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ORIGINAL RESEARCH

Heart Disease Mortality in the United States, 1970 to 2022

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BACKGROUND: Studying trends in mortality is essential to advance understanding of population health. Further evaluation of long-term heart disease mortality trends and subtypes in the United States is needed to guide public health and clinical interventions.

METHODS: This study used the National Vital Statistics System Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research data for adults aged 25 years and older in the United States from 1970 to 2022. Outcomes included absolute number and age-adjusted mortality of total heart disease, ischemic heart disease, and other heart disease subtypes.

RESULTS: From 1970 to 2022, overall age-adjusted heart disease mortality decreased by 66% from 1970 to 2022 (from 761 to 258 per 100 000). In 1970, 91% of all heart disease deaths were ischemic, declining to 53% of all heart disease deaths in 2022. From 1970 to 2022, age-adjusted mortality decreased by 89% for acute myocardial infarction (from 354 to 40 per 100 000) and 81% for all ischemic heart disease (from 693 to 135 per 10 000). In contrast, from 1970 to 2022 age-adjusted mortality for other heart disease subtypes increased by 81% (from 68 to 123 per 100 000), with the greatest increases in heart failure (146% increase), hypertensive heart disease (106% increase) and arrhythmias (450% increase).

CONCLUSIONS: Heart disease mortality has decreased over the past 5 decades. There is an increasing burden of mortality from other heart conditions including heart failure, hypertensive heart disease, and arrhythmias. Further efforts must be undertaken to address the growing challenge of these other heart conditions.

Key Words: heart disease ■ ischemic ■ mortality

Studying trends in mortality is essential to advance our understanding of population health, to guide public health and clinical interventions, and to improve health outcomes for individuals. In the United States, heart disease has been the leading cause of death for over a century.[1,2] Concrete advancements in medical technology, targeted interventions aimed at managing risk factors such as hypertension, hyperlipidemia, and smoking cessation, and significant strides in the management of acute myocardial infarction (AMI) have been posited to have led to a striking decline in ischemic (coronary) heart disease mortality since the 1960s.[3–6] However, although there have been remarkable improvements in ischemic heart disease mortality, recent studies suggest an increase in mortality rates in the 21st century from other heart diseases such as hypertensive heart disease, heart failure, and arrhythmias.[7,8]

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CLINICAL PERSPECTIVE

What Is New?

- In this study of mortality records from 1970 to 2022 in the United States, age-adjusted mortality for acute myocardial infarction decreased by 89%, and ischemic heart disease decreased by 81%, whereas other heart disease age-adjusted mortality, including heart failure and arrhythmias, increased by 81%.

What Are the Clinical Implications?

- Heart disease mortality has evolved over the past 5 decades, reflecting the successes in ischemic heart disease management and the emerging challenges posed by other heart conditions such as heart failure and arrhythmias.

Nonstandard Abbreviations and Acronyms

AAPC	average annual percentage change

To further evaluate long-term trajectories in heart disease mortality, this study examines the mortality trends in ischemic heart disease and other heart disease subtypes, including heart failure, arrhythmias, and hypertensive heart disease, from 1970 to 2022 in the United States. This study contributes to the existing body of research by specifically analyzing AMI mortality as part of ischemic heart disease, identifying periods of significant progress and describing the chronology of public health and clinical advancements. Unlike prior studies, this analysis extends over a broader time span, offering a comprehensive view that not only reflects on historical achievements but may also enable a forward-looking approach to guide future advancements. Through this analysis, we affirm the extensive efforts and therapeutic innovation that has led to a reduction in ischemic heart disease mortality, while examining and positing explanations for the concurrent rise in mortality from other heart disease subtypes.

METHODS

The data that support the findings of this study are available from the corresponding author upon reasonable request and are publicly available at https://wonder.cdc.gov/.

Data Sources

We accessed mortality data for all United States adults aged 25 years and older from 1970 through 2022 from the National Vital Statistics System through the Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research (WONDER) database, which compiles information from all registered United States death certificates. We used *International Classification of Diseases* (*ICD*) codes to ascertain underlying cause of death related to heart disease across multiple revisions of the coding system (*Eighth Revision* [*ICD-8*; 1970–1978], *Ninth Revision* [*ICD-9*; 1979–1998], *Tenth Revision* [*ICD-10*; 1999–2022]).[9–11] Data extraction focused on ischemic (coronary) heart disease (AMI defined as *ICD-10* I21, I22, and *ICD-8*, *ICD-9* equivalents, and other ischemic heart disease defined as *ICD-10* I20, I24, I25, and *ICD-8*, *ICD-9* equivalents) and other heart disease, which encompassed *ICD-10* subtypes such as heart failure (I50), cardiomyopathy (I42), hypertensive heart disease (I11, I13), valvular heart disease (nonrheumatic) (I34–I38), rheumatic heart disease (I00–I09), arrhythmia (I47–I49, excluding I49.0), cardiac arrest and ventricular arrhythmias (I46.2, I46.8, I46.9, I49.0), pulmonary heart disease (I26–I28) and other cardiac conditions (I30-I33, I40, I44–I45, I51) with corresponding *ICD-8* and *ICD-9* equivalents (Table S1).[12,13] Given that >90% of other ischemic heart disease mortality was *ICD-10* I25 and its *ICD-8*, *ICD-9* equivalents, it was renamed chronic ischemic heart disease for this analysis. Population size and life expectancy were extracted from Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research population estimates reported within the underlying cause of death data and annual life tables, respectively.[9–11,14]

Statistical Analysis

Deaths were reported as absolute number and age-adjusted rates, with annual age-adjusted mortality rates using the 2000 US Census as the standard population. The Joinpoint Regression Program (Joinpoint V 5.0 available from the National Cancer Institute) was used to calculate interval and overall percentage change over the time period.[7,15,16] Annual percentage change with 95% CIs were calculated among intervals identified by the joinpoint regression (Table S2). The weighted averages of the annual percentage changes were reported as average annual percentage changes (AAPCs) and 95% CIs as a summary of the reported mortality trend for all heart disease subtypes across the study period (Table S3). The research received an exemption from institutional review board review as it used publicly accessible, deidentified data.

RESULTS

From the years 1970 through 2022, the US population over the age of 25 years increased from 108.9 million

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to 229.0 million, and life expectancy increased from 70.9 years to 77.5 years. During this time period, the National Vital Statistics System recorded a cumulative total of 119 152 492 deaths, with 37 276 835 (31%) attributable to heart disease over 50 years. In 1970 there were 733 273 heart disease deaths (41% of total deaths), of which 666 257 (91%) were ischemic and 67 016 (9%) were from other heart disease (Figure 1A). In 2022 there were 701 443 heart disease deaths (24% of total deaths), of which 371 360 (53%) were ischemic and 330 083 (47%) were from other heart disease. Of ischemic heart disease deaths in 1970, 356 984 (54%) deaths were attributed to AMI and 309 273 (46%) were attributed to chronic ischemic heart disease (Figure 1A). Of ischemic heart disease deaths in 2022, 108 651 (29%) were attributed to AMI and 267 514 (71%) were attributed to chronic ischemic heart disease (Figure 1A).

The age-adjusted mortality for AMI decreased 89%, from 354 per 100 000 in 1970 to 40 per 100 000 in 2022 (Figure 1B). AAPC for AMI was −4.2% (95% CI, −4.3 to −4.1) from 1970 to 2022. The age-adjusted mortality for chronic ischemic heart disease decreased 71%, from 343 per 100 000 in 1970 to 98 per 100 000 in 2022 (Figure 1B). AAPC for chronic ischemic heart disease was −2.5% (95% CI, −2.6 to −2.4) from 1970 to 2022. Correspondingly, with the decrease in both AMI and chronic ischemic heart disease, the age-adjusted mortality for ischemic heart disease decreased 81% from 693 per 100 000 in 1970 to 135 per 100 000 in 2022 (Figure 1B). AAPC for ischemic heart disease was −3.1% (95% CI, −3.2 to −3.1) from 1970 to 2022. The age-adjusted mortality for all heart disease (ischemic and other) deaths decreased 66% from 761 per 100 000 in 1970 to 258 per 100 000 in 2022. AAPC for overall heart disease was −2.0% (95% CI, −2.1 to −2.0) from 1970 to 2022.

In contrast, the age-adjusted mortality for other heart disease subtypes increased 81%, from 68 per 100 000 in 1970 to 123 per 100 000 in 2022. AAPC for other heart disease subtypes was 1.2% (95% CI, 1.1–1.2) from 1970 to 2022. Among other heart disease subtypes, heart failure, hypertensive heart disease, and arrhythmia had the greatest increases in mortality, with age-adjusted mortality rising from 13 to 32 per 100 000 (146% increase), 16 to 33 per 100 000 (106% increase), and 2 to 11 per 100 000 (450% increase), respectively from 1970 to 2022 (Figure 2). There were also increases in mortality from pulmonary heart disease, nonrheumatic valvular heart disease, cardiomyopathy, and cardiac arrest from 1970 to 2022. In contrast, rheumatic heart disease age-adjusted mortality decreased from 13 per 100 000 in 1970 to 2 per 100 000 in 2022 (85% decrease).

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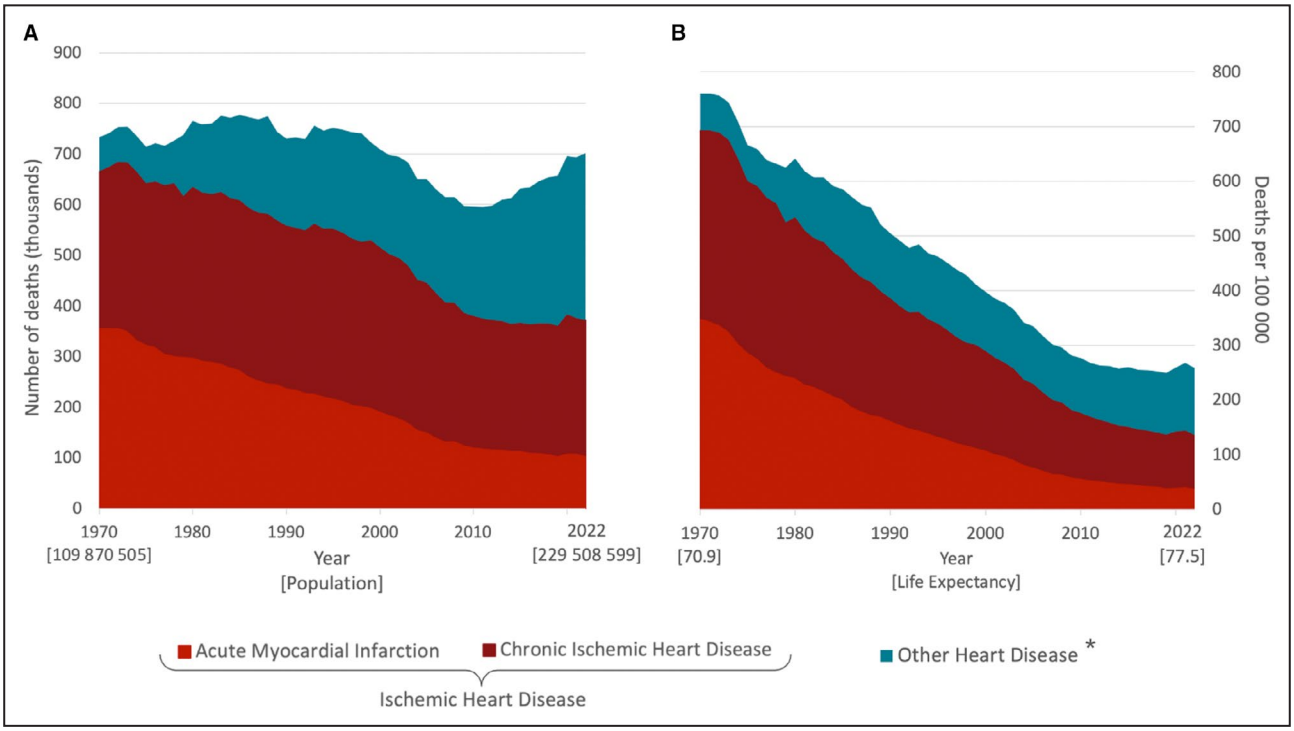

Figure 1. Absolute and age-adjusted mortality for ischemic and other heart disease in the United States, 1970 to 2022. Absolute (**A**) and age-adjusted (**B**) mortality for ischemic heart disease (acute myocardial infarction in bright red, chronic ischemic heart disease in dark red) and other heart disease (blue) from 1970 to 2022 in the United States. * See Figure 2 for other heart disease subtypes.

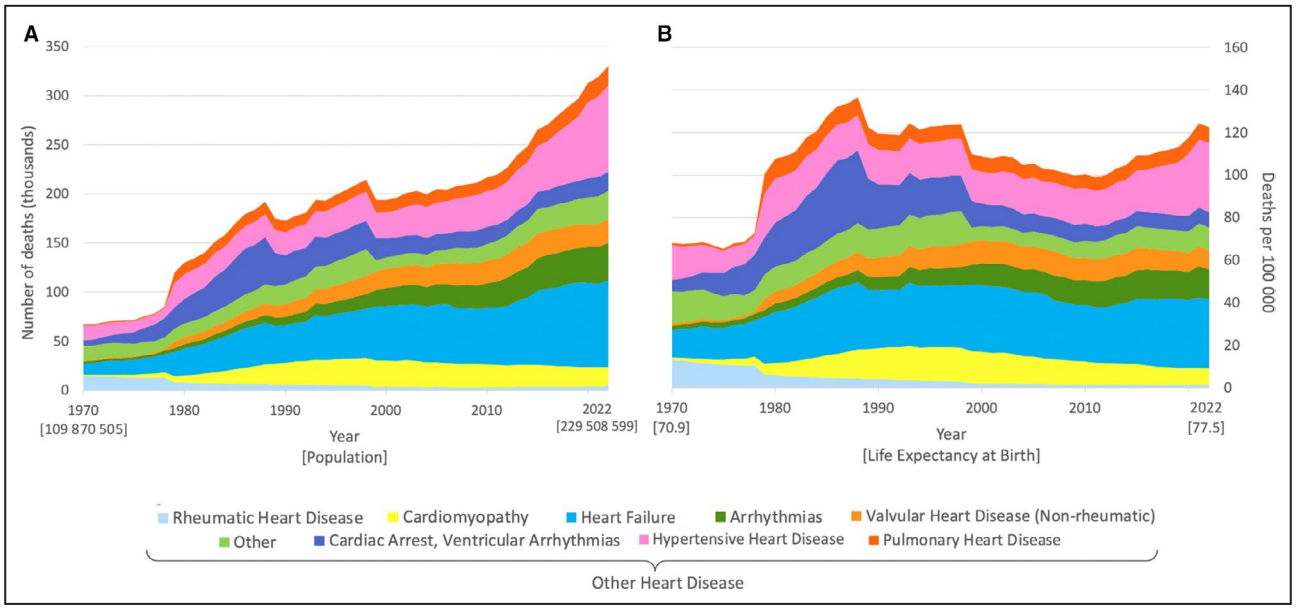

Figure 2. Absolute and age-adjusted mortality for other heart disease subtypes in the United States, 1970 to 2022.
Absolute (**A**) and age-adjusted (**B**) mortality for other heart disease subtypes from 1970 to 2022 in the United States.

DISCUSSION

Reflecting on the past 50 years, there has been a profound transformation in heart disease mortality. Over this period, we observed a remarkable 89% decline in age-adjusted mortality from AMI and an 81% decline in age-adjusted mortality from all ischemic heart disease. In contrast, we found that there has been an 81% increase in age-adjusted mortality from other heart disease subtypes, most significantly heart failure, hypertensive heart disease, and arrhythmia, which have increased to represent 12%, 13%, and 4%, respectively, of the total heart disease mortality in 2022. Our results expand previous studies that found significant rise of these conditions since the turn of the century, with similar proportions of 13%, 9%, and 6% in 2018.[7,8] Correspondingly, we found that from 1970 to 2022, the distribution of deaths within heart disease has shifted; in 1970 ischemic heart disease comprised 91% of all heart disease deaths, but only 53% in 2022, whereas other heart disease subtypes have increased from 9% of all heart disease deaths in 1970 to 47% in 2022.

We also observed a shift in mortality patterns characterized by a transition from AMI to chronic ischemic heart disease. We found that within ischemic heart disease, deaths from AMI significantly declined from 54% in 1970 to 29% in 2022, with a corresponding rise in the percentage of mortality from chronic ischemic heart disease from 46% in 1970 to 71% in 2022.

These changes in heart disease mortality over the past 5 decades likely reflect the successes in medical and public health interventions for ischemic heart disease, and in particular, AMI. However, our analysis reveals the emerging challenges posed by chronic ischemic heart disease and other heart conditions such as heart failure, hypertensive heart disease, and arrhythmias.

Several underlying factors may account for this shift from mortality from ischemic heart disease to other heart conditions. The first is the establishment of effective interventions that significantly reduced mortality from AMI. Beginning in the 1960s, the establishment and promotion of bystander cardiopulmonary resuscitation and later mobile external defibrillators affected preadmission survival, while the invention of coronary artery bypass grafting and the formation of coronary care units improved in-hospital and long-term AMI mortality.[17–20] Cardiac imaging improved into the 1970s with coronary angiography, which was capitalized by the advent of balloon angioplasty in 1977, followed by thrombolytic therapy, the use of aspirin, and coronary stenting in the 1980s to 1990s.[21–27] Simultaneously, the development of medical therapies such as beta blockers, renal-angiotensin-aldosterone system inhibitors, and statins in the 1980s to 1990s all contributed to the decline in AMI mortality from a treatment and secondary prevention perspective.[28–30] At the turn of the 21st century, high-intensity statin therapy and dual antiplatelet therapy were established, as well as landmark “door-to-balloon” trials that displayed substantial mortality benefits from expedited care.[31–35] Finally, from 2009 to 2022, high-sensitivity troponins improved the rapid diagnosis of AMI and advanced antiplatelet agents further improved mortality after revascularization, while lipid-lowering therapies such as ezetimibe

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and PCSK9 (proprotein convertase subtilisin/kexin type 9) inhibitors emerged to contribute to secondary prevention.[36–39]

More broadly, the identification and management of clinical risk factors also likely contributed to the reduction in AMI mortality and ischemic heart disease as a whole. These efforts target primary prevention, as well as secondary and tertiary prevention to reduce harmful comorbidities that drive progression of disease among patients with ischemic heart disease.[4–6] One of the first major strides in public health was against cigarette smoking, which was estimated to contribute to as much as 21% of ischemic heart disease mortality.[40] Smoke-free policies, increased taxation on tobacco products, and public awareness campaigns beginning with the pivotal 1964 surgeon general's report all played roles in the reduction of smoking from approximately 40% in 1970 to 14% in 2019.[41–43] In addition, during this time period from 1977 to 2022, physical activity was encouraged to reduce cardiovascular mortality, cholesterol and blood pressure goals were set and lowered, and clinical guidelines to treat these conditions were expanded.[44] For blood pressure, the Joint National Committee issued 8 sets of hypertension guidelines from 1977 to 2014, with sequential lowering of blood pressure goals to reduce the burden of heart disease and its sequelae.[45–48] Similarly, from 1988 to 2013, cholesterol goals were lowered according to the National Cholesterol Education Program's guidelines, driving the proportion of adults taking cholesterol-lowering medications from 3% in 1988 to approximately 45% in 2013, and subsequently decreasing the mean total cholesterol and low-density lipoprotein levels in the United States.[49–52]

However, despite the progress in therapies and guidelines, there has been rising prevalence of several heart disease risk factors such as obesity, diabetes, hypertension, and physical inactivity in the United States. From the 1970s to 2022, obesity prevalence has risen from 15% to 40%.[53] Diabetes, including prediabetes, has risen to affect an estimated 50% of United States adults in 2020.[54,55] Hypertension has increased from a prevalence of approximately 30% in 1978 to nearly 50% in 2022, and although partially attributable to lowered blood pressure goals, continues to see an absolute increase in the 21st century.[48,56,57] All of these risk factors contribute to an ongoing burden of ischemic heart disease but may also be accelerating pathophysiological processes leading to increased prevalence and subsequent mortality from other heart diseases such as heart failure, hypertensive heart disease, and arrhythmias.[58–61]

Demographic shifts in the United States have additionally contributed significant changes to the landscape of heart disease mortality. Over the decades spanning from 1970 to 2022, there has been a notable increase in life expectancy, from 70.9 years to 77.5 years in the United States.[14] This demographic change, and the successful management of AMI, have led to an increased survivorship burdened with chronic ischemic heart conditions. Consequently, the aging demographic contributes to the rising proportion of chronic ischemic heart disease prevalence and subsequent mortality, even amid the backdrop of overall declining heart disease mortality.[62,63] Similarly, the demographic shift toward an aging population allows for longer accumulation and thus mortality from other heart disease conditions such as heart failure, hypertensive heart disease, and arrhythmias, particularly atrial fibrillation.[7,8,64–66] Notably, although studies cite an increase in heart disease mortality, particularly AMI in the setting of the COVID-19 pandemic, our study found no reversal of long-term mortality trends, rather an acute increase in 2020 followed by decline.[67]

Finally, improvements in diagnostic capabilities and refinement of definitions over the years have led to improved identification of heart conditions such as heart failure with preserved ejection fraction and pulmonary hypertension, potentially allowing these conditions to more frequently be defined as ultimate underlying causes of mortality.[68,69] Regardless of identification, several studies show independent increases in mortality from these conditions in the 21st century, with significant increases in mortality due to heart failure, pulmonary hypertension, and arrhythmia, particularly atrial fibrillation.[70–72]

Limitations

Our study has several limitations. The use of multiple iterations of the *ICD* coding system can allow for potential miscoding and presents challenges in maintaining consistency in comparisons across the years. Particularly prominent is the change from *ICD-8* to *ICD-9* in 1979, when the mortality of several conditions (valvular heart disease, hypertensive heart disease, pulmonary heart disease) dramatically increased. This is thought to be a result of regroupings ("other diseases of the endocardium" into "valvular heart disease," heart diseases with hypertension into "hypertensive heart disease," "diseases of pulmonary circulation" defined).[73] Similarly, the decline in 1989, driven by an apparent decline in cardiac arrest, is hypothesized to be due to a major change in death certificates to encourage the inclusion of chronic conditions as the underlying cause of death and requiring the attending physician of record, who had more knowledge of the patient's chronic conditions, to certify the death certificate.[74] However, there is also potential for misclassification, as it has been shown that nonheart disease diagnoses are often assigned coronary heart disease on death certificates in cases with unknown cause.[75] A second limitation of our study is that certain conditions including heart failure,

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cardiomyopathy, arrhythmias, and in particular ventricular arrhythmias and cardiac arrest, may be overly simplistic, as many of these cases likely have underlying ischemic causes that cannot be precisely differentiated using current or past *ICD* codes. This limitation suggests that the true burden of ischemic heart disease may be underestimated in our findings. We also used "underlying cause of death" from Centers for Disease Control and Prevention Wide-Ranging Online Data for Epidemiologic Research rather than "multiple cause of death," perhaps underestimating contributions to aggregate mortality from each heart disease subtype.

We recognize that we did not perform a causal analysis, and the observed mortality shifts are not solely or directly linked to the interventions described herein. Instead, this narrative summarizes medical advances and public health progress that have been previously associated with improved cardiovascular mortality in the literature. We also acknowledge there is likely substantial heterogeneity in these reductions in heart disease mortality by age, sex, race, ethnicity, region, and urbanization, which we did not analyze in the present article and should be prioritized in future studies to confirm these overall trends in subpopulations. Finally, given data availability only until 2022, we were unable to assess the full impact of the COVID-19 pandemic on heart disease mortality trends.

CONCLUSIONS

In summary, the past half-century has witnessed a dramatic decrease in ischemic heart disease mortality, likely reflecting advancements in prevention and treatment strategies, particularly surrounding AMI. However, although the decline in ischemic heart disease mortality represents a pivotal achievement, the concomitant rise in heart disease mortality from conditions such as heart failure, hypertensive heart disease, and arrhythmias must be addressed. An aging population, improved diagnostic capabilities, and increased ischemic survivorship now burdened with chronic heart conditions may contribute to this rise in mortality, however, further research is needed to elucidate the specific underlying factors. In the future, research and patient care should focus on addressing the growing challenge of these heart conditions, while continuing to maintain and expand our progress in ischemic heart disease.

ARTICLE INFORMATION

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Disclaimer

The views expressed in this articleare those of the authors and do not necessarily represent the views of the American Heart Association; National Heart, Lung, and Blood Institute; the National Institutes of Health; or the US Department of Health and Human Services.

Supplemental Material

Tables S1–S3

REFERENCES

1. The Center for Disease Control: National Center for Health Statistics, National Vital Statistics System. Leading causes of death, 1990–1998. Accessed February 20, 2024. https://www.cdc.gov/nchs/data/dvs/lead1900_98.pdf.
2. The Center for Disease Control: National Center for Health Statistics, National Vital Statistics System. Deaths, percent of total deaths, and death rates for the 15 leading causes of death in a 5-year age group, by race and sex, 1999–2015. Accessed February 20, 2024. https://www.cdc.gov/nchs/nvss/mortality/lcwk1.htm.
3. National Institute of Health: National Heart, Lung, and Blood Institute. Morbidity & mortality: 2012 chartbook on cardiovascular, lung, and blood diseases, chart 2–5 unadjusted death rate for selected causes, U.S. 1950–2008. Accessed March 1, 2024. https://www.astrazeneca.com/content/dam/az/media-centre-docs/article_files/articles-2015/Documents/2012_ChartBook_508.pdf.
4. Ford ES, Ajani UA, Croft JB, Critchley JA, Labarthe DR, Kottke TE, Giles WH, Capewell S. Explaining the decrease in U.S. deaths from coronary disease, 1980–2000. *N Engl J Med*. 2007;356:2388–2398. doi: 10.1056/NEJMsa053935
5. Mensah GA, Wei GS, Sorlie PD, Fine LJ, Rosenberg Y, Kaufmann PG, Mussolino ME, Hsu LL, Addou E, Engelgau MM, et al. Decline in cardiovascular mortality: possible causes and implications. *Circ Res*. 2017;120(2):366–380. doi: 10.1161/CIRCRESAHA.116.309115
6. Braunwald E. Shattuck lecture-cardiovascular medicine at the turn of the millennium: triumphs, concerns, and opportunities. *N Engl J Med*. 1997;337:1360–1369. doi: 10.1056/NEJM199711063371906

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7. Shah NS, Molsberry R, Rana JS, Sidney S, Capewell S, O'Flaherty M, Carnethon M, Lloyd-Jones DM, Khan SS. Heterogeneous trends in burden of heart disease mortality by subtypes in the United States, 1999–2018: observational analysis of vital statistics. *BMJ*. 2020;370:m2688. doi: 10.1136/bmj.m2688
8. Sidney S, Quesenberry CP, Jaffe MG, Sorel M, Go AS, Rana JS. Heterogeneity in national U.S. mortality trends within heart disease subgroups, 2000–2015. *BMC Cardiovasc Disord*. 2017;17(1):192. doi: 10.1186/s12872-017-0630-2
9. The Center for Disease Control and Prevention: National Center for Health Statistics. Underlying cause of death: 1999–2020. Accessed March 2, 2024. https://wonder.cdc.gov/ucd-icd10.html.
10. The Center for Disease Control and Prevention: National Center for Health Statistics. Compressed mortality file: 1979–1998. Accessed March 2, 2024. https://wonder.cdc.gov/cmf-icd9.html.
11. The Center for Disease Control and Prevention: National Center for Health Statistics. Compressed mortality file: 1968–1978. Accessed March 2, 2024. https://wonder.cdc.gov/cmf-icd8.html.
12. National Institute of Health: National Heart, Lung, and Blood Institute. Morbidity & mortality: 2012 chartbook on cardiovascular, lung, and blood diseases, appendix A. International Classification of Diseases: codes for selected diagnostic categories (6th, 7th, 8th, 9th and 10th revisions). Accessed March 2, 2024. https://www.astrazeneca.com/content/dam/az/media-centre-docs/article_files/articles-2015/Documents/2012_ChartBook_508.pdf.
13. Martin SS, Aday AW, Almarzooq ZI, Anderson CA, Arora P, Avery CL, Baker-Smith CM, Barone Gibbs B, Beaton AZ, Boehme AK, et al. 2024 Heart disease and stroke statistics: a report of US and global data from the American Heart Association. *Circulation*. 2024;149:e347–e913. doi: 10.1161/CIR.0000000000001209
14. The Center for Disease Control: National Center for Health Statistics. National vital statistics system, life tables. Accessed March 2, 2024. https://www.cdc.gov/nchs/products/life_tables.htm#life.
15. Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute. Joinpoint Regression Program, Version 5.0.2. 2023 Accessed January 15, 2024. https://surveillance.cancer.gov/joinpoint/.
16. Ma J, Ward EM, Siegel RL, Jemal A. Temporal trends in mortality in the United States, 1969-2013. *JAMA*. 2015;314:1731–1739. doi: 10.1001/jama.2015.12319
17. Ritter G, Wolfe RA, Goldstein S, Landis JR, Vasu CM, Acheson A, Leighton R, Medendrop SV. The effect of bystander CPR on survival of out-of-hospital cardiac arrest victims. *Am Heart J*. 1985;110:932–937. doi: 10.1016/0002-8703(85)90187-5
18. Chapman BL. Effect of coronary care on myocardial infarct mortality. *Br Heart J*. 1979;42:386–395. doi: 10.1136/hrt.42.4.386
19. Liberthson RR, Nagel EL, Hirschman JC, Nussenfeld SR. Prehospital ventricular defibrillation. Prognosis and follow-up course. *N Engl J Med*. 1974;291(7):317–321. doi: 10.1056/NEJM197408152910701
20. Spencer FC, Isom OW, Glassman E, Boyd AD, Engelman RM, Reed GE, Pasternack BS, Dembrow JM. The long-term influence of coronary bypass grafts on myocardial infarction and survival. *Ann Surg*. 1974;180:439–451. doi: 10.1097/00000658-197410000-00009
21. Judkins MP. Selective coronary arteriography. I. A percutaneous transfemoral technic. *Radiology*. 1967;89(5):815–824. doi: 10.1148/89.5.815
22. Gruntzig A. Transluminal dilatation of coronary-artery stenosis. *Lancet*. 1978;1:263. doi: 10.1016/s0140-6736(78)90500-7
23. Kent KM, Bentivoglio LG, Block PC, Cowley MJ, Dorros G, Gosselin AJ, Gruntzig A, Myler RK, Simpson J, Stertzer SH, et al. Percutaneous transluminal coronary angioplasty: report from the registry of the National Heart, Lung, and Blood Institute. *Am J Cardiol*. 1982;49:2011–2020. doi: 10.1016/0002-9149(82)90223-5
24. Gruppo Italiano per lo Studio della Streptochinasi nell'Infarto Miocardico (GISSI). Effectiveness of intravenous thrombolytic treatment in acute myocardial infarction. *Lancet*. 1986;1:397–402. doi: 10.1016/S0140-6736(86)92368-8
25. Baigent C, Collins R, Appleby P, Parish S, Sleight P, Peto R. ISIS-2: 10 year survival among patients with suspected acute myocardial infarction in randomised comparison of intravenous streptokinase, oral aspirin, both, or neither. The ISIS-2 (Second International Study of Infarct Survival) Collaborative Group. *BMJ*. 1998;316:1337–1343. doi: 10.1136/bmj.316.7141.1337
26. Fischman DL, Leon MB, Baim DS, Schatz RA, Savage MP, Penn I, Detre K, Veltri L, Ricci D, Nobuyoshi M, et al. A randomized comparison of coronary-stent placement and balloon angioplasty in the treatment of coronary artery disease. *N Engl J Med*. 1994;331:496–501. doi: 10.1056/NEJM199408253310
27. Kimmel SE, Localio AR, Krone RJ, Laskey WK. The effects of contemporary use of coronary stents on in-hospital mortality. Registry Committee of the Society for Cardiac Angiography and Interventions. *J Am Coll Cardiol*. 2000;37:499–504. doi: 10.1016/s0735-1097(00)01115-3
28. Goldstein S. Propranolol therapy in patients with acute myocardial infarction: the beta-blocker heart attack trial. *Circulation*. 1983;67(6 Pt 2):I53–I157.
29. Pfeffer MA, Braunwald E, Moyé LA, Basta L, Brown EJ, Cuddy TE, Davis BR, Geltman EM, Goldman S, Flaker GC. Effect of captopril on mortality and morbidity in patients with left ventricular dysfunction after myocardial infarction. Results of the survival and ventricular enlargement trial. The SAVE investigators. *N Engl J Med*. 1992;327:669–677. doi: 10.1056/NEJM199209033271001
30. Randomised trial of cholesterol lowering in 4444 patients with coronary heart disease: the Scandinavian Simvastatin Survival Study (4S). *Lancet*. 1994;344:1383–1389. doi: 10.1016/S0140-6736(94)90566-5
31. Cannon CP, Braunwald E, McCabe CH, Rader DJ, Rouleau JL, Belder R, Joyal SV, Hill KA, Pfeffer MA, Skene AM. Intensive versus moderate lipid lowering with statins after acute coronary syndromes. *N Engl J Med*. 2004;350:1495–1504. doi: 10.1056/NEJMoa040583
32. Schömig A, Neumann FJ, Kastrati A, Schühlen H, Blasini R, Hadamitzky M, Walter H, Zitzmann-Roth EM, Richardt G, Alt E, et al. A randomized comparison of antiplatelet and anticoagulant therapy after the placement of coronary-artery stents. *N Engl J Med*. 1996;334:1084–1089. doi: 10.1056/NEJM199604253341702
33. Sabatine MS, Cannon CP, Gibson CM, López-Sendón JL, Montalescot G, Theroux P, Claeys MJ, Cools F, Hill KA, Skene AM, et al. Addition of clopidogrel to aspirin and fibrinolytic therapy for myocardial infarction with ST-segment elevation. *N Engl J Med*. 2005;352:1179–1189. doi: 10.1056/NEJMoa050522
34. Berger PB, Ellis SG, Holmes DR Jr, Granger CB, Criger DA, Betriu A, Topol EJ, Califf RM. Relationship between delay in performing direct coronary angioplasty and early clinical outcome in patients with acute myocardial infarction: results from the global use of strategies to open occluded arteries in Acute Coronary Syndromes (GUSTO-IIb) trial. *Circulation*. 1999;100(1):14–20. doi: 10.1161/01.cir.100.1.14
35. De Luca G, Suryapranata H, Ottervanger JP, Antman EM. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction: every minute of delay counts. *Circulation*. 2004;109(10):1223–1225. doi: 10.1161/01.CIR.0000121424.76486.20
36. Keller T, Zeller T, Peetz D, Tzikas S, Roth A, Czyz E, Bickel C, Baldus S, Warnholtz A, Fröhlich M, et al. Sensitive troponin I assay in early diagnosis of acute myocardial infarction. *N Engl J Med*. 2009;361:868–877. doi: 10.1056/NEJMoa0903515
37. Wallentin L, Becker RC, Budaj A, Cannon CP, Emanuelsson H, Held C, Horrow J, Husted S, James S, Katus H, et al. Ticagrelor versus clopidogrel in patients with acute coronary syndromes. *N Engl J Med*. 2009;361:1045–1057. doi: 10.1056/NEJMoa0904327
38. Cannon CP, Blazing MA, Giugliano RP, McCagg A, White JA, Theroux P, Darius H, Lewis BS, Ophuis TO, Jukema JW, et al. Ezetimibe added to statin therapy after acute coronary syndromes. *N Engl J Med*. 2015;372:2387–2397. doi: 10.1056/NEJMoa1410489
39. Sabatine MS, Giugliano RP, Keech AC, Honarpour N, Wiviott SD, Murphy SA, Kuder JF, Wang H, Liu T, Wasserman SM, et al. Evolocumab and clinical outcomes in patients with cardiovascular disease. *N Engl J Med*. 2017;376:1713–1722. doi: 10.1056/NEJMoa1615664
40. US Dept of Health and Human Services. Reducing the health consequences of smoking: 25 years of progress: a report of the Surgeon General. Accessed March 5, 2024. https://stacks.cdc.gov/view/cdc/13240.
41. US Dept of Health and Human Services. The health consequences of smoking: 50 years of progress: a report of the Surgeon General. Accessed March 5, 2024. https://www.ncbi.nlm.nih.gov/books/NBK179276/.
42. Institute of Medicine (US) Committee on Secondhand Smoke Exposure and Acute Coronary Events. Secondhand smoke exposure and cardiovascular effects: making sense of the evidence. Accessed March 5, 2024. https://www.ncbi.nlm.nih.gov/books/NBK219563/m.
43. Center for Disease Control and Prevention, National Health Interview Survey (NHIS). Current cigarette smoking among adults aged 18 and over, by sex, race, and age: United States, selected years 1965–2019.

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Accessed March 5, 2024. https://www.cdc.gov/nchs/data/hus/2020-2021/SmokSex.pdf.
44. Kannel WB, Belanger A, D'Agostino R, Israel I. Physical activity and physical demand on the job and risk of cardiovascular disease and death: the Framingham Study. *Am Heart J*. 1986;112:820–825. doi: 10.1016/0002-8703(86)90480-1
45. Joint National Committee. Report of the Joint National Committee on detection, evaluation, and treatment of high blood pressure. A cooperative study. *JAMA*. 1977;237:255–261. doi: 10.1001/jama.1977.03270300059008
46. James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, Lackland DT, ML LF, TD MK, Ogedegbe O, et al. 2014 evidence-based guideline for the management of high blood pressure in adults: report from the panel members appointed to the Eighth Joint National Committee (JNC 8). *JAMA*. 2014;311:507–520. doi: 10.1001/jama.2013.284427
47. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Dennison Himmelfarb C, SM DP, Gidding S, Jamerson KA, Jones DW, et al. 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: executive summary: a report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. *Hypertension*. 2018;71:1269–1324. doi: 10.1161/HYP.0000000000000066
48. Dorans KS, Mills KT, Liu Y, He J. Trends in prevalence and control of hypertension according to the 2017 American College of Cardiology/American Heart Association (ACC/AHA) guideline. *J Am Heart Assoc*. 2018;7:e008888. doi: 10.1161/JAHA.118.008888
49. Expert panel on detection, evaluation and treatment of high blood cholesterol in adults. Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. *Arch Intern Med*. 1988;148(1):36–69. doi: 10.1001/archinte.1988.00380010040006
50. Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA*. 2001;285:2486–2497. doi: 10.1001/jama.285.19.2486
51. Carroll MD, Kit BK, Lacher DA, Shero ST, Mussolino ME. Trends in lipids and lipoproteins in US adults, 1988–2010. *JAMA*. 2012;308:1545–1554. doi: 10.1001/jama.2012.13260
52. Tsao CW, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, Baker-Smith CM, Beaton AZ, Boehme AK, Buxton AE, et al. Heart disease and stroke statistics-2023 update: a report from the American Heart Association. *Circulation*. 2023;147:e93–e621. doi: 10.1161/CIR.0000000000001123
53. Emmerich SD, Fryar CD, Stierman B, Ogden CL; Center for Disease Control and Prevention. Obesity and severe obesity prevalence in adults: United States, August 2021—August 2023. Accessed December 20, 2024. https://www.cdc.gov/nchs/products/databriefs/db508.htm.
54. Centers for Disease Control and Prevention. National diabetes statistics report website. Appendix A, Tables 2 and 7. Accessed March 20, 2024. https://www.cdc.gov/diabetes/data/statistics-report/appendix.html#tabs-1-2.
55. National Center for Chronic Disease Prevention and Health Promotion, U.S. Division of Diabetes Translation. Long-term trends in diabetes. Accessed March 20, 2024. https://stacks.cdc.gov/view/cdc/42550.
56. Drizd T, Dannenberg AL, Engel A. Blood pressure levels in persons 18–74 years of age in 1976–1980, and trends in blood pressure from 1960 to 1980 in the United States. Accessed March 20, 2024. https://www.cdc.gov/nchs/data/series/sr_11/sr11_234.pdf.
57. Fryar CD, Kit B, Carroll MD, Afful J; Center for Disease Control and Prevention. Hypertension prevalence, awareness, treatment, and control among adults age 18 and older: United States, August 2021–August 2023. Accessed December 20, 2024. https://www.cdc.gov/nchs/products/databriefs/db511.htm.
58. Dhingra R, Vasan RS. Diabetes and the risk of heart failure. *Heart Fail Clin*. 2012;8:125–133. doi: 10.1016/j.hfc.2011.08.008
59. Kenchaiah S, Evans JC, Levy D, Wilson PW, Benjamin EJ, Larson MG, Kannel WB, Vasan RS. Obesity and the risk of heart failure. *N Engl J Med*. 2002;347:305–313. doi: 10.1056/NEJMoa020245
60. Drazner MH. The progression of hypertensive heart disease. *Circulation*. 2011;123(3):327–334. doi: 10.1161/CIRCULATIONAHA.108.845792
61. Benjamin EJ, Levy D, Vaziri SM, D'Agostino RB, Belanger AJ, Wolf PA. Independent risk factors for atrial fibrillation in a population-based cohort: the Framingham Heart Study. *JAMA*. 1994;271:840–844. doi: 10.1001/jama.1994.03510350050036
62. Dai X, Busby-Whitehead J, Forman DE, Alexander KP. Stable ischemic heart disease in the older adults. *J Geriatr Cardiol*. 2016;13:109–114. doi: 10.11909/j.issn.1671-5411.2016.02.013
63. Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, Chiuve SE, Cushman M, Delling FN, Deo R, et al. Heart disease and stroke statistics—2018 update. *Circulation*. 2018;137:e67–e492. doi: 10.1161/CIR.0000000000000558
64. Ritchey MD, Loustalot F, Bowman BA, Hong Y. Trends in mortality rates by subtypes of heart disease in the United States, 2000-2010. *JAMA*. 2014;312:2037–2039. doi: 10.1001/jama.2014.11344
65. Sidney S, Go AS, Jaffe MG, Solomon MD, Ambrosy AP, Rana JS. Association between aging of the US population and heart disease mortality from 2011 to 2017. *JAMA Cardiol*. 2019;4:1280–1286. doi: 10.1001/jamacardio.2019.4187
66. Chugh SS, Havmoeller R, Narayanan K, Singh D, Rienstra M, Benjamin EJ, Gillum RF, Kim YH, McAnulty JH, Zheng ZJ, et al. Worldwide epidemiology of atrial fibrillation: a global burden of disease 2010 study. *Circulation*. 2014;129(8):837–847. doi: 10.1161/CIRCULATIONAHA.113.005119
67. Woodruff RC, Tong X, Loustalot FV, Khan SS, Shah NS, Jackson SL, Vaughan AS. Cardiovascular disease mortality trends, 2010–2022: An update with final data. *Am J Prev Med*. 2025;68(2):391–395. doi: 10.1016/j.amepre.2024.09.014
68. Paulus WJ, Tschope C, Sanderson JE, Rusconi C, Flachskampf FA, Rademakers FE, Marino P, Smiseth OA, De Keulenaer G, Leite-Moreira AF, et al. How to diagnose diastolic heart failure: a consensus statement on the diagnosis of heart failure with normal left ventricular ejection fraction by the Heart Failure and Echocardiography Associations of the European Society of Cardiology. *Eur Heart J*. 2007;28:2539–2550. doi: 10.1093/eurheartj/ehm037
69. Hyduk A, Croft JB, Ayala C, Zheng K, Zheng ZJ, Mensah GA. Pulmonary hypertension surveillance—United States 1980–2002. *MMWR Surveill Summ*. 2005;54:1–28. Accessed March 30, 2024. https://www.cdc.gov/mmwr/preview/mmwrhtml/ss5405a1.htm
70. Kang M, Hart CM, Kempker JA, Veeraraghavan S, Trammell AW. Pulmonary hypertension mortality trends in United States 1999–2019. *Ann Epidemiol*. 2022;75:47–52. doi: 10.1016/j.annepidem.2022.09.001
71. Bozkurt B, Ahmad T, Alexander KM, Baker WL, Bosak K, Breathett K, Fonarow GC, Heidenreich P, Ho JE, Hsich E. Heart failure epidemiology and outcomes statistics: a report of the Heart Failure Society of America. *J Card Fail*. 2023;29:1412–1451. doi: 10.1016/j.cardfail.2023.07.006
72. Tanaka Y, Shah NS, Passman R, Greenland P, Lloyd-Jones DM, Khan SS. Trends in cardiovascular mortality related to atrial fibrillation in the United States, 2011 to 2018. *J Am Heart Assoc*. 2021;10:e020163. doi: 10.1161/JAHA.120.020163
73. Klebba AJ, Scott JA. Estimate of selected comparability of ratios based on dual coding of 1976 death certificates by the eighth and ninth revisions of the International Classification of Diseases. Accessed March 29, 2024. https://stacks.cdc.gov/view/cdc/107996.
74. Freedman MA, Gay GA, Brockert JE, Potrzebowski PW, Rothwell CJ. The 1989 revisions of the US standard certificates of live birth and death and the US standard report of fetal death. *Am J Public Health*. 1988;78:168–172. doi: 10.2105/ajph.78.2.168
75. Lloyd-Jones DM, Martin DO, Larson MG, Levy D. Accuracy of death certificates for coding coronary heart disease as the cause of death. *Ann Intern Med*. 1998;129:1020–1026. doi: 10.7326/0003-4819-129-12-199812150-00005

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