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ORIGINAL RESEARCH

Sex Disparities in Ischemic Heart Disease Death Across the United States: The Southern Burden of Excess Body Weight and Diet

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BACKGROUND: While prior studies have assessed sex disparities in ischemic heart disease (IHD) outcomes in the United States, little is known about how these differences vary across states.

METHODS: We analyzed GBD (Global Burden of Disease) data from 2011 to 2021 for all 50 US states. Sex-specific IHD age-standardized mortality rates and IHD age-standardized prevalence rates were used to calculate the mortality-to-prevalence ratios per 100 000 inhabitants per year, enabling comparison of death rates relative to the population at risk. Hawaii, the state with the lowest age-standardized prevalence rate and age-standardized mortality rate in both sexes, served as the reference for *Z* score analyses, with 99% (Z>2.58) or 95% (Z>1.96) confidence thresholds.

RESULTS: In 2011, 30 states had significantly higher mortality-to-prevalence ratios in women than men (Z>2.58), indicating an elevated mortality rate in women with IHD. By 2021, only Arkansas (6.7% [95% uncertainty interval, 4.6–9.3]) and Mississippi (7.1% [95% uncertainty interval, 4.8–9.7]) exceeded this threshold, while 11 additional states, mainly in the South, retained moderate disparities (Z>1.96). Higher mortality-to-prevalence ratios were inversely associated with state gross domestic product per capita. High body mass index, processed meat intake, low fiber, and low vegetable intake emerged as the most significant contributors (Z>1.96, 95% confidence level) to excess IHD death in women but not men.

CONCLUSIONS: Despite an overall decline, sex disparities in IHD death persist, with Arkansas and Mississippi continuing to bear the highest burden. These disparities are largely driven by overweight/obesity and dietary risk factors, warranting targeted, state-level interventions.

Key Words: deaths ■ ischemic heart disease ■ prevalence ■ risk factors ■ sex differences

Ischemic heart disease (IHD) remained the leading cause of death in the United States from 1990 to 2021, contributing to ≈493 000 deaths (95% uncertainty interval, 432 000–527 000) in 2021. Although women generally have lower age-standardized IHD prevalence and mortality rates than men, evidence suggests that they face a higher risk of death following an IHD event.[1,2] This disparity raises questions about whether higher post-IHD mortality rates in women are driven by inherent biological differences or disparities in cardiovascular risk factors and health care access.

Most available data on sex-specific IHD outcomes in the United States stem from registries that aggregate data from 1995 to 2014.[2,3] However, the US population

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CLINICAL PERSPECTIVE

What Is New?

- Using GBD (Global Burden of Disease) data from 2011 to 2021, this study provides the first state-level evaluation of sex differences in ischemic heart disease death across the United States, revealing how disparities vary geographically and economically.

What Are the Clinical Implications?

- Despite nationwide improvements in ischemic heart disease survival, women in southern and lower-income states continue to experience a disproportionately higher mortality burden than men, driven by excess body weight and suboptimal diet quality.
- These findings underscore the need for targeted, state-specific prevention strategies focused on metabolic health, healthy food access, and weight management to close persistent sex-based gaps in cardiovascular outcomes.

Nonstandard Abbreviations and Acronyms

ASMR	age-standardized mortality rate
GBD	Global Burden of Disease
IHD	ischemic heart disease
MPR	mortality-to-prevalence ratio

has undergone significant demographic changes from 2014 to 2021, including aging and increasing life expectancy, in addition to institution of the Affordable Care Act.[4] These shifts may have altered the balance between IHD prevalence and death across sexes, potentially modifying sex-based health disparities within the health care system.

Beyond demographic shifts, socioeconomic disparities play a crucial role in shaping IHD outcomes both globally and within the United States.[5,6] Income inequality across US states is striking, with high median household incomes in states like Massachusetts and New Jersey and much lower incomes in states like Mississippi and West Virginia. These economic variations raise important questions: Are sex differences in the burden of IHD more pronounced in economically disadvantaged areas? Do sex disparities in death following IHD worsen in these regions? Or do both trends intersect to amplify inequities?

To address these questions, we analyzed sex-specific mortality rates for IHD across US states from 2011 to 2021, examining variations by income level, risk factor burden, and geography. Data for this analysis were sourced from the GBD (Global Burden of Disease) database, which ensures comprehensive coverage and comparability across regions and time periods.[7,8] Updated analyses are necessary to inform targeted strategies that may address sex-specific challenges and reduce health disparities in IHD outcomes across diverse US populations.

METHODS

Data Sources

This study complies with the Guidelines for Accurate and Transparent Health Estimates Reporting. We used publicly available mortality and population data from individual US states provided by the GBD study,[7] complemented by economic classifications from the US Bureau of Economic Analysis and the US Census Bureau. The US Bureau of Economic Analysis ranked state-level gross domestic product per capita into 7 categories, from "$80K or more" to "less than $50K," which we consolidated into 4 broader groups—Very High, High, Middle/Upper Middle, and Low—to reflect relative economic status (Figure S1, Table S1). In accordance with American Heart Association Research Guidelines, this study analyzed deidentified, aggregate, publicly available data and therefore did not require institutional review board approval or informed consent.

Transparency and Openness Statement

The data, analytic methods, and materials used in this research are publicly available to allow replication. All mortality and prevalence data are accessible at the Global Health Data Exchange (http://ghdx.healthdata.org), and economic indicators are available from the US Bureau of Economic Analysis (https://www.bea.gov) and the US Census Bureau (https://www.census.gov).

Sex Definition and Ascertainment

The GBD study defines sex on the basis of biological classification recorded in vital registration and survey data. Accordingly, all analyses are sex-stratified (female/male). We use the terms women and men for consistency with conventional clinical reporting, while acknowledging that these categories reflect biological sex rather than gender identity.

Time Frame and Trends

The analysis covered the period from 2011 to 2021 on the basis of data availability from the GBD mortality database. Given the standard 12- to 18-month reporting lag, 2021 was the most recent year with complete state-level data. The year 2011 was selected as the baseline to allow for a 10-year comparison, providing sufficient time to capture meaningful trends in IHD death across diverse US states. Five-year trends were also assessed to evaluate patterns across varying geographic and economic contexts.

Risk Factor Estimation

We selected conventional risk factors for IHD on the basis of evidence of causality, including high systolic blood pressure (SBP), elevated low-density lipoprotein cholesterol (LDL-C), high fasting plasma glucose, tobacco use, and high body mass index (BMI). According to the GBD 2021 Risk Factors Collaborators, smoking exposure included current or previous use of any tobacco product, as well as second-hand smoke, with the theoretical minimum risk exposure level set at 0.[9] Theoretical minimum risk exposure levels for other risk factors were set as follows: SBP, 110 to 115 mm Hg; fasting plasma glucose, 4.8 to 5.4 mmol/L; LDL-C, 0.7 to 1.3 mmol/L; and BMI, 20 to 25 kg/m^2. In addition, other behavioral and environmental risk factors, such as low physical activity (<3000–4500 metabolic equivalent minutes per week) and exposure to ambient air pollution (ambient ozone, particulate matter with a diameter of ≤2.5 μm, and household air pollution from solid fuel use) were assessed using similar standardization methods.

Health Effects of Dietary Risks

We identified and evaluated 12 dietary risk factors for IHD on the basis of GBD selection criteria. These included inadequate intake of whole grains, fruits, fiber, legumes, vegetables, nuts and seeds, seafood omega-3 fatty acids, and polyunsaturated fatty acids, as well as excessive consumption of red meat, processed meat, sodium, and sugar-sweetened beverages. Data on trans-fat intake were not available for 2021 and were therefore excluded from this analysis. Optimal intake levels for each factor are provided in Table S2.

Statistical Analysis

We analyzed sex-specific IHD outcomes across US states from 2011 to 2021, focusing on age-standardized mortality rates (ASMRs), age-standardized prevalence rates, and mortality-to-prevalence ratios (MPRs) per 100 000 inhabitants. The MPR provides a standardized measure of the mortality burden among individuals diagnosed with IHD, enabling comparison across states and between sexes. Both ASMRs and age-standardized prevalence rates were standardized to the GBD reference population, as described in prior analyses.[6]

To evaluate the impact of modifiable risk factors, we used GBD estimates of IHD ASMRs attributable to each risk factor, assuming theoretical minimum risk exposure levels. These attributable mortality rates were derived using meta-regression analyses conducted in the GBD and Burden of Proof studies.[10] Full data sources for each risk–outcome pair and analytical code are available online (https://github.com/ihmeuw-msca/burden-of-proof).

We assessed sex-specific differences in MPRs and risk factor–attributable mortality rates by comparing each state's values for women and men separately to those of Hawaii, which had the lowest ASMR and age-standardized prevalence rate in both sexes. For each comparison, *Z* scores were calculated on the basis of the difference relative to Hawaii, using standard errors derived from the uncertainty intervals reported in the GBD data set. This reference-based approach highlights state-level deviations from a relatively low-burden baseline. *Z* scores >1.96 or 2.58 were considered statistically significant at the 95% and 99% confidence levels, respectively.

To assess trends and associations, we calculated Pearson's correlation coefficient (*r*), with a *P* value <0.05 indicating statistical significance. The normality assumption for the Pearson correlation was tested using the Shapiro–Wilk test to ensure validity. Analyses were conducted using publicly available GBD and World Bank data with Stata 17.0 (StataCorp, College Station, TX). Further details on statistical methods and adjustments are provided in the Supplemental Material.

RESULTS

IHD Mortality Rates

Between 2011 and 2021, ASMRs for IHD declined significantly across US states: by 12.2% in men and 19.0% in women (Table , Figure S2). Throughout the period, men consistently had higher mortality rates than women. In 2011, ASMRs exceeded the ninth decile threshold (135 per 100 000 in men; 74 per 100 000 in women) in several southern states, including Arkansas, Mississippi, Tennessee, West Virginia, and Louisiana. By 2021, Mississippi, Arkansas, and West Virginia remained above this threshold in both sexes, while Kentucky persisted among the highest for men only.

IHD Prevalence Rates

From 2011 to 2021, IHD prevalence declined in all US states, reaching 2019.3 per 100 000 in men (−6.8%) and 1034.5 in women (−8.9%) (Table , Figure S3). Despite these reductions, age-standardized prevalence rates remained highest mainly in the South. In 2021, Arkansas, Florida, Kentucky, Louisiana, Missouri, Oklahoma, and West Virginia exceeded the ninth decile threshold, defined as >2273 per 100 000 for men and >1199 per 100 000 for women.

Table. Age-Standardized Prevalence Rates, Mortality Rates, and Mortality-to-Prevalence Ratios in Individuals of All Ages, per 100 000 Inhabitants

States	Age-standardized prevalence rate of IHD per 100 000 inhabitants				Age-standardized mortality rate of IHD per 100 000 inhabitants				Mortality-to-prevalence ratio, %			
	2011		2021		2011		2021		2011		2021	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Alabama	2292.93	1133.30	2187.27	1093.42	151.60	86.73	132.93	70.56	6.61	7.65	6.08	6.45
LB	1985.86	984.56	1832.33	919.92	139.56	75.84	107.54	56.67	5.31	5.80	4.15	4.33
UB	2630.67	1307.28	2589.16	1307.45	158.50	93.16	159.04	84.33	7.98	9.46	8.68	9.17
Alaska	1848.69	906.37	1836.39	925.94	109.89	49.12	90.85	36.78	5.94	5.42	4.95	3.97
LB	1590.23	783.97	1545.18	780.48	98.72	41.09	75.54	30.20	4.61	3.90	3.43	2.74
UB	2143.24	1054.07	2203.07	1101.87	117.86	54.21	109.15	43.45	7.41	6.92	7.06	5.57
Arizona	1912.26	958.72	1839.17	935.86	112.35	61.97	101.50	50.37	5.88	6.46	5.52	5.38
LB	1661.48	837.16	1543.83	784.48	100.75	50.94	82.80	39.74	4.58	4.63	3.72	3.56
UB	2201.59	1100.75	2225.08	1115.25	119.07	67.77	122.59	60.81	7.17	8.10	7.94	7.75
Arkansas	2588.57	1366.74	2353.07	1253.99	163.59	89.78	155.28	84.14	6.32	6.57	6.60	6.71
LB	2262.26	1211.60	1991.56	1076.15	150.87	78.00	127.52	67.88	5.11	5.02	4.57	4.60
UB	2950.28	1555.12	2793.19	1476.81	172.20	96.91	188.43	100.30	7.61	8.00	9.46	9.32
California	1915.50	964.63	1814.50	906.89	109.16	61.15	93.21	45.50	5.70	6.34	5.14	5.02
LB	1671.11	841.17	1525.34	763.25	98.23	49.84	76.72	35.21	4.49	4.50	3.53	3.23
UB	2187.99	1106.50	2176.05	1090.24	115.39	67.19	110.80	55.17	6.90	7.99	7.26	7.23
Colorado	1575.20	726.40	1576.94	756.20	93.09	48.97	79.36	37.70	5.91	6.74	5.03	4.99
LB	1352.74	628.47	1315.87	626.27	83.46	40.41	61.86	28.98	4.54	4.75	3.30	3.14
UB	1840.27	851.13	1875.03	922.61	98.81	53.87	96.84	45.59	7.30	8.57	7.36	7.28
Connecticut	2063.38	1018.23	1866.07	923.08	99.86	53.84	87.22	45.12	4.84	5.29	4.67	4.89
LB	1800.12	884.03	1564.29	784.33	89.60	43.76	68.21	35.19	3.79	3.72	3.04	3.20
UB	2362.67	1176.24	2241.80	1099.27	106.64	59.46	105.50	55.88	5.92	6.73	6.74	7.12
Delaware	2052.73	1084.86	1935.13	1013.90	120.44	70.37	105.85	54.22	5.87	6.49	5.47	5.35
LB	1791.54	944.29	1622.85	858.03	107.87	58.21	88.64	44.58	4.59	4.67	3.85	3.68
UB	2349.81	1247.55	2304.08	1210.85	128.49	76.72	124.24	62.27	7.17	8.12	7.66	7.26
District of Columbia	1798.21	1022.09	1848.84	1008.53	123.67	72.89	106.01	57.22	6.88	7.13	5.73	5.67
LB	1550.14	885.63	1562.00	845.09	111.32	61.63	83.08	46.23	5.39	5.25	3.73	3.85
UB	2064.90	1173.29	2227.19	1201.63	132.79	80.15	132.15	69.05	8.57	9.05	8.46	8.17
Florida	2477.13	1407.18	2273.38	1266.11	112.61	62.26	103.07	51.64	4.55	4.42	4.53	4.08
LB	2191.30	1251.14	1951.49	1087.18	101.78	50.39	83.17	39.99	3.66	3.18	3.12	2.73
UB	2783.45	1584.19	2661.62	1464.89	119.25	68.72	124.22	62.39	5.44	5.49	6.37	5.74
Georgia	2146.14	1063.74	2074.37	1029.88	122.89	69.85	109.23	57.40	5.73	6.57	5.27	5.57
LB	1857.48	919.88	1740.88	872.82	112.33	59.30	87.60	45.84	4.58	4.82	3.52	3.76
UB	2452.31	1231.03	2486.41	1220.63	129.34	75.70	132.00	68.17	6.96	8.23	7.58	7.81
Hawaii	2035.68	1091.53	1895.79	1004.49	90.14	39.39	78.20	31.84	4.43	3.61	4.13	3.17
LB	1750.65	959.41	1591.30	850.54	80.23	31.00	62.52	24.51	3.43	2.49	2.77	2.06
UB	2339.55	1244.14	2253.46	1190.25	96.51	44.56	95.59	38.24	5.51	4.64	6.01	4.50
Idaho	1663.45	832.74	1695.47	841.88	112.30	55.54	95.55	45.18	6.75	6.67	5.64	5.37
LB	1440.65	724.00	1426.97	709.45	101.48	46.89	76.60	37.15	5.25	4.88	3.74	3.67
UB	1931.25	960.31	2045.71	1012.09	119.95	61.20	115.20	53.21	8.33	8.45	8.07	7.50
Illinois	2088.78	1039.53	2009.89	1015.31	123.00	66.92	105.38	53.62	5.89	6.44	5.24	5.28
LB	1820.70	904.61	1657.14	867.79	113.06	55.29	86.27	41.32	4.72	4.61	3.60	3.41
UB	2393.88	1198.64	2394.61	1212.01	129.84	72.82	126.86	65.26	7.13	8.05	7.66	7.52
Indiana	2482.50	1284.01	2259.59	1170.91	137.40	74.66	122.70	63.89	5.53	5.81	5.43	5.46
LB	2176.77	1123.22	1900.31	993.86	127.09	63.48	99.40	51.69	4.45	4.34	3.67	3.68

(*Continued*)

Table. Continued

States	Age-standardized prevalence rate of IHD per 100 000 inhabitants				Age-standardized mortality rate of IHD per 100 000 inhabitants				Mortality-to-prevalence ratio, %			
	2011		2021		2011		2021		2011		2021	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
UB	2855.35	1462.31	2705.08	1403.61	144.32	80.58	147.31	75.50	6.63	7.17	7.75	7.60
Iowa	1945.28	960.02	1907.42	942.59	126.09	67.39	119.81	56.24	6.48	7.02	6.28	5.97
LB	1690.44	830.78	1591.53	789.79	114.79	56.27	96.92	44.37	5.14	5.08	4.27	3.95
UB	2233.55	1108.64	2270.77	1122.86	133.52	73.81	144.45	68.01	7.90	8.88	9.08	8.61
Kansas	2007.00	992.36	1925.94	973.93	118.64	62.91	119.42	59.79	5.91	6.34	6.20	6.14
LB	1749.70	864.99	1605.85	822.23	108.72	52.87	97.44	47.69	4.65	4.61	4.17	4.10
UB	2335.57	1147.25	2336.28	1162.91	126.06	68.53	144.39	73.00	7.20	7.92	8.99	8.88
Kentucky	2548.85	1325.27	2305.51	1199.51	152.52	82.12	134.59	71.03	5.98	6.20	5.84	5.92
LB	2222.63	1161.83	1959.14	1017.51	140.93	72.37	109.08	56.95	4.80	4.78	3.97	4.05
UB	2935.12	1515.56	2748.07	1407.31	160.04	88.02	162.04	85.85	7.20	7.58	8.27	8.44
Louisiana	2421.38	1291.92	2296.19	1228.96	144.90	84.29	137.80	74.89	5.98	6.52	6.00	6.09
LB	2119.75	1138.36	1947.73	1038.10	134.48	74.07	113.22	60.15	4.86	5.05	4.15	4.16
UB	2765.53	1466.57	2729.87	1445.56	151.86	90.72	167.43	89.25	7.16	7.97	8.60	8.60
Maine	2176.75	1006.90	1942.38	953.06	105.32	55.82	98.97	47.87	4.84	5.54	5.10	5.02
LB	1910.18	874.42	1635.06	797.33	94.48	46.27	79.50	37.47	3.79	4.00	3.42	3.28
UB	2494.05	1158.17	2324.02	1143.65	112.53	61.29	120.65	56.47	5.89	7.01	7.38	7.08
Maryland	2041.62	1090.73	1904.93	996.02	115.98	67.94	99.78	53.92	5.68	6.23	5.24	5.41
LB	1772.79	950.92	1605.46	840.02	104.56	56.30	80.32	42.02	4.49	4.48	3.53	3.51
UB	2329.27	1256.27	2277.90	1195.73	122.23	74.14	121.20	66.65	6.89	7.80	7.55	7.93
Massachusetts	2113.66	1016.00	1941.32	961.70	106.53	53.72	81.59	39.61	5.04	5.29	4.20	4.12
LB	1844.40	884.11	1636.53	811.94	96.56	44.19	65.94	29.79	3.98	3.77	2.86	2.58
UB	2427.05	1171.20	2307.53	1153.27	112.41	59.05	99.45	47.98	6.09	6.68	6.08	5.91
Michigan	2426.38	1313.20	2230.53	1191.23	145.17	82.15	124.59	65.10	5.98	6.26	5.59	5.47
LB	2126.73	1149.09	1891.50	1006.17	132.76	69.37	101.57	51.36	4.78	4.60	3.81	3.62
UB	2779.25	1509.06	2662.59	1420.10	152.50	88.92	148.30	76.97	7.17	7.74	7.84	7.65
Minnesota	1943.55	880.98	1801.95	852.00	88.77	39.73	80.78	36.42	4.57	4.51	4.48	4.27
LB	1687.42	757.32	1518.88	715.70	80.03	32.54	63.41	28.79	3.58	3.18	2.91	2.80
UB	2232.71	1022.18	2178.63	1027.85	94.75	43.81	98.24	44.19	5.62	5.78	6.47	6.17
Mississippi	2303.33	1118.40	2193.55	1099.60	158.36	89.97	152.72	77.60	6.88	8.04	6.96	7.06
LB	2007.27	975.87	1834.29	929.47	148.08	78.31	125.07	62.96	5.55	6.06	4.74	4.82
UB	2666.17	1292.14	2637.48	1305.31	166.33	96.58	180.08	92.59	8.29	9.90	9.82	9.96
Missouri	2377.51	1218.00	2230.13	1144.64	144.09	81.35	128.47	65.61	6.06	6.68	5.76	5.73
LB	2071.18	1059.10	1873.99	961.82	131.54	69.26	104.95	52.75	4.79	4.99	3.96	3.85
UB	2743.77	1388.81	2652.05	1370.97	151.77	88.07	154.66	77.58	7.33	8.32	8.25	8.07
Montana	1749.77	840.39	1736.92	875.46	110.60	52.63	103.43	48.07	6.32	6.26	5.95	5.49
LB	1528.59	728.07	1464.00	737.27	100.22	43.97	81.55	38.93	4.95	4.49	3.86	3.67
UB	2026.22	978.98	2112.06	1061.17	118.52	57.76	126.59	55.24	7.75	7.93	8.65	7.49
Nebraska	1906.58	929.89	1818.36	912.07	104.83	52.35	98.31	46.62	5.50	5.63	5.41	5.11
LB	1672.03	801.45	1524.43	764.59	94.81	43.25	78.38	37.28	4.29	4.06	3.57	3.39
UB	2212.14	1065.56	2195.12	1099.97	111.70	57.74	117.69	54.78	6.68	7.20	7.72	7.16
Nevada	2031.81	1056.56	1987.56	1034.89	128.08	71.10	124.84	60.61	6.30	6.73	6.28	5.86
LB	1763.45	924.73	1678.25	870.44	116.37	60.42	99.91	50.04	4.93	4.99	4.24	4.10
UB	2361.78	1212.02	2356.48	1222.01	135.46	77.39	149.89	69.99	7.68	8.37	8.93	8.04
New Hampshire	1990.63	971.06	1829.83	914.59	107.25	55.26	95.05	48.36	5.39	5.69	5.19	5.29
LB	1723.72	838.64	1543.72	764.25	95.65	45.51	76.55	38.48	4.16	4.06	3.46	3.49
UB	2297.01	1121.90	2211.66	1103.60	115.46	61.50	117.87	57.47	6.70	7.33	7.64	7.52

(*Continued*)

Table. Continued

States	Age-standardized prevalence rate of IHD per 100000 inhabitants				Age-standardized mortality rate of IHD per 100000 inhabitants				Mortality-to-prevalence ratio, %			
	2011		2021		2011		2021		2011		2021	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
New Jersey	2239.06	1111.61	2023.45	1024.33	120.91	68.87	97.79	51.62	5.40	6.20	4.83	5.04
LB	1961.59	974.22	1718.74	872.82	108.40	57.18	77.57	39.62	4.20	4.50	3.23	3.28
UB	2582.78	1270.59	2404.34	1208.04	127.98	75.52	119.30	62.87	6.52	7.75	6.94	7.20
New Mexico	1839.56	919.31	1751.12	875.79	107.38	60.87	113.84	56.62	5.84	6.62	6.50	6.47
LB	1605.50	795.03	1471.70	736.28	96.60	50.53	91.90	43.39	4.56	4.75	4.38	4.10
UB	2119.61	1064.69	2098.91	1057.98	114.22	66.87	137.02	68.56	7.11	8.41	9.31	9.31
New York	2276.20	1194.64	2044.32	1059.98	134.91	80.47	115.33	61.42	5.93	6.74	5.64	5.79
LB	2014.46	1053.77	1730.90	898.79	121.83	65.85	93.56	47.89	4.70	4.83	3.84	3.78
UB	2592.92	1364.19	2437.31	1268.40	141.93	88.37	138.77	74.56	7.05	8.39	8.02	8.30
North Carolina	2164.84	1064.39	2007.29	1009.14	124.19	67.05	107.08	54.00	5.74	6.30	5.33	5.35
LB	1882.31	924.66	1688.22	845.83	112.50	56.80	85.03	42.08	4.52	4.66	3.55	3.52
UB	2490.94	1219.42	2395.77	1195.11	131.49	72.76	129.44	64.58	6.99	7.87	7.67	7.63
North Dakota	1994.87	1020.07	1954.68	1005.54	115.43	53.39	93.52	41.14	5.79	5.23	4.78	4.09
LB	1734.01	884.88	1660.48	847.32	103.70	43.99	76.81	32.52	4.55	3.76	3.31	2.71
UB	2278.58	1169.68	2319.05	1202.19	123.12	59.01	109.72	49.59	7.10	6.67	6.61	5.85
Ohio	2414.10	1262.48	2203.01	1153.36	138.14	77.39	123.98	65.99	5.72	6.13	5.63	5.72
LB	2115.99	1102.49	1868.36	969.46	126.75	65.88	102.05	52.90	4.61	4.59	3.86	3.85
UB	2750.41	1436.32	2640.55	1375.35	144.87	83.62	148.34	77.77	6.85	7.58	7.94	8.02
Oklahoma	2508.11	1313.84	2330.12	1222.14	168.50	98.28	132.74	74.64	6.72	7.48	5.70	6.11
LB	2195.38	1163.54	1975.30	1043.57	155.96	85.37	108.75	60.97	5.44	5.72	3.95	4.23
UB	2868.44	1492.14	2756.39	1441.65	176.55	105.87	157.96	89.25	8.04	9.10	8.00	8.55
Oregon	1693.07	819.42	1672.90	806.19	96.07	44.95	80.92	34.74	5.67	5.49	4.84	4.31
LB	1456.00	706.42	1398.74	676.27	87.41	37.63	65.73	26.70	4.46	3.99	3.26	2.74
UB	1960.15	944.24	2014.05	972.72	101.77	49.56	100.62	43.03	6.99	7.02	7.19	6.36
Pennsylvania	2205.48	1093.76	1997.98	984.77	129.08	69.80	109.97	58.23	5.85	6.38	5.50	5.91
LB	1916.74	947.96	1672.53	827.16	117.11	57.71	89.93	45.52	4.63	4.59	3.79	3.88
UB	2528.46	1258.10	2370.44	1171.78	136.64	76.10	134.01	70.07	7.13	8.03	8.01	8.47
Rhode Island	2120.60	1044.70	1943.89	981.09	124.20	71.11	110.00	56.38	5.86	6.81	5.66	5.75
LB	1829.15	907.83	1636.05	824.12	111.95	59.00	89.10	44.28	4.60	4.92	3.81	3.74
UB	2435.73	1198.41	2340.69	1183.76	133.52	78.74	134.69	68.40	7.30	8.67	8.23	8.30
South Carolina	2129.81	1026.19	2047.79	1006.41	136.03	70.54	115.74	57.58	6.39	6.87	5.65	5.72
LB	1842.15	888.29	1723.55	845.45	125.85	60.72	93.00	47.27	5.14	5.13	3.81	3.89
UB	2449.38	1184.21	2443.77	1214.14	143.20	76.16	139.32	69.12	7.77	8.57	8.08	8.18
South Dakota	1974.49	879.57	1861.05	896.57	121.22	58.09	114.11	46.33	6.14	6.60	6.13	5.17
LB	1710.69	764.31	1560.94	752.44	109.53	48.45	95.42	36.66	4.80	4.73	4.29	3.40
UB	2279.93	1024.18	2225.28	1077.93	130.22	64.51	136.20	53.90	7.61	8.44	8.73	7.16
Tennessee	2450.30	1220.91	2268.63	1141.26	158.81	89.06	146.63	73.61	6.48	7.29	6.46	6.45
LB	2138.78	1068.62	1914.68	960.45	148.53	78.11	118.62	59.44	5.25	5.58	4.41	4.41
UB	2828.85	1400.92	2691.80	1346.74	166.14	95.51	176.97	87.32	7.77	8.94	9.24	9.09
Texas	2267.85	1188.40	2107.37	1094.45	123.30	70.67	115.22	59.64	5.44	5.95	5.47	5.45
LB	1978.92	1049.53	1774.77	933.16	112.97	60.30	95.90	47.60	4.37	4.43	3.85	3.67
UB	2584.63	1360.60	2489.57	1297.36	129.54	76.77	136.95	71.07	6.55	7.31	7.72	7.62
Utah	1711.74	787.63	1622.69	790.84	96.22	56.76	83.66	48.02	5.62	7.21	5.16	6.07
LB	1477.34	684.17	1366.34	665.71	86.79	48.12	67.75	39.15	4.41	5.27	3.49	4.13
UB	1969.78	913.39	1942.79	946.90	101.99	62.51	101.35	55.95	6.90	9.14	7.42	8.40
Vermont	2126.38	1040.96	1930.62	968.34	108.66	53.07	102.76	47.84	5.11	5.10	5.32	4.94

(*Continued*)

Table. Continued

States	Age-standardized prevalence rate of IHD per 100000 inhabitants				Age-standardized mortality rate of IHD per 100000 inhabitants				Mortality-to-prevalence ratio, %			
	2011		2021		2011		2021		2011		2021	
	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
LB	1836.90	910.03	1621.85	819.67	97.97	43.60	84.49	39.18	4.02	3.64	3.64	3.37
UB	2437.64	1196.75	2322.87	1164.10	116.95	58.83	121.34	56.17	6.37	6.46	7.48	6.85
Virginia	2106.66	1049.21	1975.03	992.02	111.78	62.80	96.89	52.42	5.31	5.99	4.91	5.28
LB	1838.05	911.25	1650.69	836.67	102.33	52.92	79.41	41.68	4.24	4.38	3.32	3.51
UB	2415.88	1208.15	2391.94	1186.78	117.82	68.18	117.25	62.96	6.41	7.48	7.10	7.53
Washington	1772.76	845.17	1777.69	861.16	102.32	51.69	86.03	40.48	5.77	6.12	4.84	4.70
LB	1550.23	727.91	1493.98	723.32	92.63	42.67	70.56	30.96	4.54	4.34	3.29	3.01
UB	2038.34	983.19	2145.88	1028.31	108.54	57.14	102.80	49.97	7.00	7.85	6.88	6.91
West Virginia	2551.56	1430.79	2279.71	1255.31	158.68	92.27	139.01	83.38	6.22	6.45	6.10	6.64
LB	2237.57	1252.21	1928.27	1064.69	146.47	80.21	112.29	67.71	5.01	4.94	4.16	4.59
UB	2921.52	1623.59	2699.84	1476.79	167.58	99.34	165.23	99.93	7.49	7.93	8.57	9.39
Wisconsin	1859.33	892.23	1822.23	885.03	116.30	58.65	103.52	49.85	6.26	6.57	5.68	5.63
LB	1610.65	776.49	1529.89	746.28	104.86	48.91	82.63	39.89	4.89	4.73	3.80	3.76
UB	2146.45	1033.50	2172.72	1061.42	122.48	64.35	126.85	59.71	7.60	8.29	8.29	8.00
Wyoming	1889.25	999.43	1816.47	957.35	114.90	55.63	99.41	45.28	6.08	5.57	5.47	4.73
LB	1631.16	867.84	1507.16	799.01	104.72	46.98	84.44	36.74	4.80	4.03	3.83	3.20
UB	2183.35	1166.35	2206.14	1146.76	123.35	60.90	117.99	52.09	7.56	7.02	7.83	6.52
USA Mean	2167.12	1109.54	2019.28	1034.55	123.21	68.30	108.10	55.30	5.69	6.16	5.35	5.35
LB	1898.17	971.65	1708.93	877.06	112.45	57.39	98.47	46.05	4.54	4.52	4.13	3.74
UB	2476.05	1268.38	2385.81	1230.76	128.38	73.77	113.83	59.98	6.76	7.59	6.66	6.84

Data and definitions from the Global Burden of Disease Database, 2021. The Global Burden of Disease 2021 definition describes IHD as *International Classification of Diseases*, *Tenth Revision* (*ICD-10*) classes I20 to I25.9, namely, angina pectoris, acute myocardial infarction, subsequent ST-segment–elevation and non–ST-segment–elevation myocardial infarction, certain current complications following ST-segment elevation and non–ST-segment–elevation myocardial infarction (within the 28-day period), other acute ischemic heart disease, and chronic ischemic heart disease. ASMR indicates age-standardized mortality rate; ASPR, age-standardized prevalence rate; IHD, ischemic heart disease; LB, lower bound; and UB, upper bound.

Death Normalized for the Prevalence of IHD

Between 2011 and 2021, MPRs declined nationwide, from 5.69% to 5.35% in men and from 6.16% to 5.35% in women (Table and Figure 1). However, these averages obscure substantial state-specific differences. In 2021, Arkansas, Mississippi, and Tennessee exceeded the ninth decile threshold (≥6.28% in men, ≥6.45% in women), indicating a disproportionately high IHD mortality rate relative to prevalence. Elevated MPRs were observed only in men in Nevada and only in women in Alabama and West Virginia. However, wide uncertainty intervals add variability to these estimates and warrant further analysis.

Z Score Analysis for Death Normalized for the Prevalence of IHD

Hawaii consistently ranked as the best-performing US state for IHD death, prevalence, and MPR in both sexes, serving as the benchmark for comparison. In 2011, 33 states showed significantly worse MPRs for women ($Z>2.58$; 99% confidence level), while only Mississippi and Oklahoma exceeded this threshold for men (Figure 2, Table S3). By 2021, disparities disappeared for men (Figure 2 and Table S4), with no state exceeding the 95% or 99% threshold. However, disparities among women persisted. Arkansas and Mississippi remained above the 99% threshold, and 21 states, mainly in the South, retained moderate disparities ($Z>1.96$). These states included Alabama, Delaware, District of Columbia, Georgia, Iowa, Kansas, Kentucky, Louisiana, Missouri, Montana, Nevada, New York, New Mexico, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Utah, West Virginia, and Wisconsin.

MPR and Nominal Gross Domestic Product Scores

Pearson correlation analysis demonstrated a strict inverse correlation between the MPR and gross domestic product per capita of women and men ($r=-0.21$; $P=0.03$), as shown in Figure S4.

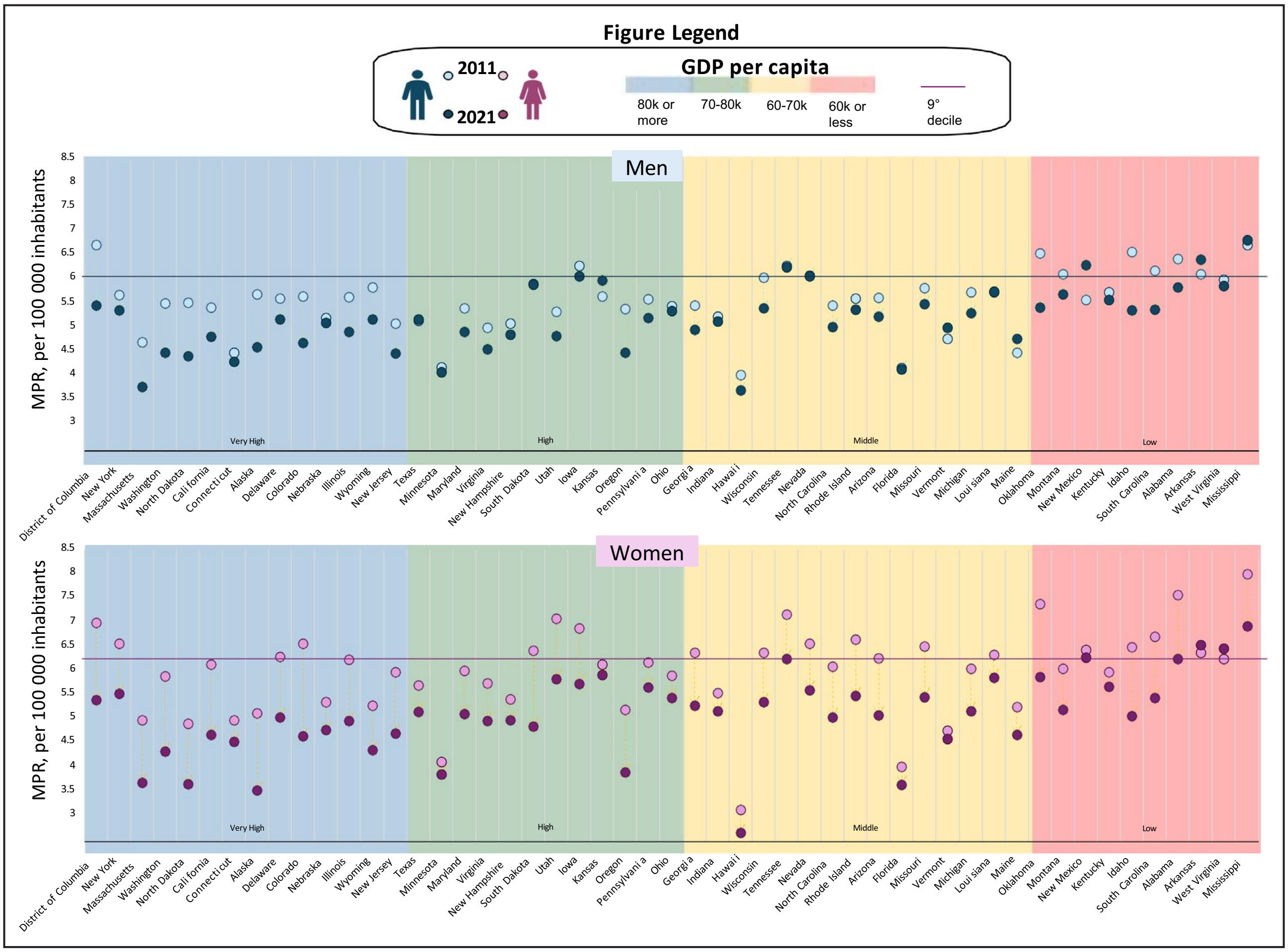

Figure 1. Trends in MPR, stratified by state and sex (2011 vs 2021).
Data from GBD 2021. GBD indicates Global Burden of Disease; GDP, gross domestic product; and MPR, mortality-to-prevalence ratio.

Death Attributable to Metabolic Risk Factors

Figure 3 shows the top 5 US states with the highest female-to-male ratios for IHD death attributable to key metabolic risk factors: high SBP, fasting plasma glucose, LDL-C, and BMI. Complete state-level data are provided in Tables S5 through S8. Although these risk factors consistently imposed a higher mortality burden on men in both 2011 and 2021, sex differences varied by region. In 2021, the smallest gaps were observed in West Virginia for LDL-C (risk ratio [RR], 0.58), SBP (RR, 0.70), and fasting glucose (RR, 0.52), while the District of Columbia exhibited the narrowest BMI gap (RR, 0.57). These patterns highlight geographic disparities, with the greatest burden among women in economically disadvantaged southern states.

Death Attributable to Behavioral and Environmental Risk Factors

Figure 4 displays the top 5 states with the highest female-to-male ratios for IHD death attributable to behavioral and environmental risk factors. Full data are reported in Tables S9 through S11. Tobacco use showed the largest sex disparity, with women consistently having lower attributable IHD death than men; the smallest gap was in West Virginia (RR, 0.39). Air pollution similarly posed less risk for women, with the narrowest gap in West Virginia (RR, 0.60) as well. In contrast, physical inactivity disproportionately affected women, with the highest female-to-male mortality ratios in Arkansas (RR, 1.74).

Death Attributable to Dietary Risk Factors

Between 2011 and 2021, mortality rates attributable to most dietary risk factors declined, suggesting improvements in diet or health care delivery (Tables S12 and S23). Across all dietary risks, women exhibited lower mortality rates than men, with female-to-male RRs typically ranging from 0.3 to 0.6. However, in several states, female-to-male RRs exceeded the 2021 national average, indicating a comparatively higher burden for women. Figure 5 ranks US states by RRs for each dietary risk factor to highlight

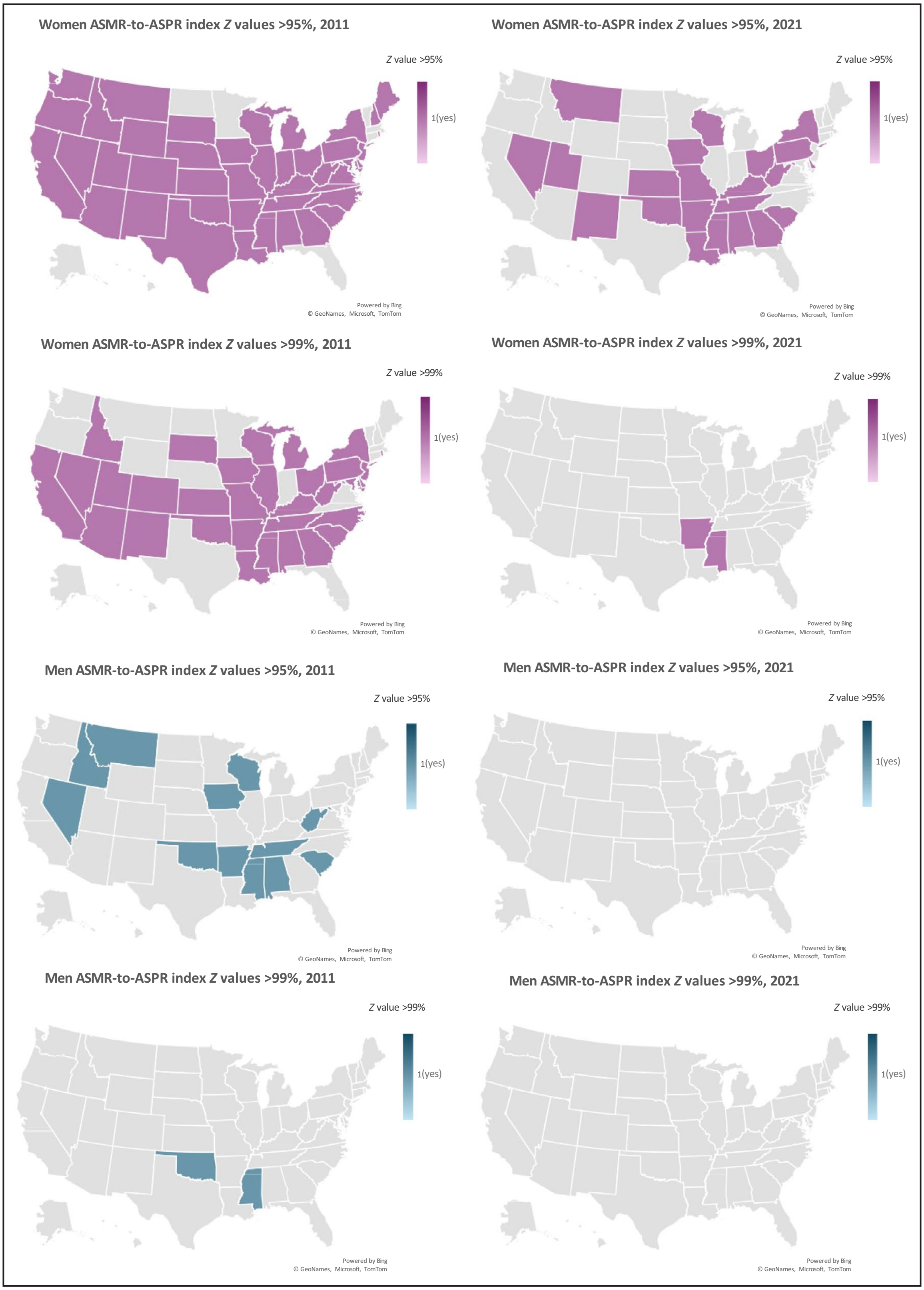

Figure 2. US states exceeding the 95% and 99% *Z* value thresholds for MPR, stratified by sex, in 2011 and 2021.

ASMR indicates age-standardized mortality rate; ASPR, age-standardized prevalence rate; and MPR, mortality-to-prevalence ratio.

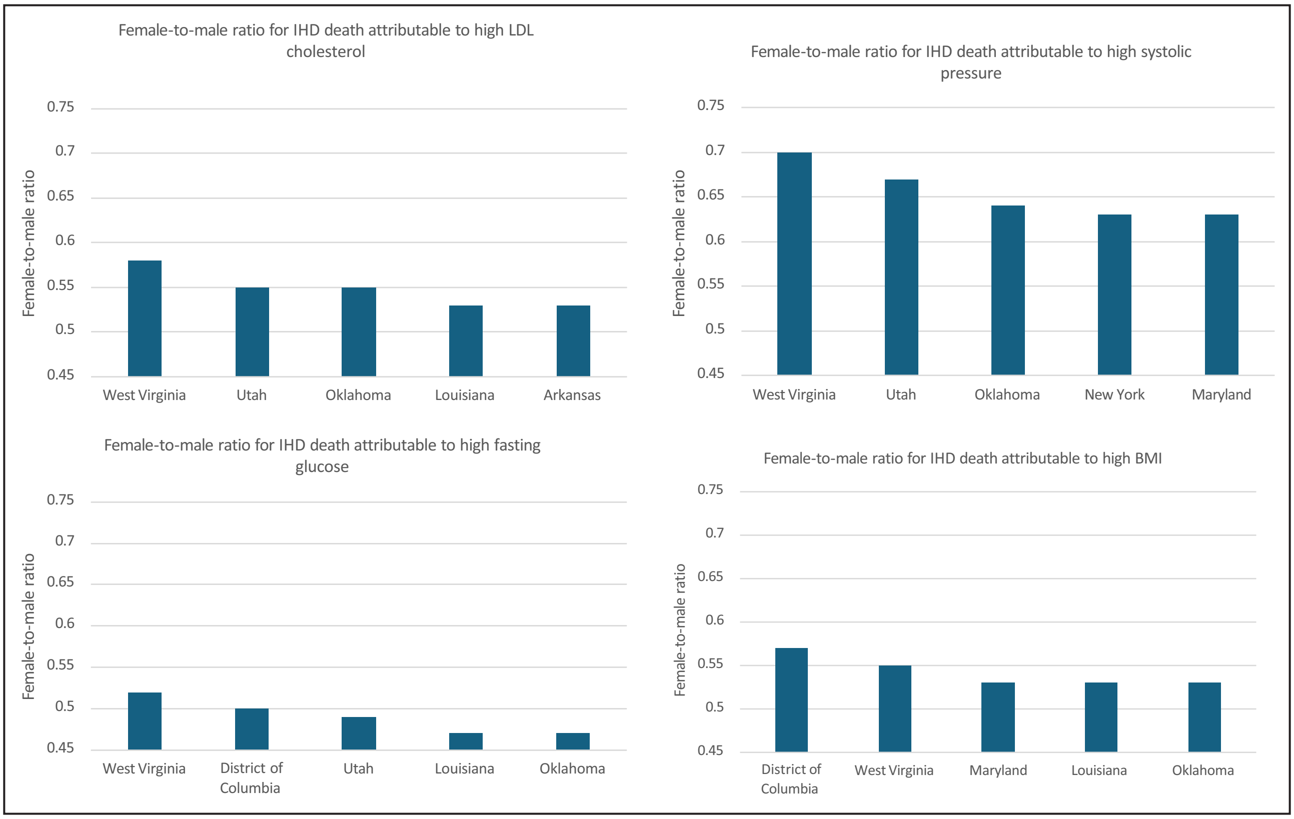

Figure 3. Female-to-male ratio for IHD, attributable to metabolic risk factors, per 100 000 inhabitants.
Data from GBD 2021. BMI indicates body mass index; GBD, Global Burden of Disease; IHD, ischemic heart disease; and LDL, low-density lipoprotein.

high-risk regions for women. West Virginia led in death for women associated with low intake of whole grains, nuts and seeds, legumes, fiber, and omega-6 and polyunsaturated fatty acids, as well as high sodium. Ohio followed, with low fruit intake and high consumption of red meat. Additional high-burden states included Oklahoma (processed meat), District of Columbia (low seafood omega-3 fatty acids), Maryland (diet low in vegetables) and Louisiana (sugar-sweetened beverages).

Z Score Analysis for IHD Risk Factors

Due to wide uncertainty intervals in the estimates of death attributable to risk factors, formal *Z* score testing was used to assess statistically significant sex differences in risk for 2021. Hawaii, consistently ranking lowest in IHD burden, served as the reference state (Tables S24–S37).

Z Score Analysis for Metabolic Risk Factors

In southern states, including Arkansas, Mississippi, Louisiana, Oklahoma, Tennessee, and West Virginia, high SBP, fasting plasma glucose, and LDL-C, were significantly associated with elevated IHD death ($Z>1.96$). These risks affected both sexes similarly and do not fully explain observed sex disparities. In contrast, high BMI showed a disproportionate impact on women, with *Z* scores ranging from 1.96 to 2.18, while corresponding values in men remained below significance (Figure 6A; Tables S24–S31).

Z Score Analysis for Behavioral Risk Factors

Tobacco use remained the leading behavioral risk factor for IHD death nationwide. Extremely high Z scores ($Z>2.58$) for both sexes were observed in southern states such as Alabama, Arkansas, Indiana, Kentucky, Louisiana, Mississippi, Missouri, Oklahoma, Tennessee, and West Virginia (Figure 6B; Tables S32 and S33). In contrast, several other states, including Delaware, District of Columbia, Georgia, Illinois, Iowa, Kansas, Michigan, Nevada, New Mexico, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Texas, and Virginia exceeded this threshold in women only, suggesting a disproportionate burden for women. Physical inactivity, by comparison, showed no significant sex differences, with *Z* scores <1.96 in all states (Tables S34 and S35).

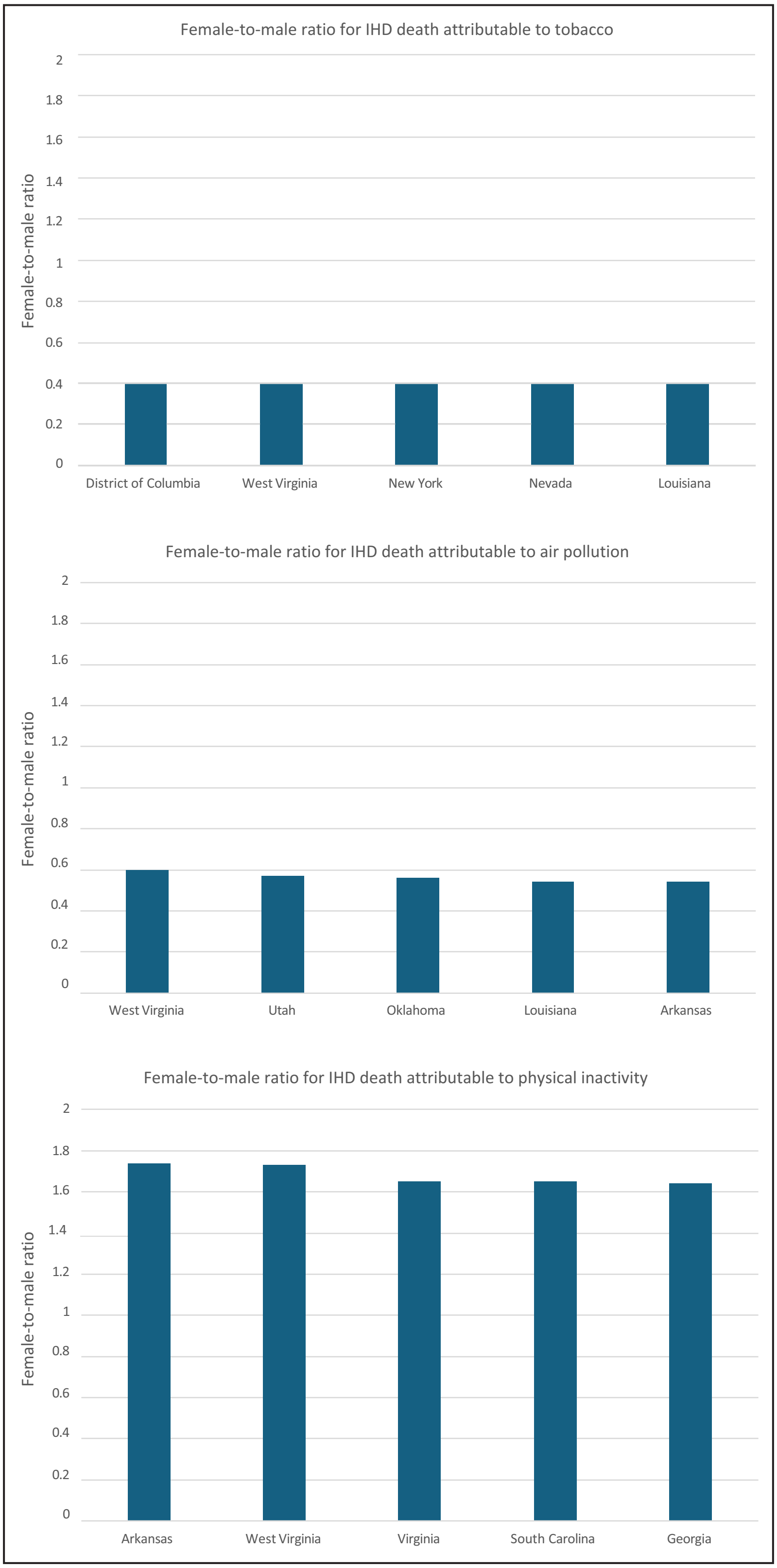

Figure 4. Female-to-male ratio for IHD, attributable to behavioral and environmental risk factors, per 100000 inhabitants.
Data from GBD 2021. GBD indicates Global Burden of Disease; and IHD, ischemic heart disease.

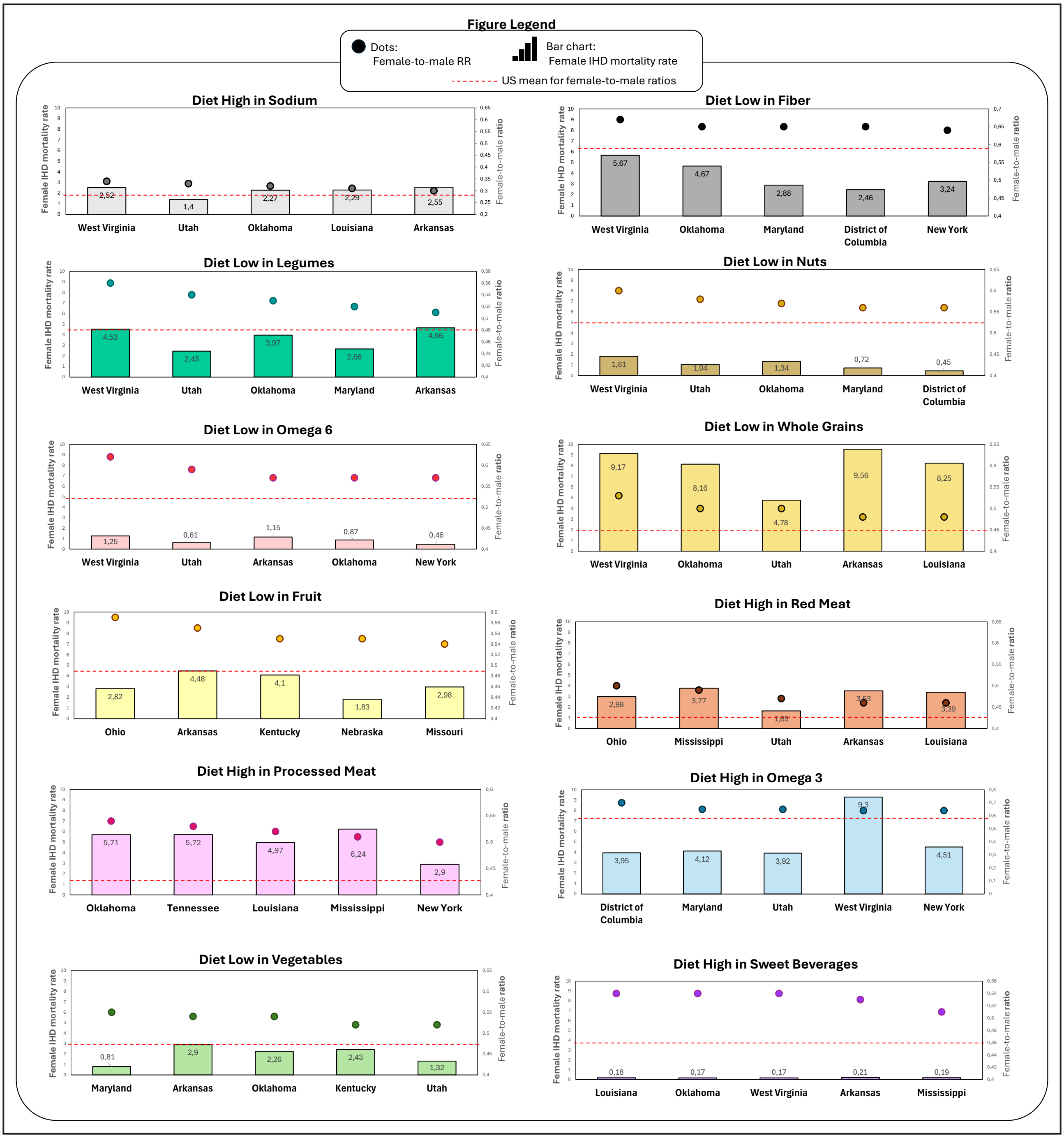

Figure 5. Female-to-male ratios of IHD death attributable to dietary factors (dots), ranked by ratio and corresponding female IHD mortality rates (bars), 2021.
IHD indicates ischemic heart disease; and RR, risk ratio.

Z Score Analysis for Environmental Risk Factors

Figure 6C displays states where both sexes surpassed the 99% confidence threshold (*Z*>2.58) for IHD death attributable to air pollution in 2021. No meaningful sex differences were observed in these high-burden states. Additional states, including Arizona, Connecticut, Kansas, Nebraska, New Jersey, New York, North Carolina, Utah, Virginia, and West Virginia exceeded the 95% confidence threshold (*Z*>1.96) in both sexes, reinforcing that air pollution contributes similarly to IHD mortality risk in men and women (Tables S36 and S37).

Z Score Analysis for Diet-Driven Death

Z score analysis revealed significant geographic and sex-specific disparities in IHD death attributable to dietary factors across US states in 2021 using Hawaii as the reference state (Figure 7; Tables S38–S61). Four key dietary risks were identified with significant *Z* scores (Z>1.96): low intake of whole grains, vegetables, and fiber and high consumption of processed meat. The greatest disparities (Z>1.96, 95% confidence level) were observed in Arkansas and Mississippi, where both sexes had a high disease mortality burden linked to low whole grain intake. Among women, additional risks included low vegetable and fiber intake and high processed meat consumption. Other southern states also showed a clustering of dietary risk-related death among women. Alabama, Tennessee, and West Virginia showed an elevated mortality rate for women associated with high processed meat intake and low consumption of fiber and whole grains. Louisiana, Missouri, Kentucky, and Ohio also had significant female-specific dietary risks from high processed meat and low whole grain consumption. The District of Columbia and Oklahoma demonstrated significant sex-specific differences attributable exclusively to processed meat intake, while Indiana and Michigan stood out for an elevated mortality rate for women associated with low whole grain intake. These clustered dietary risk patterns, particularly in the South, underscore enduring nutritional disparities that disproportionately impact women's IHD outcomes.

Variability in Trends

To address potential year-to-year variability that could affect direct comparisons between 2011 and 2021, we analyzed trends in female-to-male MPRs across 3 intervals: 2011, 2016, and 2021 (Tables S62 and S63). Over this period, only 8 states—Alaska, Florida, Hawaii, Minnesota, Montana, North Dakota, Oregon, and Wyoming—consistently exhibited a female-to-male ratio <1.0, suggesting a persistently lower relative IHD mortality burden for women or a comparatively higher burden for men in these populations.

DISCUSSION

Between 2011 and 2021, ASMRs for IHD declined across US states, with an average reduction of 12% in men and 19% in women. However, the broad uncertainty intervals indicate substantial geographic variation and do not rule out persistent sex-based disparities in IHD outcomes following an IHD event.

Interpretation of the MPR

To better interpret mortality patterns relative to disease burden, we used the MPR, a metric developed within the GBD framework to assess the quality of care for noncommunicable diseases, including IHD.[11] The MPR contextualizes death by evaluating whether the number of deaths is proportionate to the number of individuals living with the disease. This approach is relevant for sex-based comparisons, as IHD prevalence is typically higher in men. Similarly, geographic disparities in IHD death may be driven in part by differences in disease prevalence, which can obscure deeper inequities in health care access, quality of disease management, and clinical severity of the disease. By jointly considering both death and prevalence, the MPR provides a more meaningful measure of outcome disparities and health care system performance across populations.

Main Findings

Two key findings emerged from our analysis. First, sex disparities in IHD outcomes have narrowed since 2011 but remain significant in several US states. In 2011, 33 states exhibited highly significant differences between women and men in MPRs (Z>2.58, 99% confidence level). By 2021, this gap had dropped sharply: Only 2 southern states, Arkansas and Mississippi, still exhibited highly significant sex disparities, while 11 other states, mostly in the South, continued to show moderate but statistically significant differences (Z>1.96, 95% confidence level), again unfavorable to women.

Second, we identified metabolic and dietary risk factors as primary contributors to persistent excess death in women. High BMI and poor diet, particularly high intake of processed meat and low consumption of fiber and vegetables, were the most influential risk factors for women in states where disparities were greatest. These patterns were most evident in Arkansas and Mississippi but extended across other southern states as well as parts of the Midwest and Mountain West.

Persisting High IHD Mortality Rate Among Women in the Southern United States

The 2010 landmark Institute of Medicine report, "Women's Health Research—Progress, Pitfalls and Promise," highlighted that despite overall declines in cardiovascular death, significant disparities persisted among subgroups of women, particularly those facing socioeconomic disadvantage.[12] Our findings reinforce this concern more than a decade later, showing that in 2021, women in many US states, especially in the South, continue to experience a disproportionately high mortality rate following a diagnosis of IHD. Disparities were most pronounced in states designated by the US Census Bureau as southern, such as Alabama, Arkansas, Georgia, Mississippi, South Carolina, and Tennessee, as well as Midwestern states, such as Ohio, Missouri, Iowa, and Wisconsin. These persistent gaps are not simply statistical fluctuations but reflect

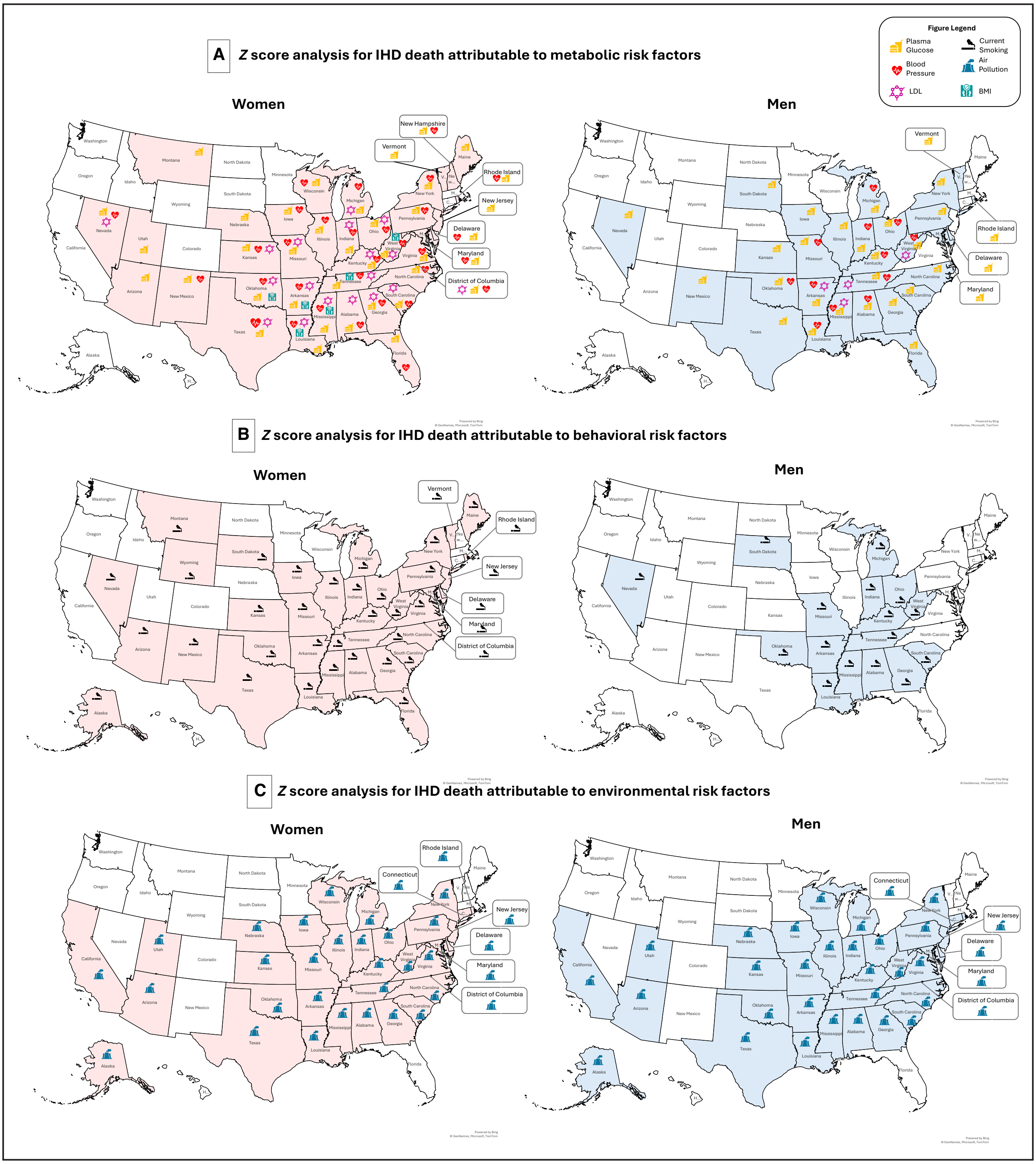

Figure 6. *Z* scores for IHD attributable to metabolic (A), behavioral (B), and environmental (C) risk factors, by state and sex (2021).

States exceeding the 95% *Z* score threshold are highlighted. IHD indicates ischemic heart disease.

a combination of structural and individual-level determinants. Our analysis showed that MPRs in both sexes were strongly correlated with state income levels, suggesting that regions with lower economic resources tend to exhibit greater sex-based inequities in cardiovascular outcomes. In these settings, women may face heightened vulnerability not only due to systemic barriers, such as limited access to health care or preventive services, but also because of greater biological susceptibility to key IHD risk factors.[13–15] As a result,

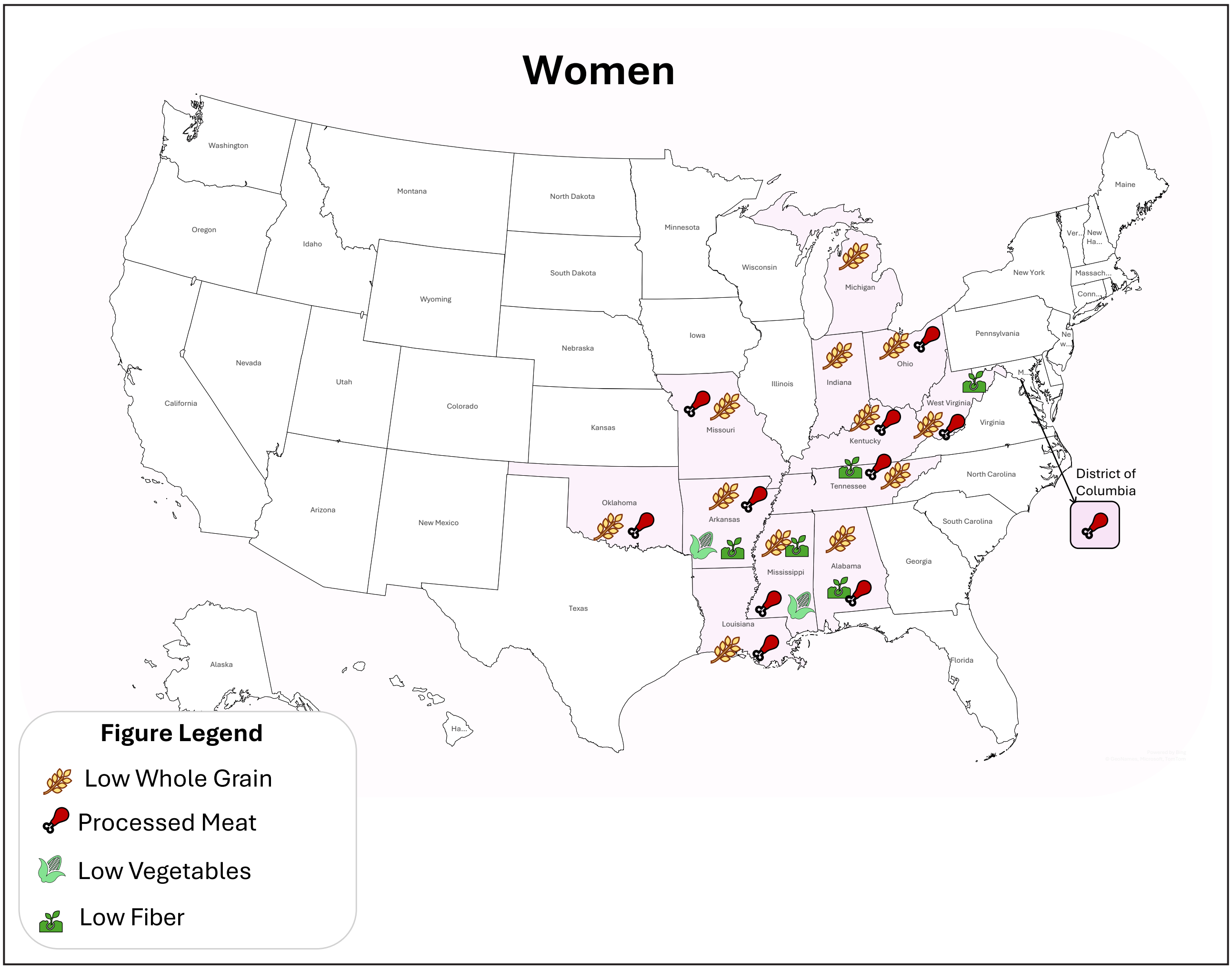

Figure 7. ***Z* scores for IHD attributable to dietary risk factors, by state, for women, 2021.**
States exceeding the 95% *Z* score threshold are highlighted. IHD indicates ischemic heart disease.

even when risk exposures are similar to those of men, the health consequences for women may be more severe, compounding the impact of structural inequities.

Metabolic Risk Factors: Shared Burden, Unequal Impact

A persisting high IHD mortality rate in women across the South largely reflects the widespread epidemic of metabolic risk factors in these regions. Death attributable to high LDL-C, elevated fasting plasma glucose, and high SBP was significantly higher in states such as Arkansas, Mississippi, Louisiana, Oklahoma, Tennessee, and West Virginia ($Z>2.58$), compared with Hawaii, the state with the lowest cardiovascular mortality rate and our benchmark for optimal outcomes. However, these metabolic risk factors contributed similarly to death in both sexes, suggesting that they do not fully explain the persistent sex disparities observed in IHD outcomes.

In contrast, high BMI emerged as a consistent and disproportionately female-specific driver of excess IHD death. Significant associations ($Z>1.96$) were observed for women but not for men, particularly in the southern states. These findings echo earlier studies, including data from the Framingham Heart Study, showing that obesity increases the risk of coronary artery disease more in women (64%) than in men (46%). Additionally, sex differences in fat distribution, such as higher visceral adiposity in women, may further exacerbate risk.[16]

This biological vulnerability may be further intensified by structural inequities. The 2019 Lancet Commission on Obesity emphasized that excess body weight often reflects broader forces, including poverty, food insecurity, limited access to healthy foods, and educational disadvantage.[17] These conditions are prevalent in the South, contributing to enhancement of the adverse impact of obesity on women's cardiovascular health.

Dietary Patterns and Regional Inequities

The quality of diet plays a crucial role in shaping the occurrence of overweight/obesity and cardiovascular outcomes. Sex-stratified analyses showed that in states like Arkansas and Mississippi, poor diet, characterized by low intake of vegetables and fiber and high consumption of processed meat, was particularly harmful to women. These findings align with broader epidemiologic research describing the so-called "Southern dietary pattern," which is characterized by high intake of fried foods and processed meats. This pattern has been associated with increased cardiovascular morbidity and death in previous large cohort studies, including the REGARDS (Reasons for Geographic and Racial Differences in Stroke) study and others.[18,19] Long-standing dietary habits make the southern United States an epicenter of diet-related risk, with women disproportionately affected.

Sex-Specific Interactions Between Diet, Behavior, and Cardiovascular Risk

While poor diet is a critical contributor to IHD risk, its impact is amplified in women by intersecting behavioral and environmental vulnerabilities. Beyond economic constraints, psychosocial stressors, such as chronic stress, depression, and caregiving responsibilities, are more prevalent among women and contribute to emotional eating and reduced time or energy for preparing nutritious meals. These behavioral pressures exacerbate dietary risks and deepen existing health inequities. Physical inactivity is another key contributor. Prior studies have shown a consistently higher mortality burden from physical inactivity in women compared with men.[20] Our analysis supports this pattern: Southern states such as Arkansas, Mississippi, Tennessee, and West Virginia had the highest IHD mortality rates attributable to physical inactivity among women, each exceeding 2.74 attributable deaths per 100 000 inhabitants. These states also exhibited the largest sex gaps in inactivity-related IHD death. The convergence of poor diet, low physical activity, and psychosocial stress creates a compounding risk profile that increases IHD vulnerability among women in underserved regions. This is supported by a recent National Health and Nutrition Examination Survey analysis of 22 761 US adults, which found that women scored lower than men on behavioral metrics of the American Heart Association's "Life's Essential 8," despite outperforming men on health factors.[21] These findings highlight the need for integrated, multidimensional prevention strategies tailored to women's risk profiles.

Tobacco Use and Synergistic Risk in Women

Tobacco use, another key behavioral risk factor, further compounds this vulnerability. Although sex disparities in tobacco-attributable IHD death were not consistently observed across southern states, the absolute burden among women was the highest in the United States with age-standardized mortality rates exceeding 12 per 100 000 inhabitants in Arkansas, Mississippi, Tennessee, and West Virginia. These high rates suggest a synergistic effect, where tobacco use interacts with other prevalent risks, such as poor diet and high BMI, to amplify women's vulnerability to IHD. Even in the absence of large sex gaps, the clustering of multiple modifiable risk factors may disproportionately impact female populations in these high-risk regions.

Addressing the Challenge of Healthy Diet in the Southern United States

The American Heart Association recommends a diet rich in vegetables, fruits, whole grains, lean proteins, and healthy oils, while limiting saturated fats, sodium, added sugars, and processed meats.[22] However, adherence to these guidelines remains low in the southern United States not merely due to personal choice but because of long-standing structural barriers. Nearly half of all rural Americans live in the South, where health resources are often sparse and dietary risk is compounded by socioeconomic disadvantage. Effective interventions must go beyond education and include systemic changes, such as subsidies for healthy food, taxes on processed meats, and local initiatives like the Arkansas High Obesity Program and the Mississippi Obesity Alliance. Urban and regional planning and regulatory efforts, such as promoting walkable neighborhoods and limiting unhealthy food marketing near schools, are also essential.

Limitations

As with any study of this scope, there are several important limitations to consider. First, the GBD study lacked individual-level data on reporting practices, which may influence the accuracy of cause-of-death determinations. Second, accuracy of cause-of-death estimates can be impacted by errors or biases in data collection. Third, in locations for which GBD has limited data, estimates are interpolated from neighboring regional patterns by relying on predictive covariates. Fourth, the bounding method used for estimating uncertainty in sex ratios is conservative and assumes independence between estimates. Furthermore, deaths attributed to specific dietary risk factors may not be mutually exclusive, potentially leading to overestimation of diet-related disease burden. Fifth, our analysis did not include all known modifiable or nonmodifiable risk factors for IHD, such as medication adherence, access to care, or genetic predisposition, due to the constraints of the GBD comparative risk assessment framework. We acknowledge that including a broader array of factors, or alternatively modeling trends in IHD death in relation to changes in risk exposures over time via regression analysis, could offer complementary insights for prevention and treatment strategies. Our focus, however, was on characterizing the most current sex- and location-specific burden of death attributable to a standardized set of modifiable risk factors using 2021 data. Sixth, our analysis does not account for race, ethnicity, or intersectionality, all of which play a significant role in health disparities. People of color, particularly women, are more likely to experience unequal social conditions that contribute to poorer health outcomes. These effects are likely compounded by differences in rurality and geographic isolation, which may further limit health care access or healthy food availability. The omission of these variables reflects data limitations, and thus, we caution that sex differences reported here represent only 1 dimension of a multifactorial disparity landscape, which also includes sociocultural, racial, and structural determinants. Finally, we were unable to distinguish between different clinical subtypes of IHD, such as ST-segment–elevation myocardial infarction, non–ST-segment–elevation myocardial infarction, and unstable or stable angina. This limitation is important, as sex disparities in outcomes are more pronounced in ST-segment–elevation myocardial infarction, with women experiencing worse outcomes compared with men, whereas differences in other IHD presentations may be less significant.[1,2]

CONCLUSIONS

In summary, sex disparities in IHD death remain deeply entrenched across the United States, with striking regional inequalities. Despite overall declines in IHD death among women from 2011 to 2021, the southern states, particularly Mississippi and Arkansas, continue to experience the highest burden. These patterns suggest structural inequities in the distribution of sex- and region-specific risk factors, although our ecological design precludes casual attribution.

Our analysis identifies strong associations between poor diet, overweight, and a higher IHD mortality rate in women. While glucagon-like peptide-1 agonists may offer pharmacological benefits for obesity-related risks, broader prevention strategies, such as policies targeting dietary quality and metabolic health, could help mitigate disparities. Prioritizing public health interventions in high-burden southern states may reduce sex-based gaps and improve cardiovascular outcomes nationally.

ARTICLE INFORMATION

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Supplemental Material

Data S1. Supplemental Material
Tables S1–S64
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