JACC: ADVANCES VOL. 3, NO. 12, 2024

ORIGINAL RESEARCH

ISCHEMIC HEART DISEASE

Trends and Disparities in CAD and AMI in the United States From 2000 to 2020

Christian Akem Dimala, MD, MScPH, MRes,[a] Christopher Reggio, DO,[b] Marvel Changoh, MD,[c] Anthony Donato, MD, MPHE[b,d]

ABSTRACT

BACKGROUND Coronary artery disease (CAD) and acute myocardial infarction (AMI) still pose a significant burden to the health care system, affecting population subgroups differently.

OBJECTIVES The purpose of the study was to describe age, sex, and racial disparities in mortality rates for CAD and AMI in the United States between 2000 and 2020.

METHODS This was an ecological study with trend analysis of mortality rates using data from the National Centers for Disease Control and Prevention surveillance databases.

RESULTS Between 2000 and 2020, there was a significant decrease in the age-standardized mortality rates of both CAD (from 249.4 to 118 per 100,000 cases [$P < 0.001$]) and AMI (from 93.4 to 34.1 per 100,000 cases [$P < 0.001$]), with deceleration in the decline of mortality rates after 2011. CAD and AMI mortality rates were both significantly higher in males ($P < 0.001$), the 75+ years age group ($P < 0.001$), and in non-Hispanic Blacks (NHBs) and non-Hispanic Whites (NHWs) compared to Hispanics ($P < 0.001$). While CAD mortality rates were higher in NHB compared to NHW ($P = 0.037$), there was no significant difference in AMI mortality rates between NHB and NHW ($P = 0.144$). There was also no difference in both CAD and AMI mortality rates between the 25 to 44 years and 45 to 64 years age groups ($P = 0.051$ and $P = 0.072$).

CONCLUSIONS While a significant reduction in mortality rates is evident, the notable deceleration in this decline in recent years reflects a plateauing of earlier gains and highlights the need to identify new targets. The persistent disparities in the identified population subgroups necessitate further exploration to inform targeted interventions and policies. (JACC Adv. 2024;3:101373) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

From the [a]Division of Cardiovascular Medicine, Department of Medicine, University of Texas Medical Branch, Galveston, Texas, USA; [b]Department of Medicine, Reading Hospital, Tower Health, West Reading, Pennsylvania, USA; [c]Department of Medicine, Richmond University Medical Center, Staten Island, New York, USA; and the [d]Department of Medicine, Drexel University College of Medicine, Philadelphia, Pennsylvania, USA.
The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received June 10, 2024; revised manuscript received September 9, 2024, accepted September 25, 2024.

ISSN 2772-963X https://doi.org/10.1016/j.jacadv.2024.101373

ABBREVIATIONS AND ACRONYMS

AMI = acute myocardial infarction

CAD = coronary artery disease

CDC = Centers for Disease Control and Prevention

CVD = cardiovascular disease

ICD = International Classification of Diseases

NVSS = National Vital Statistics System

U.S. = United States

Coronary artery disease (CAD) is a type of heart disease characterized by plaque buildup in the walls of the arteries of the heart, resulting in the inability of these arteries to supply adequate oxygen-rich blood to the heart.[1,2] CAD is the main cause of acute myocardial infarction (AMI).[3] AMI occurs when there is a sudden interruption of the blood flow and oxygenation to the heart muscle, resulting in myocardial ischemia, infarction, and necrosis.[4] Over 18 million United States (U.S.) adults have CAD, making it the most common type of heart disease and also the leading cause of death in the United States, with more than 350,000 deaths each year.[1,2,5] According to the National Centers for Disease Control and Prevention (CDC), approximately 800,000 people in the United States have an AMI every year, and someone has an AMI every 40 seconds.[3] Despite these statistics, there has been a remarkable decline in the overall prevalence and mortality rates of cardiovascular diseases (CVDs) in the United States over the past few decades.[6-8] This is in part due to a reduction in the prevalence of some major risk factors and significant advancements in treatment options for these conditions.[9-13] The decline in mortality rates for several heart diseases has, however, not been consistent across all age groups, sexes, and races.[14,15] Studies examining different cohorts over different timeframes have reported different findings, often specific to their study populations, settings, and times. For instance, the study by Peters et al noted considerable decline in recurrent myocardial infarction and coronary heart disease events and mortality, with proportionally greater reductions in women compared to men and rates remaining higher in men.[16] Gupta et al also noted a decline in in-hospital AMI mortality between 2001 and 2010 with higher mortality in women compared to men.[17] The study by Dani et al focused on premature mortality (age <65 years) from AMI over a longer period (1999-2019),[18] while the study by Kyalwazi explored disparities in overall cardiovascular mortality over the same time frame, noting higher cardiovascular mortality rates in Black women and men compared to their White counterparts.[19] This study aimed to comprehensively review, analyze, and describe actual national trends and sex, age, and racial disparities in the mortality rates of selected CVDs for the entire adult U.S. population (18 years and older) over a longer time period (2000-2020) than prior reviews, with focus on CAD and AMI. The simultaneous exploration of CAD and AMI in this study could bring to light nuances in mortality trends and disparities that may have been less clear in prior broader studies on all CVDs.

TABLE 1 Age-Standardized Mortality Rates per 100,000 for Coronary Artery Disease and Acute Myocardial Infarction in the United States From 2000 to 2020

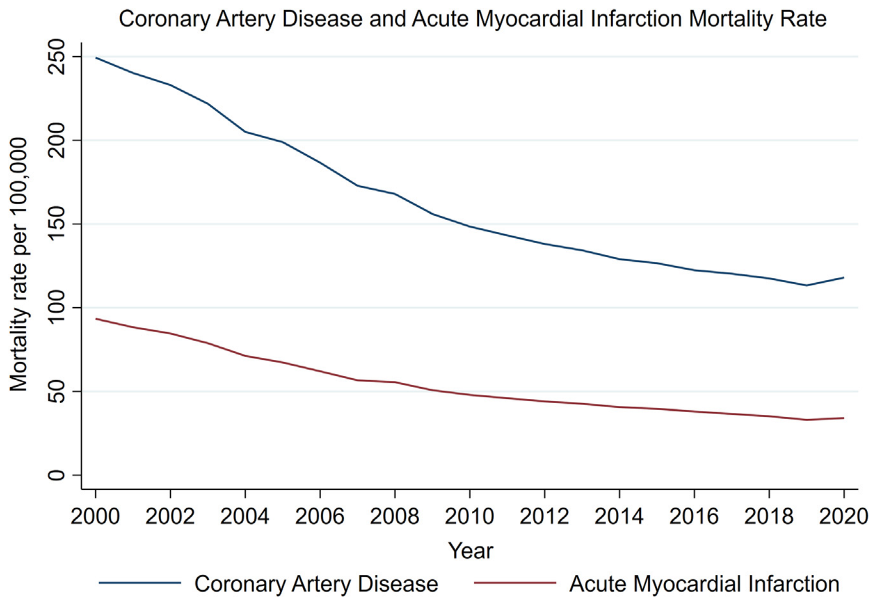
Year	Age-Standardized Mortality per 100,000 Cases: Coronary Artery Disease	Age-Standardized Mortality per 100,000 Cases: Acute Myocardial Infarction
2000	249.4	93.4
2001	240.2	88.3
2002	233.0	84.6
2003	221.8	78.8
2004	205.0	71.2
2005	198.9	67.3
2006	186.6	62.0
2007	172.8	56.6
2008	167.9	55.5
2009	156.0	50.7
2010	148.5	47.9
2011	143.2	45.9
2012	138.1	44.0
2013	134.3	42.6
2014	129.0	40.6
2015	126.6	39.6
2016	122.4	38.0
2017	120.3	36.6
2018	117.5	35.2
2019	113.3	33.1
2020	118.0	34.1
P linear	<0.001	<0.001
NB *P* value (Pseudo R^2)	<0.001 0.2986	<0.001 0.3064
K tau-b *P* value	−0.9810 <0.001	−0.9905 <0.001

NB = negative binomial regression.

METHODS

STUDY DESIGN AND DATA SOURCES. This was an ecological study with trend analysis of the mortality from CAD and AMI in the United States between 2000 and 2020. Data on CAD were obtained from the National Vital Statistics System (NVSS) of the National CDC surveillance databases. Mortality data are collected by the respective state registries and provided to the NVSS. These data are county-level national mortality and population data over several years. The data are based on death certificates of U.S. residents, which contain both demographic and a single underlying cause of death (with International Classification of Diseases [ICD]-10 codes) and up to 20 additional causes. CAD and AMI were defined

FIGURE 1 Age-Standardized Mortality Rate per 100,000 for Coronary Artery Disease and Acute Myocardial Infarction in the United States From 2000 to 2020



according to indicator definitions of the division for heart disease and stroke prevention of the CDC.[20] CAD was defined according to the ICD-10: I20-I25 codes, and AMI was defined according to the ICD-10: I21-I22 code.

SELECTION CRITERIA. This study included:

- U.S. adults aged 18 and above.
- Deaths between 2000 and 2020 with issued death certificates, reported by the state registries to the NVSS.
- Deaths due to CAD and AMI.

This study excluded:

- Deaths not reported to state registries.

DATA MANAGEMENT AND ANALYSIS. Data exported from the NVSS Database included: overall AMI and CAD mortality rates among U.S. adults aged 18 and above, categorized by sex, race, and age groups. Data were first exported to an Excel sheet and then to STATA version 17 (STATA Corp) statistical software for data analysis. The 2 primary outcomes of interest were the age-standardized mortality rate per 100,000 cases for CAD and AMI. Mortality rates for CAD were calculated as the number of adults aged 18+ who died with CAD listed as the underlying cause of death, divided by the number of adults (18+) per 100,000. Likewise, mortality rates for AMI were calculated as the number of adults aged 18+ who died with AMI listed as the underlying cause of death, divided by the number of adults aged 18+, per 100,000. Graphs of mortality rates over time for the 2 outcomes were plotted. The linear-by-linear trends test and negative binomial regression models were used to evaluate trends in mortality rates for both outcomes, over time. Groups were compared within the models using the likelihood ratios and the Wald-Chi[2] test. The goodness of fit of the models were assessed using the pseudo-R^2. The Mann-Kendall test for trends was also used to assess nonlinear trends, and the corresponding Kendall's tau-b correlation coefficient was reported. Multiple linear regression was used to assess for significant linear associations between the various demographic variables and both outcome variables over time. *P* values of <0.05 were considered statistically significant.

ETHICAL CONSIDERATIONS. This was an analysis of de-identified disease surveillance data retrieved from the CDC databases, and ethical approval was therefore not required.

RESULTS

Table 1 summarizes the age-standardized mortality rates per 100,000 cases for the 2 outcomes explored:

TABLE 2 Age-Standardized Mortality Rates per 100,000 by Sex for Coronary Artery Disease and Acute Myocardial Infarction in the United States From 2000 to 2020

	Age-Standardized Mortality per 100,000 Cases			
	Coronary Artery Disease		Acute Myocardial Infarction	
Year	Male	Female	Male	Female
2000	289.1	216.7	111	78.9
2001	277.4	209.4	104.4	75.1
2002	270.8	201.6	100.3	71.6
2003	257.6	191.7	93.3	66.6
2004	239.1	176.2	84.6	59.9
2005	232.6	170.4	80.0	56.6
2006	220.3	158.0	74.4	51.5
2007	204.8	145.4	67.8	46.9
2008	199.2	141.0	66.6	46.0
2009	188.2	128.4	61.6	41.4
2010	179.5	121.7	58.3	38.8
2011	174.2	116.3	56.2	36.9
2012	169.3	111.1	54.2	35.1
2013	166.5	106.4	52.9	33.6
2014	161.4	101.0	50.8	31.6
2015	158.6	98.7	49.7	30.8
2016	155.4	93.8	48.1	29.0
2017	153.8	91.1	46.8	27.7
2018	151.5	87.8	45.5	26.2
2019	146.9	84.0	42.9	24.5
2020	153.9	86.6	44.5	25.0
P linear	<0.001	<0.001	<0.001	<0.001
NB *P* value (Pseudo R^2)	<0.001 0.2699	<0.001 0.3285	<0.001 0.2915	<0.001 0.3245
K tau-b *P* value	−0.9714 <0.001	−0.9905 <0.001	−0.9905 <0.001	−0.9905 <0.001

NB = negative binomial.

CAD and AMI. There was a general downtrend in the age-standardized mortality rates of both outcomes from 2000 to 2020 (Figure 1).

CORONARY ARTERY DISEASE. There was a significant decrease in the age-standardized mortality rates of CAD from 249.4 per 100,000 cases in 2000 to 118 per 100,000 cases in 2020 ($P < 0.001$, K tau-b correlation coefficient = −0.98) (Table 1).

Across sexes, there was a significant reduction in mortality rates between 2000 and 2020, from 289.1 to 153.9 per 100,000 cases in males ($P < 0.001$, K tau-b = −0.97) and from 216.7 to 86.6 in females ($P < 0.001$, K tau-b = −0.99). Mortality rates were significantly higher in males compared to females ($P < 0.001$, $R^2 = 0.95$) (Tables 2 and 3, Figure 2).

There was a significant decrease in mortality rates across all races between 2000 and 2020, from 274.7 to 139.3 per 100,000 cases in non-Hispanic Blacks ($P < 0.001$, K tau-b = −0.95), 256.4 to 122.7 per 100,000 cases in non-Hispanic Whites ($P < 0.001$, K tau-b = −0.99), 181 to 88.3 per 100,000 cases in Hispanics ($P < 0.001$, K tau-b = −0.93), and 122.1 to 72.5 per 100,000 cases in other races ($P < 0.001$, K tau-b = −0.91) (Table 4). Mortality rates were significantly higher in non-Hispanic Blacks ($P = 0.037$), but significantly lower in Hispanics ($P < 0.001$) and other races ($P < 0.001$), compared to non-Hispanic Whites (Tables 3 and 4, Figure 3).

With regard to age groups, mortality rates significantly decreased in all age groups between 2000 and 2020, except for the 18 to 24 years age group, where the change in mortality rates was not significant ($P = 0.725$, K tau-b = −0.54) (Table 5). Mortality rates were significantly higher in the 75+ years ($P < 0.001$), followed by the 65+ years ($P < 0.001$), then the 35+ years ($P < 0.001$) age groups, and significantly lower in the 18 to 24 years age group ($P = 0.033$) compared to the 45 to 64 years age group (Table 3). There was, however, no significant difference in mortality rates in the 25 to 44 years age group ($P = 0.051$) compared to the 45 to 64 years age group (Table 3, Figure 4).

ACUTE MYOCARDIAL INFARCTION. There was a significant decrease in the age-standardized mortality rates of AMI from 93.4 per 100,000 cases in 2000 to 34.1 per 100,000 cases in 2020 ($P < 0.001$, K tau-b correlation coefficient = −0.99) (Table 1).

Across sexes, from 2000 to 2020, there has been a significant gradual decrease in mortality rates among males from 111 to 44.5 per 100,000 cases ($P < 0.001$, K tau-b = −0.99) and among females from 78.9 to 25 per 100,000 cases ($P < 0.001$, K tau-b = −0.99) (Table 1). Mortality rates were significantly higher in males as compared to females ($P < 0.001$, $R^2 = 0.93$) (Tables 2 and 3, Figure 5).

Across races, there was a significant decrease in mortality rates between 2000 and 2020 from 102.5 to 39.9 per 100,000 in non-Hispanic Blacks ($P < 0.001$, K tau-b = −0.97), 96.5 to 35.8 per 100,000 cases in non-Hispanic Whites ($P < 0.001$, K tau-b = −0.99), 63.4 to 26.1 per 100,000 cases in Hispanics ($P < 0.001$, K tau-b = −0.95), and 45.8 to 21.1 per 100,000 cases in other races ($P < 0.001$, K tau-b = −0.96) (Table 4). There was no significant difference in mortality rates between non-Hispanic Whites and non-Hispanic Blacks ($P = 0.144$) (Table 3). Mortality rates were, however, significantly lower in Hispanics ($P < 0.001$) and other races ($P < 0.001$) compared to non-Hispanic Whites (Table 3, Figure 6).

With regard to age groups, there was a significant decrease in mortality rates between 2000 and 2020 in the 75+ years age group from 712.5 to 240.8 per

TABLE 3 Linear Regression Coefficients for the Association Between Mortality Rates for Coronary Artery Disease and Acute Myocardial Infarction and Sex, Race, and Age Groups

Outcome	Demographic		Coefficients (95% CI)	*P* Value	Adjusted R^2
Coronary artery disease	Sex	Female	Reference	-	0.95
		Male	62.5 (54.8-70.1)	<0.001	
		Year	−7.0 (−7.7 to −6.4)		
		Constant	14,254.7 (12,990.0-15,518.5)		
	Race	Non-Hispanic Whites	Reference	-	0.91
		Non-Hispanic Blacks	10.8 (0.7-20.9)	0.037	
		Hispanics	−55.6 (−65.7 to −45.5)	<0.001	
		Other	−83.4 (−93.6 to −73.4)	<0.001	
		Year	−5.7 (−6.3 to −5.1)		
		Constant	11,640.7 (10,452.9-12,828.4)		
	Age group	18-24 y	−91.2 (−175.1 to −7.4)	0.033	0.94
		25-44 y	−83.5 (−167.3-0.4)	0.051	
		35+ y	162.9 (79.0-246.7)	<0.001	
		45-64 y	Reference	-	
		65+ y	718.0 (634.1-801.8)	<0.001	
		75+ y	1,287.3 (1,203.5-1,371.2)	<0.001	
		Year	−16.8 (−20.8 to −12.8)		
		Constant	33,890.1 (25,856.7-41,923.5)		
Acute myocardial infarction	Sex	Female	Reference	-	0.93
		Male	21.9 (18.2-25.6)	<0.001	
		Year	−3.0 (−3.3 to −2.7)		
		Constant	6,064.4 (5,445.9-6,682.9)		
	Race	Non-Hispanic Whites	Reference	-	0.89
		Non-Hispanic Blacks	3.2 (−1.1-7.5)	0.144	
		Hispanics	−19.2 (−23.5 to −14.8)	<0.001	
		Other	−28.6 (−32.9 to −24.3)	<0.001	
		Year	−2.4 (−2.6 to −2.2)		
		Constant	4,893.3 (4,386.6-5,400.1)		
	Age group	18-24 y	−35.4 (−70.6 to −0.1)	0.049	0.89
		25-44 y	−32.3 (−67.6-2.9)	0.072	
		35+ y	48.5 (13.3-83.7)	0.007	
		45-64 y	Reference	-	
		65+ y	222.5 (187.3-257.7)	<0.001	
		75+ y	382.6 (347.4-417.8)	<0.001	
		Year	−7.1 (−8.8 to −5.4)		
		Constant	14,353.1 (10,978.4-17,727.9)		

100,000 cases ($P < 0.001$, K tau-b = −1), 65+ years age group from 448.9 to 147.1 per 100,000 cases ($P < 0.001$, K tau-b = −0.99), 45 to 64 years age group from 51.1 to 30.1 per 100,000 cases ($P < 0.001$, K tau-b = −0.96), and the 35+ years age group from 134.9 to 60.2 per 100,000 cases ($P < 0.001$, K tau-b = −0.99), but not in the 25 to 44 years ($P = 0.109$, K tau-b = −0.90) and 18 to 24 years ($P = 0.755$, K tau-b = −0.52) age groups (Table 4). Mortality rates were significantly higher in the 75+ years ($P < 0.001$), followed by the 65+ years ($P < 0.001$), then the 35+ years ($P = 0.007$) age groups, and significantly lower in the 18 to 24 years age group ($P = 0.049$) compared to the 45 to 64 years age group (Table 3). There was no significant difference in mortality rates in the 25 to 44 years age group ($P = 0.072$) compared to the 45 to 64 years age group (Table 3, Figure 7).

DISCUSSION

This study examined the evolving landscape of CAD and AMI mortality in the United States over the past 2 decades. The findings reveal a significant downward trend in overall mortality rates for both CAD and AMI during this period. Though this decrease in mortality rates for CAD and AMI cuts across all sexes, races, and age groups, it has been uneven in particular demographics (Central Illustration). Notably, mortality rates over this period were disproportionately higher among males, non-Hispanic Black individuals, and

JACC: ADVANCES, VOL. 3, NO. 12, 2024
DECEMBER 2024:101373

FIGURE 2 Coronary Artery Disease Mortality Rate per 100,000 by Sex in the United States From 2000 to 2020

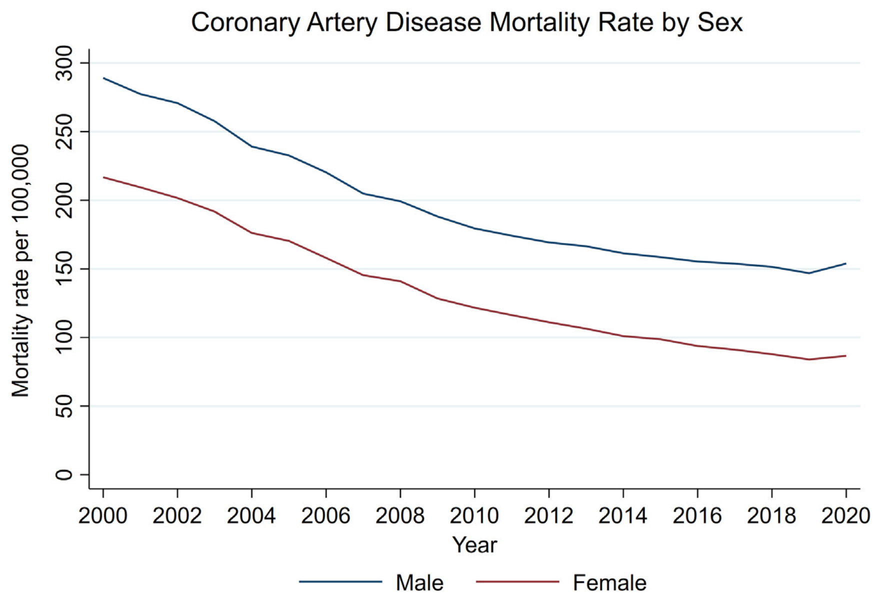


TABLE 4 Mortality Rates per 100,000 by Race for Coronary Artery Disease and Acute Myocardial Infarction in the United States From 2000 to 2020

	Age-Standardized Mortality per 100,000 Cases							
	Coronary Artery Disease				Acute Myocardial Infarction			
Year	H	NHB	NHW	O	H	NHB	NHW	O
2000	181.0	274.7	256.4	122.1	63.4	102.5	96.5	45.8
2001	178.6	267.9	246.6	118.6	62.6	97.8	91.1	43.8
2002	173.0	258.9	239.7	117.0	61.3	94.8	87.1	42.5
2003	150.7	248.6	228.4	112.8	53.2	87.9	81.4	39.0
2004	141.2	230.1	211.4	103.6	48.9	79.8	73.7	34.4
2005	142.8	221.5	205.2	101.5	49.3	74.6	69.6	33.9
2006	130.3	209.7	192.8	98.5	43.2	69.4	64.3	32.7
2007	120.6	194.8	178.9	90.6	39.8	64.4	58.7	29.1
2008	113.1	185.4	174.7	89.4	36.7	60.9	58.1	28.4
2009	107.1	173.5	162.3	84.2	33.7	56.8	53.1	26.9
2010	101.3	160.3	155.6	79.6	32.1	51.5	50.4	25.8
2011	95.1	154.2	150.6	76.1	29.6	50.1	48.5	24.2
2012	92.4	149.4	145.3	74.3	29.2	47.7	46.6	23.5
2013	92.4	145.4	141.2	74.7	29.3	46.1	45.0	22.9
2014	87.9	139.3	136.0	70.4	27.8	43.1	43.2	21.3
2015	87.7	135.4	133.4	70.6	27.8	42.0	42.1	21.3
2016	85.3	134.9	129.0	68.3	26.6	41.4	40.3	20.8
2017	83.4	130.9	127.0	69.2	25.8	39.2	39.0	20.8
2018	81.6	129.0	124.2	68.2	25.1	38.4	37.5	20.2
2019	79.4	124.8	119.9	65.7	23.5	36.2	35.3	18.9
2020	88.3	139.3	122.7	72.5	26.1	39.9	35.8	21.1
P linear	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
NB P value (Pseudo R^2)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	0.2643	0.2783	0.2977	0.2409	0.2766	0.3072	0.3029	0.2426
K tau-b *P* value	−0.9308	−0.9476	−0.9905	−0.9143	−0.9499	−0.9714	−0.9905	−0.9569
	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

H = Hispanic; NB = negative binomial; NHW = non-Hispanic White; NHB = non-Hispanic Black; O = other.

FIGURE 3 Coronary Artery Disease Mortality Rate per 100,000 by Race in the United States From 2000 to 2020

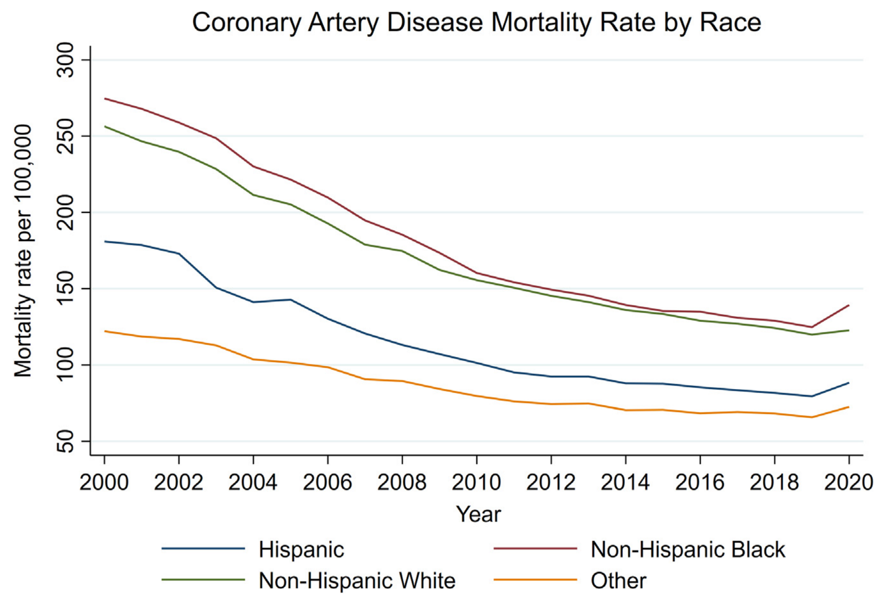
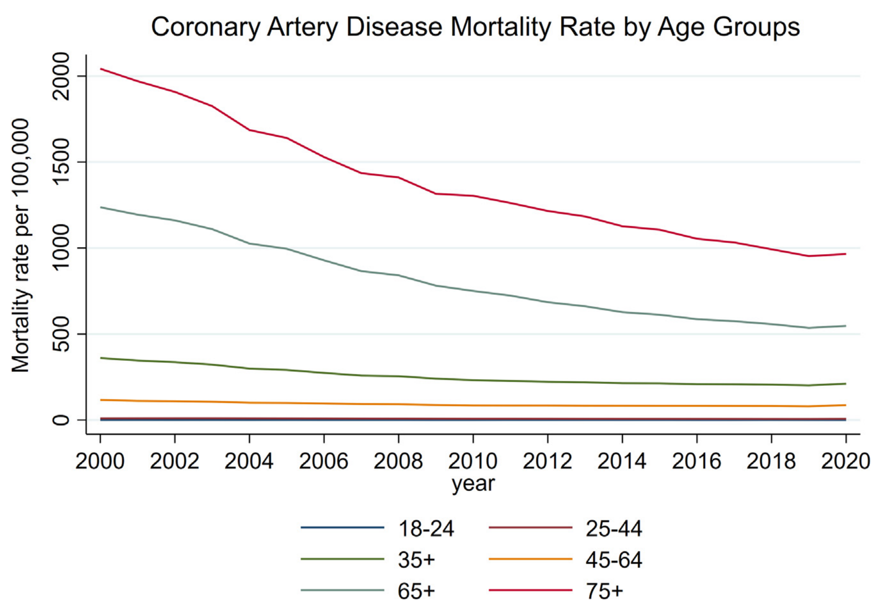


TABLE 5 Mortality Rates per 100,000 by Age Groups for Coronary Artery Disease and Acute Myocardial Infarction in the United States From 2000 to 2020

	Crude Mortality per 100,000 Cases											
	Coronary Artery Disease						Acute Myocardial Infarction					
Year	18-24	25-44	35+	45-64	65+	75+	18-24	25-44	35+	45-64	65+	75+
2000	0.4	9.9	360.4	116.4	1,237.3	2042.6	0.2	4.1	134.9	51.1	448.9	712.5
2001	0.6	10.2	346.1	111.3	1,194.3	1,970.4	0.2	4.3	127.3	47.6	425.9	678.0
2002	0.4	10.3	336.3	109.6	1,160.9	1,908.0	0.2	4.2	122.1	46.0	408.8	646.0
2003	0.5	10.3	322.3	106.2	1,109.8	1,825.3	0.2	4.2	114.5	44.1	381.0	604.6
2004	0.4	9.9	299.1	100.6	1,026.1	1,686.1	0.2	3.9	103.9	40.9	343.7	543.2
2005	0.5	9.5	291.1	99.4	995.6	1,640.2	0.2	3.8	98.6	39.5	324.6	513.6
2006	0.4	9.3	273.9	96.3	928.6	1,529.2	0.2	3.7	91.0	37.8	295.8	467.7
2007	0.4	8.8	258.2	92.5	865.7	1,435.6	0.2	3.4	84.5	35.8	271.0	429.4
2008	0.4	8.4	254.8	91.5	841.2	1,410.4	0.2	3.2	84.2	35.7	266.3	429.0
2009	0.3	7.9	240.5	87.6	781.2	1,315.4	0.1	3.0	78.1	33.6	242.5	389.2
2010	0.3	7.7	231.8	84.7	750.4	1,303.9	0.2	2.9	74.5	32.5	229.9	380.3
2011	0.4	7.6	227.0	84.2	723.4	1,261.8	0.2	2.9	72.5	31.8	220.3	366.0
2012	0.4	7.5	222.4	84.1	684.9	1,215.5	0.2	2.9	70.6	31.4	207.3	349.9
2013	0.4	7.2	219.5	82.9	661.4	1,183.8	0.2	2.8	69.2	30.9	198.8	337.0
2014	0.4	7.0	213.9	82.8	627.2	1,126.7	0.1	2.6	66.9	30.6	186.9	316.7
2015	0.4	6.9	212.8	82.4	612.2	1,106.5	0.2	2.6	66.1	30.5	180.8	307.3
2016	0.3	6.7	208.5	82.2	586.3	1,054.1	0.1	2.5	64.1	30.0	171.5	289.1
2017	0.3	6.5	207.7	81.7	574.4	1,032.3	0.2	2.5	62.6	29.5	164.3	275.7
2018	0.4	6.2	205.6	81.5	557.5	992.8	0.1	2.4	61.0	28.9	157.1	261.0
2019	0.3	6.1	201.1	79.2	535.6	953.0	0.1	2.3	58.1	27.7	146.5	243.6
2020	0.3	7.0	211.4	86.8	547.6	965.3	0.1	2.7	60.2	30.1	147.1	240.8
P linear	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001
NB P value (Pseudo R^2)	0.725	0.029	<0.001	<0.001	<0.001	<0.001	0.755	0.109	<0.001	<0.001	<0.001	<0.001
	0.0046	0.0549	0.2358	0.1390	0.3158	0.2912	0.0059	0.0390	0.2727	0.1629	0.3462	0.3297
K tau-b *P* value	−0.5367	−0.8905	−0.9619	−0.9048	−0.9905	−0.9905	−0.5237	−0.8986	−0.9905	−0.9619	−0.9905	−1.00
	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001

NB = negative binomial.

FIGURE 4 **Coronary Artery Disease Mortality Rate per 100,000 by Age Groups in the United States From 2000 to 2020**



the elderly, who also experienced the greatest rates of decline in mortality over the 2 decades of this study.

The early 2000s saw significant advancements in both preventive measures and treatments for CAD and AMI. These included widespread use of aspirin and statins, improved hypertension and dyslipidemia management, smoking cessation programs, and the introduction of advanced interventional techniques such as percutaneous coronary interventions.[9-13] These interventions had a substantial initial impact on reducing mortality rates.[7,21]

This reduction in CAD and AMI in the United States mirrors the trends observed globally in high-income regions such as Europe, where AMI-related mortality

FIGURE 5 **Acute Myocardial Infarction Mortality Rate per 100,000 by Sex in the United States From 2000 to 2020**

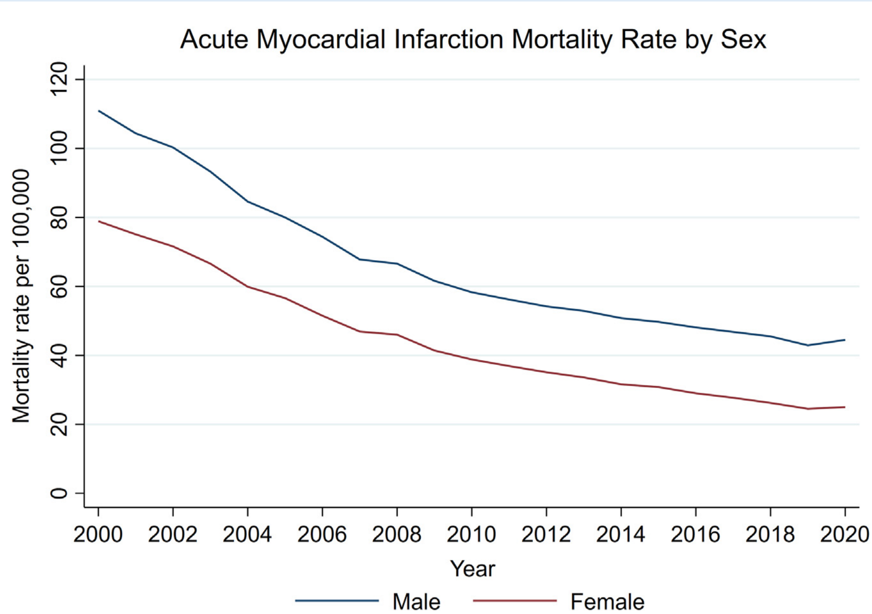
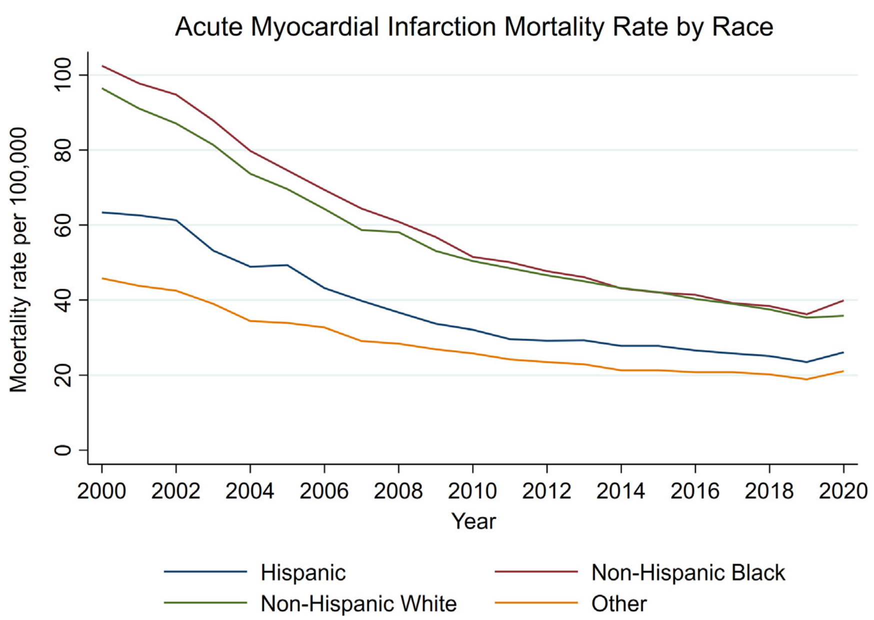


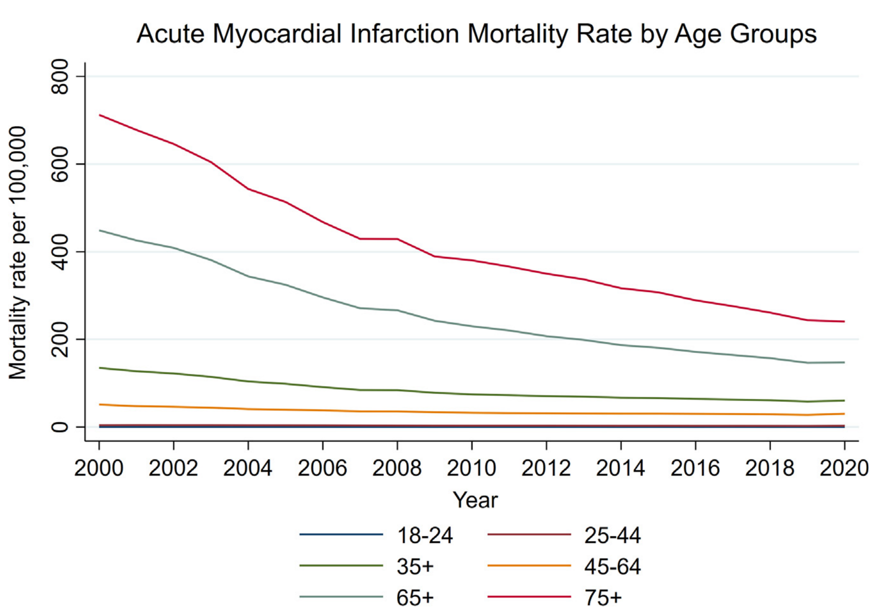
FIGURE 6 Acute Myocardial Infarction Mortality Rate per 100,000 by Race in the United States From 2000 to 2020



continuously declined between 2012 and 2020.[22] This is, however, in contrast to lower-income regions, which have seen less pronounced improvements,[23] highlighting the impact of health care advancements.

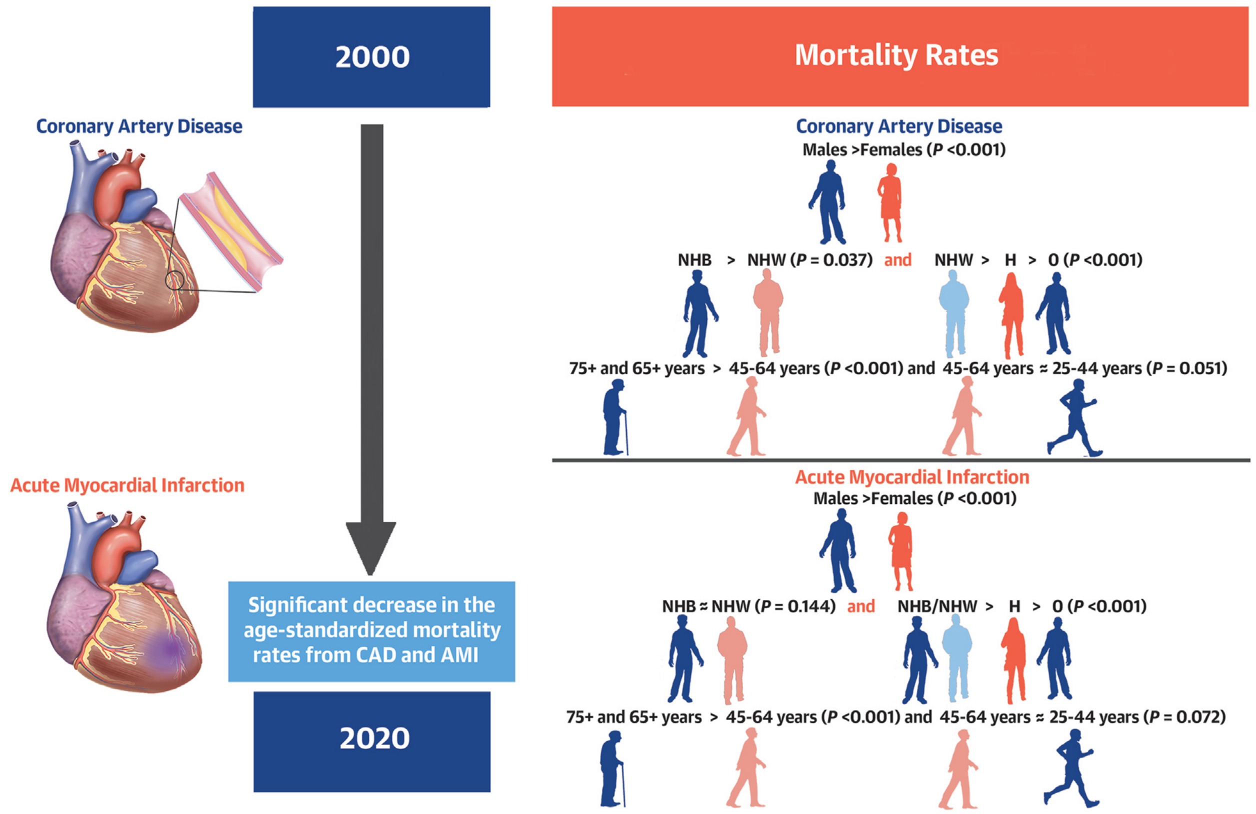
It is worth noting that the significant decline in CAD and AMI mortality over the past 2 decades predominantly occurred in the first decade, with a notable deceleration after 2011. This is likely due to

FIGURE 7 Acute Myocardial Infarction Rate per 100,000 by Age Groups in the United States From 2000 to 2020



JACC: ADVANCES, VOL. 3, NO. 12, 2024
DECEMBER 2024:101373

CENTRAL ILLUSTRATION Trends and Disparities in Coronary Artery Disease and Acute Myocardial Infarction Rates in the United States Between 2000 and 2020



Dimala CA, et al. JACC Adv. 2024;3(12):101373.

H = Hispanics; NHB = non-Hispanic Blacks; NHW = non-Hispanic Whites; O = others.

plateauing in the benefits of these health care advancements and initial interventions.[7,24] These gains in the management of CAD and AMI were also counteracted by the rising prevalence of obesity and diabetes and persistent health disparities.[24,25]

An important observation from this study was the sudden increase in both overall CAD and AMI mortality rates and across races and sexes in 2020 compared to prior years. This could possibly be attributed primarily to the impact of the COVID-19 pandemic. There were significantly reduced hospitalizations for acute cardiovascular conditions by the strained health care systems during the pandemic, coupled to the fact that patients avoided hospitals due to fear of contracting COVID-19, both resulting in delayed or missed treatments for AMI.[26-28] This rise in cardiovascular deaths, including those from ischemic heart disease, was particularly pronounced in regions heavily affected by COVID-19.[26-29] Other effects of the COVID-19 pandemic, including the psychological stress, a known risk factor for cardiovascular events, and changes in lifestyle such as reduced physical activity and exacerbation of existing health care disparities, likely contributed to the increased incidence and mortality from CAD and AMI.[30,31]

The significantly higher mortality rates of CAD and AMI among males over the past decades, as also noted in the review by Dani et al,[18] align with the known higher prevalence of CVD risk factors such as hypertension, hyperlipidemia, and smoking among males compared to females.[32] Males also experience higher levels of inflammatory markers such as C-reactive protein and interleukin-6, which are associated with CAD.[33] Beyond the risk factors for CVD, there are also inherent differences in the pathophysiology of CAD between males and females. Males tend to have more inflamed and vulnerable plaques, which are more prone to rupture, leading to AMI, as opposed to females who tend to have more plaque erosion and less acute events.[34,35] Females also experience the protective effect of estrogen in the middle age.[36]

This study highlights the significantly higher mortality rate of CAD in non-Hispanic Blacks compared to other races in the United States, which is due to several interrelated factors including inherent biological, socio-economic, environmental, and geographical factors, among others. Socio-economic disparities such as living in lower socio-economic neighborhoods, food insecurity, high unemployment rates, and lower income, which disproportionately affect Black communities due to historical and contemporary socioeconomic practices,[37] collectively account for a substantial portion of the observed racial differences in cardiovascular risks and mortality.[38-40] The lower access to timely interventions such as revascularization and to overall quality health care among black patients also contributes to this observed trend.[41,42] Also, the higher prevalence of comorbid conditions such as hypertension, diabetes, and obesity and risk factors such as smoking and lower levels of physical activity among Black individuals contributes to the observed higher CAD mortality rates.[40,43,44]

It is, however, worth noting that this study found no significant difference in mortality rates for AMI between non-Hispanic Blacks and non-Hispanic Whites. This study also highlights the consistently lower CAD and AMI mortality rates in Hispanics compared to non-Hispanic Blacks and non-Hispanic Whites over this time, a phenomenon often referred to as the "Hispanic paradox," a concept whose underlying reasons remain elusive.[45] This paradox highlights the discordance that exists between the better health outcomes of Hispanics over non-Hispanic populations despite their higher burden of CVD risk factors and socioeconomic disadvantage.[45]

Despite having the highest mortality rates, this study confirms that the older age groups (75 years and above) have also experienced the greatest rate of decline in CAD and AMI mortality rates. The higher rates of comorbidities and frailty, atypical presentation, greater severity of disease, higher risk of complications, and lower rates of procedural success in elderly patients collectively account for the higher mortality rates in the older age groups.[46-48] Our study found no significant difference in the mortality rates of CAD and AMI between the 25 to 44 years age group and the 45 to 64 years age group. While older adults experienced significant declines in CAD and AMI mortality, younger adults have not seen similar improvements. Wilmot et al noted a minimal improvement in CAD mortality in young adults, particularly women under 55, since 1990.[14] The rising prevalence of risk factors such as obesity, diabetes, and metabolic syndrome among younger adults has likely contributed to the stagnation in mortality decline.[6]

While this ecological study provides vital insights, it is important to note its limitations in making individual-level and causal inferences, as it relies on grouped population data. The findings of this study may therefore not apply to individuals in specific communities. Also, the design of our study does not enable us to account for confounding variables such as socio-economic status, access to health care and lifestyle factors, which all influence mortality rates. Variations in the reporting practices across different regions or demographic groups, as well as changes in how mortality data is collected, reported, or categorized, could affect the observed trends in mortality rates. Despite these limitations, this study offers a clear understanding of the national trends in CAD and AMI mortality across various subgroups over the past 2 decades.

CONCLUSIONS

In summary, this study delineates the trends in CAD and AMI from 2000 to 2020. While a significant reduction in mortality rates is evident, the notable deceleration in this decline in recent years reflects a plateauing of earlier gains and highlights the need to identify new targets. The persistent disparities in the identified population subgroups necessitate further exploration to inform targeted interventions and policies.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr Christian Akem Dimala, The University of Texas Medical Branch, 301 University Blvd. 5.106 John Sealy Annex, Galveston, Texas 77555-0553, USA. E-mail: Christian.akem.dimala1@alumni.lshtm.ac.uk.

PERSPECTIVES

COMPETENCY IN SYSTEMS-BASED PRACTICE: There remain significant disparities in CAD and AMI mortality rates in the United States. Identifying subpopulations with the worst mortality rates is the first step for further in-depth, individual-level research to identify and address the reasons for these disparities.

TRANSLATIONAL OUTLOOK: Clinicians' awareness of these subpopulations is important in ensuring a more systematic approach to the management of these patients as an important step in addressing disparities in care at the clinical level.

REFERENCES

1. *Coronary Heart Disease - What is Coronary heart Disease?* NHLBI, NIH; 2022. Accessed September 4, 2023. https://www.nhlbi.nih.gov/health/coronary-heart-disease

2. CDC. *Coronary Artery Disease*. Centers for Disease Control and Prevention; 2021. Accessed September 4, 2023. https://www.cdc.gov/heartdisease/coronary_ad.htm

3. CDC. *Heart Attack Symptoms, Risk Factors, and Recovery*. Centers for Disease Control and Prevention; 2022. Accessed September 4, 2023. https://www.cdc.gov/heartdisease/heart_attack.htm

4. De Silva K, Perera D, O'Kane P. Chapter 9 - acute myocardial infarction: STEMI and NSTEMI. In: Topaz O, ed. *Cardiovascular Thrombus [Internet]*. Academic Press; 2018:123-146. Accessed September 4, 2023. https://www.sciencedirect.com/science/article/pii/B9780128126158000090

5. *Heart Disease Facts*. Centers for Disease Control and Prevention; 2023. Accessed June 20, 2023. https://www.cdc.gov/heartdisease/facts.htm

6. Ford ES, Ajani UA, Croft JB, et al. Explaining the decrease in U.S. Deaths from coronary disease, 1980-2000. *N Engl J Med*. 2007;356(23):2388-2398.

7. Mensah GA, Wei GS, Sorlie PD, et al. Decline in cardiovascular mortality: possible causes and implications. *Circ Res*. 2017;120(2):366-380.

8. Tsao CW, Aday AW, Almarzooq ZI, et al. Heart disease and stroke statistics-2023 update: a report from the American heart association. *Circulation*. 2023;147(8):e93-e621.

9. Sidney S, Quesenberry CP Jr, Jaffe MG, et al. Recent trends in cardiovascular mortality in the United States and public health goals. *JAMA Cardiol*. 2016;1(5):594-599.

10. Zhou Y, Boudreau DM, Freedman AN. Trends in the use of aspirin and nonsteroidal anti-inflammatory drugs in the general U.S. population. *Pharmacoepidemiol Drug Saf*. 2014;23(1):43-50.

11. Pahigiannis K, Thompson-Paul AM, Barfield W, et al. Progress toward improved cardiovascular health in the United States. *Circulation*. 2019;139(16):1957-1973.

12. De Luca G, Suryapranata H, Marino P. Reperfusion strategies in acute ST-elevation myocardial infarction: an overview of current status. *Prog Cardiovasc Dis*. 2008;50(5):352-382.

13. Salami JA, Warraich H, Valero-Elizondo J, et al. National trends in statin use and expenditures in the US adult population from 2002 to 2013: insights from the medical expenditure panel survey. *JAMA Cardiol*. 2017;2(1):56-65.

14. Wilmot KA, O'Flaherty M, Capewell S, Ford ES, Vaccarino V. Coronary heart disease mortality declines in the United States from 1979 through 2011: evidence for stagnation in young adults, especially women. *Circulation*. 2015;132(11):997-1002.

15. Vaughan AS, Schieb L, Casper M. Historic and recent trends in county-level coronary heart disease death rates by race, gender, and age group, United States, 1979-2017. *PLoS One*. 2020;15(7):e0235839.

16. Peters SAE, Colantonio LD, Dai Y, et al. Trends in recurrent coronary heart disease after myocardial infarction among US women and men between 2008 and 2017. *Circulation*. 2021;143(7):650-660.

17. Gupta A, Wang Y, Spertus JA, et al. Trends in acute myocardial infarction in young patients and differences by sex and race, 2001 to 2010. *J Am Coll Cardiol*. 2014;64(4):337-345.

18. Dani SS, Lone AN, Javed Z, et al. Trends in premature mortality from acute myocardial infarction in the United States, 1999 to 2019. *J Am Heart Assoc*. 2022;11(1):e021682.

19. Kyalwazi AN, Loccoh EC, Brewer LC, et al. Disparities in cardiovascular mortality between black and white adults in the United States, 1999 to 2019. *Circulation*. 2022;146(3):211-228.

20. *Indicator Definitions: Cardiovascular Diseases*. CDC; 2023. Accessed September 4, 2023. https://www.cdc.gov/dhdsp/maps/dtm/indicator_definitions_cardiovascular_diseases.htm

21. Gajanana D, Weintraub WS, Kolm P, et al. Trends in death rate 2009 to 2018 following percutaneous coronary intervention stratified by acuteness of presentation. *Am J Cardiol*. 2019;124(9):1349-1356.

22. Zuin M, Rigatelli G, Temporelli P, et al. Trends in acute myocardial infarction mortality in the European Union, 2012-2020. *Eur J Prev Cardiol*. 2023;30(16):1758-1771.

23. Timmis A, Kazakiewicz D, Townsend N, Huculeci R, Aboyans V, Vardas P. Global epidemiology of acute coronary syndromes. *Nat Rev Cardiol*. 2023;20(11):778-788.

24. Lopez AD, Adair T. Is the long-term decline in cardiovascular-disease mortality in high-income countries over? Evidence from national vital statistics. *Int J Epidemiol*. 2019;48(6):1815-1823.

25. Ananth CV, Rutherford C, Rosenfeld EB, et al. Epidemiologic trends and risk factors associated with the decline in mortality from coronary heart disease in the United States, 1990-2019. *Am Heart J*. 2023;263:46-55.

26. Wadhera RK, Shen C, Gondi S, Chen S, Kazi DS, Yeh RW. Cardiovascular deaths during the COVID-19 pandemic in the United States. *J Am Coll Cardiol*. 2021;77(2):159-169.

27. Wienbergen H, Retzlaff T, Schmucker J, et al. Impact of COVID-19 pandemic on presentation and outcome of consecutive patients admitted to hospital due to ST-elevation myocardial infarction. *Am J Cardiol*. 2021;151:10-14.

28. Wilcock AD, Zubizarreta JR, Wadhera RK, et al. Factors underlying reduced hospitalizations for myocardial infarction during the COVID-19 pandemic. *JAMA Cardiol*. 2024;31:e242031.

29. Janus SE, Makhlouf M, Chahine N, Motairek I, Al-Kindi SG. Examining disparities and excess cardiovascular mortality before and during the COVID-19 pandemic. *Mayo Clin Proc*. 2022;97(12):2206-2214.

30. Gorini F, Chatzianagnostou K, Mazzone A, et al. "Acute myocardial infarction in the time of COVID-19": a review of biological, environmental, and psychosocial contributors. *Int J Environ Res Publ Health*. 2020;17(20):7371.

31. Yeo YH, Wang M, He X, et al. Excess risk for acute myocardial infarction mortality during the COVID-19 pandemic. *J Med Virol*. 2023;95(1):e28187.

32. NHANES. *National Health and Nutrition Examination Survey*. National Center for Health

Statistics; 2023. Accessed December 20, 2023. https://www.cdc.gov/nchs/nhanes/index.htm

33. Siennicka A, Jastrzebska M, Smialkowska K, et al. Gender differences in hemostatic and inflammatory factors in patients with acute coronary syndromes: a pilot study. *J Physiol Pharmacol Off J Pol Physiol Soc*. 2018;69(1):91–98.

34. Man JJ, Beckman JA, Jaffe IZ. Sex as a biological variable in atherosclerosis. *Circ Res*. 2020;126(9):1297–1319.

35. Sato Y, Kawakami R, Sakamoto A, et al. Sex differences in coronary atherosclerosis. *Curr Atherosclerosis Rep*. 2022;24(1):23–32.

36. Anand SS, Islam S, Rosengren A, et al. Risk factors for myocardial infarction in women and men: insights from the INTERHEART study. *Eur Heart J*. 2008;29(7):932–940.

37. Lynch EE, Malcoe LH, Laurent SE, Richardson J, Mitchell BC, Meier HCS. The legacy of structural racism: associations between historic redlining, current mortgage lending, and health. *SSM - Popul Health*. 2021;14:100793.

38. Tajeu GS, Safford MM, Howard G, et al. Black-white differences in cardiovascular disease mortality: a prospective us study, 2003-2017. *Am J Publ Health*. 2020;110(5):696–703.

39. Islek D, Alonso A, Rosamond W, et al. Racial differences in fatal out-of-hospital coronary heart disease and the role of income in the atherosclerosis risk in communities cohort study (1987 to 2017). *Am J Cardiol*. 2023;194:102–110.

40. He J, Bundy JD, Geng S, et al. Social, behavioral, and metabolic risk factors and racial disparities in cardiovascular disease mortality in U.S. Adults : an observational study. *Ann Intern Med*. 2023;176(9):1200–1208.

41. Popescu I, Cram P, Vaughan-Sarrazin MS. Differences in admitting hospital characteristics for black and white Medicare beneficiaries with acute myocardial infarction. *Circulation*. 2011;123(23):2710–2716.

42. Mathews R, Chen AY, Thomas L, et al. Differences in short-term versus long-term outcomes of older black versus white patients with myocardial infarction: findings from the can rapid risk stratification of unstable angina patients suppress adverse outcomes with early implementation of American College of cardiology/American heart association guidelines (CRUSADE). *Circulation*. 2014;130(8):659–667.

43. He J, Zhu Z, Bundy JD, Dorans KS, Chen J, Hamm LL. Trends in cardiovascular risk factors in US adults by race and ethnicity and socioeconomic status, 1999-2018. *JAMA*. 2021;326(13):1286–1298.

44. Alderman MH, Cohen HW, Madhavan S. Myocardial infarction in treated hypertensive patients: the paradox of lower incidence but higher mortality in young blacks compared with whites. *Circulation*. 2000;101(10):1109–1114.

45. Medina-Inojosa J, Jean N, Cortes-Bergoderi M, Lopez-Jimenez F. The Hispanic paradox in cardiovascular disease and total mortality. *Prog Cardiovasc Dis*. 2014;57(3):286–292.

46. Damluji AA, Forman DE, Wang TY, et al. Management of acute coronary syndrome in the older adult population: a scientific statement from the American heart association. *Circulation*. 2023;147(3):e32–e62.

47. Fleg JL, Forman DE, Berra K, et al. Secondary prevention of atherosclerotic cardiovascular disease in older adults: a scientific statement from the American Heart Association. *Circulation*. 2013;128(22):2422–2446.

48. Badimon L, Bugiardini R, Cubedo J. Pathophysiology of acute coronary syndromes in the elderly. *Int J Cardiol*. 2016;222:1105–1109.

KEY WORDS acute myocardial infarction, age, coronary artery disease, race, sex, trends