deaths	UI	YLL	UI
Total	691 467	8 837 616	932 269		11 627 980	
Level 1						
Non-communicable diseases	649 658	8 019 423	850 534	(850 228–850 875)	10 310 505	(10 286 687–10 327 339)
Accidents and injuries	31 718	602 354	44 805	(44 585–45 002)	847 836	(842 743–853 187)
Communicable, maternal, neonatal, and nutritional diseases	10 091	215 839	36 929	(36 707–37 123)	469 638	(464 973–473 684)
Level 2						
Neoplasms	214 720	3 312 821	267 717	(267 330–268 200)	4 095 795	(4 084 743–4 110 271)
Cardiovascular diseases	234 673	2 325 398	333 185	(332 708–333 672)	3 205 649	(3 182 810–3 223 418)
Digestive diseases	33 974	537 770	41 921	(41 705–42 112)	671 887	(667 634–676 810)
Neurological disorders	72 407	626 216	76 193	(76 041–76 395)	666 484	(659 252–672 385)
Chronic respiratory diseases	39 924	494 671	49 522	(49 251–49 771)	600 699	(597 234–603 983)
Diabetes and kidney diseases	29 797	255 278	53 471	(53 203–53 745)	479 688	(473 892–483 932)
Self-harm and violence	9128	268 219	12 240	(12 126–12 376)	369 960	(365 657–374 432)
Unintentional injuries	19 758	237 196	28 112	(27 914–28 335)	327 905	(323 975–331 763)
Other non-communicable diseases	13 984	274 232	15 611	(15 492–15 719)	310 261	(306 435–313 878)
Respiratory infections	2030	23 157	25 060	(24 870–25 246)	225 781	(222 706–228 481)
Substance use disorders	5636	140 273	7973	(7879–8067)	222 351	(219 425–226 035)
Transport injuries	2832	96 938	4453	(4377–4564)	149 971	(146 608–153 569)
Maternal and neonatal disorders	1485	118 581	1591	(1567–1614)	126 725	(125 038–128 347)
Enteric infections	4531	41 994	6942	(6849–7054)	62 614	(61 049–64 010)
Musculoskeletal disorders	2325	26 972	2436	(2400–2465)	28 722	(28 002–29 410)
Skin and subcutaneous diseases	2169	23 936	2456	(2401–2502)	27 059	(26 369–27 859)
Other infectious diseases	887	15 412	1338	(1279–1390)	23 593	(22 503–24 772)
HIV/AIDS and sexually transmitted diseases	317	9801	1061	(1031–1095)	23 243	(22 283–24 439)
Nutritional deficiencies	817	6453	904	(883–929)	7068	(6740–7512)
Mental disorders	48	1832	49	(49–52)	1884	(1865–2041)
Neglected tropical diseases and malaria	24	441	33	(26–45)	615	(482–899)

Source: BURDEN 2020 project, cause of death statistics 2017 (our own calculations, causes of death with fewer than two cases excluded, three cases excluded because they were stillbirths); UI, uncertainty interval

eTABLE 2

Life expectancy

Age group in years	Residual life expectancy
0	84.10
1–4	81.86
5–9	77.40
10–14	72.42
15–19	67.46
20–24	62.50
25–29	57.56
30–34	52.63
35–39	47.72
40–44	42.84
45–49	38.02
50–54	33.29
55–59	28.66
60–64	24.19
65–69	19.89
70–74	15.80
75–79	11.99
80–84	8.63
85–89	5.90
90+	3.23

Source: Federal Statistical Office, life tables 2016/2018
(our own calculations)

eTABLE 3 A

Classification of causes of death at levels 1 to 3

Level 1	
a) Communicable, maternal, neonatal, and nutritional diseases	

Level 2	Level 3
Enteric infections	Diarrheal diseases
	Invasive non-typhoid salmonellae (iNTS)
	Typhus and paratyphus
	Other intestinal infectious diseases
HIV/AIDS and sexually transmitted diseases	HIV/AIDS
	Sexually transmitted infections excluding HIV
Maternal and neonatal disorders	Maternal disorders
	Neonatal disorders
Neglected tropical diseases and malaria	Chagas disease
	Cystic echinococcosis
	Malaria
	Schistosomiasis
	Other neglected tropical diseases
Nutritional deficiencies	Dietary iron deficiency
	Protein–energy malnutrition
	Other nutritional deficiencies
Respiratory infections and tuberculosis In short: Respiratory infections	Upper respiratory infections
	Lower respiratory infections
	Tuberculosis
	Otitis media
Other infectious diseases	Acute hepatitis
	Encephalitis
	Measles
	Meningitis
	Whooping cough
	Rubella
	Varicella and herpes zoster
	Other unspecified infectious diseases

Source: Global Burden of Disease Study

eTABLE 3 B

Classification of causes of death at levels 1 to 3

Level 1	
b) Non-communicable diseases	

Level 2	Level 3
Cardiovascular diseases	Aortic aneurysm
	Atrial fibrillation and flutter
	Cardiomyopathy and myocarditis
	Endocarditis
	Hypertensive heart disease
	Ischemic heart disease
	Non-rheumatic valvular heart disease
	Peripheral artery disease
	Primary pulmonary arterial hypertension
	Rheumatic heart disease
	Stroke
	Other cardiovascular and circulatory diseases
Chronic respiratory diseases	Asthma
	Chronic obstructive pulmonary disease In short: COPD
	Interstitial lung disease and pulmonary sarcoidosis
	Pneumoconiosis
	Other chronic respiratory diseases
Diabetes and kidney diseases	Acute glomerulonephritis
	Chronic kidney disease
	Diabetes mellitus
Digestive diseases	Appendicitis
	Cirrhosis and other chronic liver diseases In short: Chronic liver diseases
	Gallbladder and biliary diseases
	Inflammatory bowel disease
	Inguinal, femoral, and abdominal hernia
	Pancreatitis
	Paralytic ileus and intestinal obstruction
	Upper digestive system diseases
	Vascular intestinal disorders
	Other digestive diseases

Level 1
b) Non-communicable diseases

Level 2	Level 3
Mental disorders	Eating disorders
Musculoskeletal disorders	Rheumatoid arthritis
	Other musculoskeletal disorders
(Malignant) neoplasms	Eye cancer
	Bladder cancer
	Breast cancer
	Gallbladder and biliary tract cancer
	Testicular cancer
	Hodgkin lymphoma
	Kidney cancer
	Larynx cancer
	Colon and rectum cancer In short: colon cancer
	Brain and central nervous system cancer
	Leukemia
	Lip and oral cavity cancer
	Liver cancer
	Malignant bone tumors
	Stomach cancer
	Malignant skin melanoma
	Mesothelioma
	Multiple myeloma
	Nasopharynx cancer
	Neuroblastoma and other peripheral nervous cell tumors
	Non-Hodgkin lymphoma
	Non-melanoma skin cancer
	Esophageal cancer
	Ovarian cancer
	Pancreatic cancer
	Prostate cancer
	Thyroid cancer
	Tracheal, bronchus and lung cancer In short: Lung cancer
	Uterine cancer
	Soft tissue and other extraosseous sarcomas
	Cervical cancer
	Other pharynx cancer
	Other malignant neoplasms

Level 1	
b) Non-communicable diseases	

Level 2	Level 3
	Other neoplasms
Neurological disorders	Alzheimer's disease and other dementias In short: Dementias
	Epilepsy
	Motor neuron disease
	Multiple sclerosis
	Parkinson's disease
	Other neurological disorders
Other non-communicable diseases	Congenital birth defects
	Endocrine, metabolic, blood, and immune disorders
	Gynecological diseases
	Hemoglobinopathies and hemolytic anemias
	Sudden infant death syndrome
	Urinary diseases and male infertility
Sense organ diseases	Other sense organ diseases
Skin and subcutaneous diseases	Bacterial skin diseases
	Decubitus ulcer
	Scabies
	Other skin and subcutaneous diseases
Substance use disorders In short: Drug use	Alcohol use disorders In short: Alcohol abuse
	Drug use disorders

Source: Global Burden of Disease Study

eTABLE 3 C

Classification of causes of death at levels 1 to 3

Level 1	
c) Injuries	

Level 2	Level 3
Self-harm and interpersonal violence In short: Self-harm and violence	Conflicts and terrorism
	Executions and police conflict
	Interpersonal violence
	Self-harm
Transport injuries	Road injuries
	Other transport injuries
Unintentional injuries	Adverse effects of medical treatment
	Animal contact
	Drowning
	Environmental heat and cold exposure
	Exposure to forces of nature
	Exposure to mechanical forces
	Falls
	Fire, heat, and hot substances
	Foreign bodies
	Poisoning
	Other unintentional injuries

Source: Global Burden of Disease Study