Assessing Years of Life Lost Versus Number of Deaths in the United States, 1995–2015

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Objectives. To assess years of life lost to each cause of death in the United States between 1995 and 2015, and compare it with the number of deaths.

Methods. We used Vital Statistics mortality data and defined "life-years lost" as remaining life expectancy for each decedent's age, sex, and race. We calculated the share of life-years lost to each cause of death in each year, and examined reasons for changes.

Results. In 2015, heart disease caused the most deaths, but cancer caused 23% more life-years lost. Life-years lost to heart disease declined 6% since 1995, whereas life-years lost to cancer increased 16%. The increase for cancer was entirely attributable to population growth and longer life expectancy; had these factors remained constant, life-years lost to heart disease and cancer would have fallen 56% and 38%, respectively. Accidents (including overdoses), suicides, and homicides each caused twice the share of life-years lost as deaths. Measuring life-years lost highlighted racial disparities in heart disease, homicides, and perinatal conditions.

Conclusions. Life-years lost may provide additional context for understanding long-term mortality trends. (*Am J Public Health.* 2017;107:1653–1659. doi:10.2105/AJPH.2017.303986)

See also Brenner, p. 1535, and also Galea and Vaughan, p. 1538.

Each year, the Centers for Disease Control and Prevention (CDC) publishes data on causes of death in the United States. Results include the 15 leading causes of death, currently led by heart disease and cancer, which cause more than half of all deaths.[1] Although heart disease caused more than twice as many deaths as cancer in 1970,[2,3] the difference has declined markedly,[1–3] and recent CDC projections suggest that the number of deaths from cancer will surpass that from heart disease by 2020.[3] The growing importance of cancer was highlighted by the federal government's decision in 2016 to launch a Cancer Moonshot initiative.

However, focusing solely on the number of deaths from cancer paints an incomplete picture of its impact, because cancer often occurs at younger ages than does heart disease. To better understand the burden of disease, some have suggested measuring life-years lost, rather than deaths, from each cause.[4,5] On the basis of remaining US life expectancy at each age, an infant death results in a loss of 78.8 life-years whereas a death at age 99 years results in a loss of 2.4 life-years.[6] From the standpoint of life-years, the death of 1 infant is equivalent to 33 deaths of 99-year-olds. Although some might consider this weighting a form of age discrimination, bioethicists have emphasized that it allows everyone a "fair chance" to achieve a normal life span.[7]

Because the leading causes of death primarily occur in the elderly, relying on the number of deaths from a particular condition may distort perceptions about the importance of that condition. We sought to understand causes of death by life-years lost and evaluate changes over the past 20 years. The results may help policymakers to prioritize research funding and assess progress toward mortality reduction on the basis of disease burden.

METHODS

In our first step, we followed established methods to estimate life-years lost.[4,5,8] Specifically, we obtained cause-of-death data from the National Vital Statistics System for 2015 and 1995.[9] Vital Statistics documents all resident death certificates in the United States (> 99% of deaths nationwide).[1,10] For each decedent, we defined "life-years lost" as US life expectancy for their age (with ages ≥ 100 years categorized as 100 years), sex, and race (White or Black; the national average across races was used for other minorities).[6,11] For 2015 mortality, we used 2012 life expectancy, the most recent year available.[6] For 1995 mortality, life expectancy was not available for ages 86 to 100 years, so we assumed the same proportionate decline in life expectancy for each single age as in 2012.[6,11] Results were stratified by sex and race. We then summed life-years lost across all individuals, and calculated the share of life-years lost to each cause of death to better understand how the leading causes of death compared on the basis of number of deaths and number of life-years lost.

To better understand reasons for the change in life-years lost between 1995 and 2015, we developed a mathematical model to consider 3 factors: changes in disease-specific mortality rates, population growth, and longer life expectancy. Our methods were as follows. First, we recognized that life-years lost was the product of the number of deaths and remaining life expectancy. Second, the number of deaths was the product of the mortality rate and population size, so that life-years lost equaled the mortality rate multiplied by population size multiplied by remaining life expectancy.

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Third, for each age (single-year increments), sex, race, and cause-of-death subgroup, we employed a first-order Taylor series expansion, so that the change in life-years lost was approximated by a weighted average of the change in mortality rates, the change in population size, and the change in remaining life expectancy. Available as supplements to the online version of this article at http://www.ajph.org, Appendix A provides further details, and Appendix B provides case examples of these methods for cancer and heart disease. We performed analyses in Stata/MP version 13.1 (StataCorp LP, College Station, TX).

RESULTS

Leading causes of death and life-years lost appear in Table 1. In 2015, heart disease ranked slightly above cancer as the leading cause of death (635 310 vs 596 730 deaths) but cancer accounted for almost 2 million more life-years lost (9 260 413 vs 7 529 750). Conditions that disproportionately affect young people appeared more prominently when measured by life-years lost. For example, accidents resulted in 5.4% of deaths, slightly below chronic lower respiratory diseases, but caused twice the share of life-years lost (10.6%). Similarly, suicides ranked fifth in life-years lost versus 10th in number of deaths, perinatal conditions ranked 9th versus 18th, and homicides ranked 10th versus 16th. By contrast, Alzheimer's disease was the 6th-leading cause of death but only the 11th-ranked cause of life-years lost.

Trends from 1995 to 2015 also appear in Table 1. Deaths from heart disease decreased by 103 351, saving 482 937 life-years or 4.7 life-years per death averted. Cancer deaths increased by 57 857, with a loss of almost 22 years per additional death. Accidents were the fastest growing cause of life-years lost (1 315 573), highlighting a 4.5-fold increase in life-years lost to accidental poisonings, primarily drug overdoses. Other conditions with large increases in life-years lost included chronic lower respiratory diseases, Alzheimer's disease, and suicides (448 598–670 237 each). By contrast, the largest improvement in life-years lost was from HIV (–1 341 882); other conditions with large improvements included homicides, influenza and pneumonia, and congenital malformations (–176 541 to –121 225 each). Life-years lost increased by more than 100 000 for 12 causes of death but decreased in similar magnitude for only 5 causes.

TABLE 1—Cause of Death in the United States, Ranked by Number of Deaths and Life-Years Lost: National Vital Statistics System, 1995 and 2015

	Rank		No. (% of Total)	
Cause	2015	1995	2015	1995
Ranked by no. of deaths				
Diseases of heart	1	1	635 310 (23.4)	738 661 (31.9)
Malignant neoplasms	2	2	596 730 (22.0)	538 873 (23.3)
Chronic lower respiratory diseases	3	4	155 179 (5.7)	102 920 (4.4)
Accidents (unintentional injuries)	4	5	147 534 (5.4)	90 950 (3.9)
Cerebrovascular diseases	5	3	140 589 (5.2)	157 787 (6.8)
Alzheimer's disease	6	14	110 586 (4.1)	20 607 (0.9)
Diabetes mellitus	7	7	79 622 (2.9)	59 316 (2.6)
Influenza and pneumonia	8	6	57 168 (2.1)	82 969 (3.6)
Nephritis[a]	9	11	50 016 (1.8)	23 685 (1.0)
Intentional self-harm (suicide)	10	9	44 324 (1.6)	31 341 (1.4)
Septicemia	11	13	40 847 (1.5)	20 989 (0.9)
Chronic liver disease and cirrhosis	12	10	40 428 (1.5)	25 262 (1.1)
Essential (primary) hypertension[b]	13	18	32 242 (1.2)	12 495 (0.5)
Parkinson's disease	14	20	27 985 (1.0)	10 825 (0.5)
Pneumonitis caused by solids and liquids	15	21	19 824 (0.7)	9 611 (0.4)
Other causes of death			539 814 (19.9)	388 953 (16.8)
Total			2 718 198	2 315 244
Ranked by life-years lost				
Malignant neoplasms	1	2	9 260 413 (22.8)	7 995 635 (23.1)
Diseases of heart	2	1	7 529 750 (18.6)	8 012 687 (23.1)
Accidents (unintentional injuries)	3	3	4 301 071 (10.6)	2 985 498 (8.6)
Chronic lower respiratory diseases	4	6	1 855 208 (4.6)	1 184 971 (3.4)
Intentional self-harm (suicide)	5	7	1 510 953 (3.7)	1 062 355 (3.1)
Cerebrovascular diseases	6	4	1 502 341 (3.7)	1 566 558 (4.5)
Diabetes mellitus	7	10	1 202 879 (3.0)	811 151 (2.3)
Chronic liver disease and cirrhosis	8	13	919 002 (2.3)	540 732 (1.6)
Perinatal conditions[c]	9	8	908 955 (2.2)	989 190 (2.9)
Assault (homicide)	10	9	781 958 (1.9)	958 499 (2.8)
Alzheimer's disease	11	17	704 738 (1.7)	145 774 (0.4)
Influenza and pneumonia	12	11	619 357 (1.5)	782 216 (2.3)
Nephritis[a]	13	15	593 242 (1.5)	260 986 (0.8)
Septicemia	14	14	577 422 (1.4)	265 184 (0.8)
Congenital malformations[d]	15	12	563 557 (1.4)	684 782 (2.0)
Other causes of death			7 745 436 (19.1)	6 419 224 (18.5)
Total			40 576 281	34 665 444

[a]Nephritis includes nephrotic syndrome and nephrosis.

[b]Essential (primary) hypertension includes hypertensive renal disease, following the Centers for Disease Control and Prevention's definition for leading causes of death.

[c]Perinatal conditions include causes originating before birth or in the first 28 days of life, excluding congenital malformations, external injury, and neoplasms.

[d]Congenital malformations include deformations and chromosomal abnormalities.

Reasons for the Change in Life-Years Lost

Table 2 displays reasons for the change in life-years lost between 1995 and 2015. Improvements in disease-specific mortality rates contributed to a 28% reduction in life-years

lost since 1995. However, the total number of life-years lost actually increased by 5 910 837 (17%) during the study period, attributable to population growth (mostly in individuals aged 50 to 64 years, 16% contribution) and longer life expectancy (mostly in White males, 5% contribution).

Table 3 (and Appendix C, available as a supplement to the online version of this article at http://www.ajph.org) shows the results by disease. Life-years lost to cancer increased by 1.3 million, which was entirely attributable to longer life expectancy and population growth. Had both factors remained constant since 1995, life-years lost to cancer would have fallen by 3.0 million (38%). For comparison, life-years lost to heart disease would have fallen by 4.5 million (56%) and life-years lost to accidents would have risen by about 0.5 million (16%). Substantial progress in disease-specific mortality rates also contributed to reduced life-years lost to HIV (–99%) and peptic ulcers (–76%).

More deaths in individuals aged 50 to 64 years contributed heavily to growth in life-years lost to primary hypertension (25%), septicemia (21%), nephritis (17%), and chronic liver disease (15%), and more deaths among the very elderly (individuals aged ≥ 80 years) contributed heavily to growth in life-years lost to Alzheimer's disease (189%) and Parkinson's disease (42%). For the very elderly, disease-specific mortality rates increased for only 14 leading causes of death, with Alzheimer's disease causing more growth in life-years lost than all other increases combined (275 630 vs 192 912 life-years, adjusted for population growth and longer life expectancy; data not shown). Similarly, decreases in heart disease–specific mortality caused greater reductions in life-years lost for the very elderly than did all other decreases combined (–1 123 434 vs –818 598 adjusted life-years; data not shown).

For 4 major disease categories, the change in life-years lost varied substantially by cause-of-death, as follows.

Cancer. The largest increase in life-years lost to cancer occurred for liver and pancreatic cancers (269 246 and 260 708, respectively; Appendix D, available as a supplement to the online version of this article at http://www.ajph.org). Although improved mortality rates contributed to fewer life-years lost for all but 3 cancer sites (liver, pancreas, and uterus), population growth and longer life expectancy offset these gains for 16 of 22 leading cancers (Appendix D). For example, improvements in disease-specific mortality for lung cancer contributed to a decline of 1 137 193 life-years, but life-years lost actually increased by 102 128 (Appendix D).

Heart disease. The decline in life-years lost to heart disease was primarily attributable to progress in treating acute myocardial infarction (–1 004 911 life-years lost, of which 84% was attributable to a lower disease-specific mortality rate; Appendix E, available as a supplement to the online version of this article at http://www.ajph.org). Life-saving treatment of acute disease gave rise to an increase in chronic disease as life-years lost to heart failure and hypertensive heart disease both increased (269 714 and 312 099, respectively), primarily because of population growth but also because of rising heart disease–specific mortality (Appendix E).

Accidents. Although accidents had the largest increase in life-years lost (Table 3), this was almost entirely from accidental poisonings and falls. Had these factors not changed, accidents (primarily motor vehicle accidents) would have fallen by 11.3% (–336 819 life-years; Appendix F, available as supplement to the online version of this article at http://www.ajph.org), ranking as the third largest decrease in life-years lost in 2015, between heart disease and homicide (Table 3). Nearly all growth in life-years lost to accidental poisonings was attributable to a higher mortality rate (88% of growth), but an aging population substantially contributed to growth in life-years lost to falls (46% of growth; Appendix F).

Chronic lower respiratory diseases. Chronic lower respiratory diseases had the third largest increase in life-years lost (Table 3), primarily from "other chronic lower respiratory diseases" including chronic obstructive pulmonary disease (+836 054 [102%] since 1995, caused by both higher disease-specific mortality rates [32%] and population growth [54%]; Appendix G, available as a supplement to the online version of this article at http://www.ajph.org). Life-years lost to asthma declined 23% since 1995 (Appendix G).

TABLE 2—Reasons for the Change in Life-Years Lost, 1995–2015, United States: National Vital Statistics System

Factor	%
Total increase in life-years lost	17.0
Reasons for change, 1995–2015	
Population growth	34.9
Age, y	
< 50	2.5
50–64	16.1
65–79	9.5
≥ 80	6.9
Longer life expectancy	10.0
Race and sex	
White males	5.0
White females	2.6
Black males	1.4
Black females	0.8
Other	0.3
Changes in disease-specific mortality	–27.9
Decreases	–39.6
Diseases of heart	–13.0
Malignant neoplasms	–8.7
HIV	–4.4
Other	–13.4
Increases	11.6
Accidents (unintentional injuries)	1.4
Alzheimer's disease	1.1
Intentional self-harm (suicide)	0.4
Other	8.7

Note. Life-years lost increased by 5 910 837 from 1995 to 2015. We attributed the change to 3 factors: longer life expectancy, population growth, and changes in disease-specific mortality rates.

Racial Differences

Table 4 (and Appendix H, available as a supplement to the online version of this article at http://www.ajph.org) shows results by race and sex. Progress in heart disease was mostly limited to Whites; life-years lost increased 20.8% for Black males and 3.5% for Black females, attributable to increased population size and life expectancy for young and middle-aged minorities. We observed similar differences for cerebrovascular disease (+15.9% for Black males vs –0.1% for White males). By contrast, the increase in life-years lost to accidental deaths (including overdoses), suicides, and chronic liver

TABLE 3—Change in Life-Years Lost by Cause of Death, 1995–2015, United States: National Vital Statistics System

Cause of Death	Actual Change in Life-Years Lost, No. (%)	Change in Life-Years Lost From Change in Disease-Specific Mortality Rates				
		All Ages, No. (%)	Aged < 50 Years, %	Aged 50–64 Years, %	Aged 65–79 Years, %	Aged ≥ 80 Years, %
Total	5 910 837 (17)	−1 653 262 (−28)	−9	−6	−9	−3
Largest increase in life-years lost						
Accidents (unintentional injuries)	1 315 573 (44)	481 632 (16)	6	8	1	1
Malignant neoplasms	1 264 778 (16)	−3 027 145 (−38)	−7	−15	−13	−2
Chronic lower respiratory diseases	670 237 (57)	−34 173 (−3)	−1	−1	−4	4
Alzheimer's disease	558 964 (383)	383 115 (263)	0	5	69	189
Intentional self-harm (suicide)	448 598 (42)	151 996 (14)	7	8	0	0
Diabetes mellitus	391 728 (48)	−111 280 (−14)	3	−5	−9	−2
Chronic liver disease and cirrhosis	378 269 (70)	63 362 (12)	−3	15	0	0
Nephritis[a]	332 256 (127)	133 122 (51)	5	17	20	10
Septicemia	312 238 (118)	131 509 (50)	7	21	19	3
Essential (primary) hypertension[b]	224 794 (170)	105 290 (80)	12	25	20	23
Largest decrease in life-years lost						
HIV	−1 341 882 (−88)	−1 532 394 (−99)	−92	−8	0	0
Diseases of heart	−482 937 (−6)	−4 521 626 (−56)	−4	−14	−24	−14
Assault (homicide)	−176 541 (−18)	−415 704 (−43)	−41	−2	−1	0
Influenza and pneumonia	−162 859 (−21)	−501 431 (−64)	−11	−6	−19	−28
Congenital malformations[c]	−121 225 (−18)	−182 449 (−27)	−26	1	−1	−1
Perinatal conditions[d]	−80 235 (−8)	−138 724 (−14)	−14	0	0	0
Atherosclerosis	−68 618 (−57)	−117 839 (−98)	−2	−13	−33	−50
Cerebrovascular diseases	−64 217 (−4)	−837 765 (−53)	−6	−10	−20	−17
Aortic aneurysm and dissection	−54 232 (−28)	−138 918 (−72)	−1	−16	−41	−13
Peptic ulcer	−20 311 (−32)	−47 509 (−76)	−11	−15	−28	−22

Note. For the 10 causes of death with the largest increase or decrease in life-years lost since 1995, we estimated how much of the change in life-years lost was attributable to changes in disease-specific mortality rates. Appendix C, available as a supplement to the online version of this article at http://www.ajph.org, shows the change in life-years lost attributable to population growth and longer life expectancy.

[a]Nephritis includes nephrotic syndrome and nephrosis.

[b]Essential (primary) hypertension includes hypertensive renal disease, following the Centers for Disease Control and Prevention's definition for leading causes of death.

[c]Congenital malformations include deformations and chromosomal abnormalities.

[d]Perinatal conditions include causes originating before birth or in the first 28 days of life, excluding congenital malformations, external injury, and neoplasms.

disease was at least one third smaller for Blacks than Whites, because of progress in mortality rates. Absolute racial differences in males were twice as large for homicides using life-years lost (10.7% share of deaths in Black males vs 1.4% in White males) as when using deaths (4.9% vs 0.5%; Appendixes I–J, available as supplements to the online version of this article at http://www.ajph.org), and life-years lost to homicides since 1995 increased slightly for Black males (+2.4%) while declining 29.9% for White males (Table 4). Similarly, racial differences in females were 3.5-fold larger for perinatal conditions when one considers life-years lost as opposed to deaths (Appendixes K–L, available as supplements to the online version of this article at http://www.ajph.org). HIV fell from the 3rd to the 11th-ranked cause of life-years lost in Black males; among White males, HIV declined from the 4th to the 22nd-rank (Appendixes I–J).

DISCUSSION

In this analysis of US mortality trends over 20 years, we considered changes in life-years lost, a topic that has been previously addressed in the Global Burden of Disease project[4,5] and CDC reports.[8] For all leading causes of death, we compared the number of life-years lost with the number of deaths by age, sex, and race, and developed a model to assign underlying reasons for historical patterns. Reordering mortality by life-years lost painted a fuller picture of changing mortality and its distribution across various population segments, suggesting a number of timely observations.

First, although heart disease is often cited as the most common cause of death in the United States,[1,3,12] this claim can be misleading. Heart disease caused 6% more deaths than cancer but, because of heart disease's concentration in the elderly, 23% fewer life-years lost. (Before age 75 years, heart disease caused 58% fewer deaths than cancer.) Our analysis also highlights the differential success in treating heart disease and cancer. Improvements in primary and secondary

TABLE 4—Change in Life-Years Lost By Race and Sex, 1995–2015, United States: National Vital Statistics System

Cause of Death	Black Males, %		White Males, %		Black Females, %		White Females, %	
	Actual	From Change in Disease-Specific Mortality Rates	Actual	From Change in Disease-Specific Mortality Rates	Actual	From Change in Disease-Specific Mortality Rates	Actual	From Change in Disease-Specific Mortality Rates
Total	7	−52	16	−28	14	−39	17	−16
Largest increase in life-years lost (sorted by increase for all races and sexes)								
Accidents (unintentional injuries)	25	−21	42	21	30	−5	58	40
Malignant neoplasms	22	−65	17	−39	32	−41	7	−30
Chronic lower respiratory diseases	52	−32	47	−19	81	1	62	17
Alzheimer's disease	510	305	324	186	707	476	379	284
Intentional self-harm (suicide)	19	−25	33	10	51	13	73	54
Diabetes mellitus	93	−10	76	11	26	−46	15	−22
Chronic liver disease and cirrhosis	−7[a]	−79	68	15	19	−45	96	50
Nephritis[b]	139	33	135	55	138	45	105	56
Septicemia	81	−5	143	67	94	18	110	63
Essential (primary) hypertension[c]	144	29	223	121	112	19	147	88
Largest decrease in life-years lost (sorted by decrease for all races and sexes)								
HIV	−85	−111	−92	−97	−78	−95	−87	−89
Diseases of heart	21[a]	−61	−5	−57	3[a]	−61	−18	−51
Assault (homicide)	2[a]	−36	−30	−41	−36	−56	−30	−37
Influenza and pneumonia	−23	−81	−21	−67	−23	−70	−23	−54
Congenital malformations[d]	−5	−24	−22	−25	−14	−25	−21	−22
Perinatal conditions[e]	−8	−22	−14	−12	−14	−23	−7	−3
Atherosclerosis	−31	−99	−56	−99	−46	−99	−62	−91
Cerebrovascular diseases	16[a]	−64	0	−53	1[a]	−60	−15	−47
Aortic aneurysm and dissection	28[a]	−50	−35	−79	−6	−71	−33	−60
Peptic ulcer	−42	−99	−29	−75	−28	−85	−38	−68

Note. Appendix H, available as a supplement to the online version of this article at http://www.ajph.org, provides additional details.

[a]The change in life-years lost had opposite signs between races (by sex).

[b]Nephritis includes nephrotic syndrome and nephrosis.

[c]Essential (primary) hypertension includes hypertensive renal disease, following the Centers for Disease Control and Prevention's definition for leading causes of death.

[d]Congenital malformations include deformations and chromosomal abnormalities.

[e]Perinatal conditions include causes originating before birth or in the first 28 days of life, excluding congenital malformations, external injury, and neoplasms.

prevention for atherosclerotic coronary artery disease, including statins, aspirin, smoking cessation, and blood pressure control, coupled with better acute treatments such as primary angioplasty and stenting, have led to a 42% reduction in years lost to acute myocardial infarction since 1995. (Appendix M, available as a supplement to the online version of this article, provides references.) The prevention of death from these acute events, however, gave rise to resultant chronic conditions such as heart failure and hypertensive heart disease, which have contributed to increases in premature deaths from heart disease. Life-saving treatments for these conditions, including angiotensin-converting enzyme inhibitors, beta-blockers, and implantable cardiac defibrillators have been less successful in extending life at the population level. Whether this is attributable to undertreatment or poor patient compliance,[13,14] there are clearly opportunities for improvement.

In contrast to the gains in heart disease, over the same time period, life-years lost to cancer have increased by 16%. This increase occurred because population growth (especially baby boomers) and longer life expectancy from 1995 to 2015 entirely offset gains in disease-specific mortality rates. Despite large investments in research and treatment, life-years lost only declined for 6 types of cancer: lymphoma (both non-Hodgkin's and Hodgkin's), breast, prostate, stomach, and cervical cancer. The combined gains for these sites were dwarfed by the increase in life-years lost to pancreatic and liver cancers (158 338 vs 529 953), for which screening is ineffective and survival is bleak. In addition, life-years lost to lung cancer increased 102 128 despite a 52% decline in disease-specific mortality, suggesting that as smokers avoided lethal cardiovascular events, their competing risk of lung cancer death increased. As the nascent Cancer Moonshot

initiative seeks future progress in methodological dimensions—encouraging cooperation among researchers, developing big data, and promoting genetic-based treatments—our analysis highlights the need to target cures for pancreatic, liver, and lung cancers to achieve population-level gains.

Second, the importance of "nondiseases" has risen substantially since 1995. Despite a decline in homicides, the increase in life-years lost to accidental deaths outpaced all other causes, and the increase in life-years lost to suicide was slightly above that for diabetes. To put it in context, the entire gains of the past 20 years in preventing and treating HIV were offset by the increase in accidental deaths, particularly deaths related to substance use. Although many of these deaths are attributable to heroin or fentanyl obtained illegally,[15,16] 4 in 5 new heroin users initially misuse prescription opioids,[17] and more than 240 million prescriptions for opioids are still written annually.[17] Whether initiatives such as $1.1 billion in new federal funding can reverse this tragedy remains to be seen.[18] This burden of addiction and mental illness highlights the need for effective treatment of these conditions. A notable exception for nondiseases was motor vehicle accidents, for which improved vehicle safety led to a 21% decline in life-years lost since 1995.

Third, our analysis highlights changes in causes of death for the very elderly, all of whom must die of something. Among elders aged 80 years or older, changes in disease-specific mortality rates were dominated by Alzheimer's disease and heart disease, leading to a change in life-years lost that exceeded the combined contribution of all other causes of death. The more than 3-fold increase in life-years lost to Alzheimer's disease may be partially attributable to elders not dying of heart conditions. In particular, given the low quality of life associated with neurodegenerative diseases, one must consider that future progress in other disease areas is likely to increase the need for advances in Alzheimer's and other dementia research.

Fourth, despite progress in racial disparities since 1995, challenges remain. As a consequence of narrowing racial disparities in life expectancy (Appendix N, available as a supplement to the online version of this article at http://www.ajph.org), there has been an increase in racial differences in life-years lost to heart and cerebrovascular diseases. This implies that, although life expectancy is increasing for some Black Americans, others, particularly the poor, who are more likely to suffer early cardiovascular disease,[19–21] are not sharing in those gains. Blacks are at least 50% more likely to die early from heart disease or stroke,[22] a statistic reflected by a 21% increase in life-years lost for Black males.

Moreover, violent deaths remain especially important to Black males, a topic that has drawn increased national attention with the Black Lives Matter movement. Homicides ranked third by life-years lost for Black males, compared with 16th by number of deaths across races. Our analysis also highlighted the importance of HIV; similar to past findings, Blacks represented 13% of the US population but accounted for 53% of HIV-related deaths.[23–25] Only 29% of infected Black patients achieved viral suppression in 2012.[23–25] Similarly, racial disparities in infant mortality contributed to perinatal conditions being the fourth-leading cause of life-years lost for Black females.[22] Infant mortality rates among Blacks were double that of all races (10.4 vs 5.9 per 1000 live births) in 2015,[26] although, even for Whites, the United States lagged behind all major industrialized countries.[26,27]

We acknowledge that some might consider life-years lost to be a form of age discrimination. However, bioethicists have argued that everyone in society deserves a "fair chance" to live a normal life span, with younger individuals having a stronger claim of fairness for additional years.[7,28] Others generally support our construct but argue that the greatest weighting should be attached to death in young adults, who actively contribute to the labor force and community.[29]

Limitations

Our study has several important limitations. First, death certificate data may be inaccurate[30,31] and the quality of these data may vary by year. In particular, because dementia awareness has increased in recent years,[32] it is possible that our analysis overstated growth in life-years lost to Alzheimer's disease. However, we used the same raw data that inform national reports on leading causes of death,[1,2] so to the extent that our analysis contains inaccuracies, national reports should as well. Large categories, such as heart disease and cancer, may be less susceptible to yearly coding variation.

Second, individual life expectancies were not adjusted for risk factors (such as tobacco use or obesity) or cause of death and, for some decedents, likely differed from national averages.[33,34] The information necessary to perform such adjustments was not available from death certificate filings.

Third, we only considered racial disparities between Black and White individuals, as opposed to other minorities (for whom data may be less accurate),[35] and did not address ethnicity.

Fourth, life expectancy was not adjusted for quality of life. Because this factor generally declines with age, including quality-adjusted life-years would amplify results of this analysis.

Public Health Implications

Life-years lost may provide additional context for understanding long-term mortality trends. Focusing on life-years provides perspective on the societal burden of disease (e.g., cancer has already surpassed heart disease as the leading cause of life-years lost) and highlights the disparities in disease burden by race and sex. On the basis of current trends, future progress in secondary prevention and treatment of chronic heart conditions, prevention and treatment of addiction, and research to prevent or treat certain cancers and neurodegenerative disease appear critically important. AJPH

CONTRIBUTORS

G. B. Taksler and M. B. Rothberg jointly conceptualized the study, analyzed and interpreted the data, critically revised the article for important intellectual content, and approved the final article. G. B. Taksler designed the study, drafted the article, collected and assembled data, and provided statistical expertise.

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HUMAN PARTICIPANT PROTECTION

This study did not meet criteria for human participants research at the Cleveland Clinic institutional review board, because data were for decedents.

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