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Ischemic heart disease attributable to dietary risk factors in the North Africa and Middle East (NAME) region: An analysis of data from the global burden of disease study 1990-2019

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Abstract

BACKGROUND: Diet is an important risk factor for ischemic heart disease (IHD), but its effects on IHD and trends in the North Africa and Middle East (NAME) region are unknown. We aimed to evaluate the burden of different dietary risk factors on mortality and disability-adjusted life-years (DALYs) attributable to IHD in the NAME region from 1990 to 2019.

METHODS: The data and estimations were extracted from the Global Burden of Disease (GBD) 2019 Global Health Data Exchange. The proportion of IHD burden due to dietary risks was estimated through a comparative risk assessment approach. We calculated the mortality and DALYs rate attributable to diet for IHD using disease-specific population attributable fractions.

RESULTS: The age-standardized rate of IHD mortality and DALYs attributed to dietary risk in the NAME region were 102.1 (95% uncertainty interval (UI): 81.0–121.1) and 2060.6 (95% UI: 1630.7–2471.2), respectively. These rates were higher than the global estimates for mortality (62.4 [95% UI: 51.0–73.6]) and DALYs (1271.3 [95% UI: 1061.3–1473.8]) and were greater in men than in women. Suboptimal diet contributed to 46.6% of IHD mortality and 49.5% of related DALYs. Low whole-grain intake was the leading dietary risk across all countries and years, responsible for 44.5 [95% UI: 18.6–57.1] IHD mortalities and 912.8 [95% UI: 369.7–1177.8] DALYs per 100,000.

CONCLUSION: Despite a decline in the burden of IHD attributable to diet in the NAME region, it remains substantially high. There exists considerable potential for enhancing dietary quality, particularly through the increased incorporation of whole grains.

Keywords: Myocardial Ischemia; Mortality; Disability-Adjusted Life-Years; Diet, Dietary Risk Factor

Introduction

Ischemic heart disease (IHD) is the principal cause of death and disability in the world[1]. Despite a decline in the age-standardized rates of IHD prevalence, the projection is for global IHD prevalence to reach over 1,845 per 100,000 subjects by 2030 from 1,655 per 100,000 subjects in 2017[1,2]. According to the Global Burden of Diseases (GBD) results tool, the NAME region had the world's second-highest rate of deaths and disability-adjusted life years (DALY) due to IHD among the seven GBD super regions mentioned in 2019[3]. This study also indicated that among the 12 modifiable risk factors for cardiovascular disease (CVD), dietary risk factors scored second after high systolic blood pressure in both 1990 and 2019. This highlights the major role of dietary factors in contributing to the overall burden of CVD[3].

The association between dietary factors and CVD has been widely investigated. Although the long-term relationship between dietary factors and CVD cannot be explored by randomized controlled trials, prospective cohort studies can be beneficial to reveal a causal association[4–7]. However, due to inevitable measurement errors in dietary intake assessment tools in nutritional epidemiologic studies, determining diet–disease association at the population level would be difficult and therefore may limit their utilization in guiding policy[8]. Since GBD is based on a large sample size, it potentially can mitigate errors and reflect the mean intakes of populations with more accuracy. In addition, a good measure for assessing data quality of all estimations is reflected in the width of the uncertainty interval, which covers all sources of bias such as inconsistencies in time trend, age trend, and different data sources (if available). Therefore, GBD may provide an insightful overview in this context. Building on these methodological strengths, recent iterations of the GBD study have focused on quantifying the impact of specific risk factors such as dietary habits on non-communicable diseases.

In 2019, the GBD, Injuries, and Risk Factors Study diet collaborators tried to explore the burden of non-communicable diseases (NCDs) attributable to suboptimal diet[9]. They, similar to an earlier study[10], provided comprehensive evidence emphasizing the need for improving dietary habits worldwide. The burdens of NCDs due to dietary factors were evaluated in different geographical regions in their study and illustrated that the main three dietary risks in the NAME area were, in order, low whole grains, low nuts and seeds, and low fruit consumption. In addition, this study indicated that higher intake of whole grains, nuts, fruits, and vegetables was associated with a 15% to around 30% decrease in CVD mortality risk[11]. Moreover, two recent analyses using GBD data suggested that dietary interventional priorities to reduce CVD burden are reducing sodium intake and increasing whole grains and legumes intake[12,13].

It is noteworthy that the NAME region experienced a nutrition transition characterized by a shift away from traditional, seasonal, and more diverse diets rich in whole grains, fruits, and vegetables towards a Westernized diet rich in refined cereals, animal proteins, fats, and sugars over the last decades[14]. Therefore, exploring the share of various dietary risk factors in IHD burden would be of great interest. However, earlier studies left several questions unanswered in this region. First, they did not address the disease-specific (e.g., IHD) burdens attributable to different dietary risks. Second, the burden of IHD due to dietary risk was not assessed in countries located in this region and their income, while it might be a fundamental determinant. Third, incident IHD cases related to dietary factors were not determined.

Therefore, in the present study, we aimed to evaluate the association of 14 different dietary risk factors with mortality and DALY attributable to IHD using GBD data, which is a representative dietary database collected from 21 countries at the national level in the NAME region from 1990 to 2019. We also further explored the results separately for the countries and their income levels.

Table 1. The ischemic heart disease death age-standardized rates per 100,000 population (95% uncertainty interval) attributed to dietary risks in the NAME region and global in 1990 and 2019.

Risk	NAME			Global		
	1990	2019	Percentage Change, 1990-2019	1990	2019	Percentage Change, 1990-2019
Dietary risk	159.6 (128.4,184.6)	102.1 (81.0,121.1)	-36.0%	95.7 (79.7,109.9)	62.4 (51.0,73.6)	-34.7%
high processed meat	2.1 (0.8,5.1)	1.7 (0.5,4.3)	-21.4%	5.1 (0.9,9.6)	2.5 (0.6,4.9)	-49.7%
high sugar-sweetened beverages	5.9 (4.2,7.4)	4.2 (2.7,5.5)	-29.6%	3.9 (2.7,4.8)	2.5 (1.7,3.2)	-35.2%
high sodium	5.5 (1.0,22.3)	3.9 (0.7,15.5)	-29.4%	13.5 (3.6,31.6)	9.8 (2.3,22.6)	-27.6%
low fiber	6.9 (2.7,12.1)	4.2 (1.7,7.3)	-39.0%	8.7 (3.8,13.7)	4.5 (1.9,7.3)	-48.5%
low vegetables	10.1 (5.4,14.5)	5.1 (2.7,7.5)	-49.1%	8.1 (4.3,11.5)	4.5 (2.5,6.5)	-43.9%
low fruits	9.9 (3.4,15.9)	4.9 (1.8,8.1)	-50.0%	8.8 (3.7,12.9)	5.5 (2.3,8.4)	-36.9%
high red meat	8.3 (0.7,16.3)	5.7 (0.5,11.4)	-30.5%	7.1 (1.1,12.9)	4.5 (0.7,8.3)	-36.5%
low polyunsaturated fatty acids	12.4 (1.5,25.5)	7.5 (0.9,15.6)	-40.0%	6.3 (0.9,12.9)	4.4 (0.6,9.0)	-30.9%
low seafood omega-3 fatty acids	11.7 (4.4,15.9)	8.2 (3.8,10.9)	-30.2%	6.3 (3.1,8.0)	4.3 (2.1,5.6)	-31.1%
low nuts and seeds	22.1 (11.3,30.3)	11.7 (5.6,17.0)	-47.0%	12.1 (6.5,16.2)	7.0 (3.6,9.7)	-42.2%
high trans fatty acids	25.6 (3.8,35.2)	17.2 (1.6,23.8)	-33.1%	13.5 (1.5,17.9)	8.2 (1.0,11.3)	-38.8%
low legumes	36.9 (7.2,61.0)	17.8 (3.4,29.8)	-51.9%	23.4 (6.1,37.5)	14.3 (3.3,23.1)	-38.9%
low whole grains	65.0 (26.9,81.3)	44.5 (18.6,57.1)	-31.5%	28.0 (10.5,36.4)	18.6 (7.0,24.4)	-33.5%

NAME=North Africa and Middle East.

Methods

Overview

The GBD 2019 provides the most comprehensive source of burden of disease estimates for 204 countries and territories during the period of 1990-2019. It is coordinated by the Institute for Health Metrics and Evaluation (IHME). The GBD estimates health summary and epidemiological measures, which are available by sex and age. Details of GBD 2019 have been reported elsewhere[1]. The GBD groups divided countries into seven super-regions; one of the regions is the North Africa and Middle East (NAME) region. This region includes 21 countries: Iran (Islamic Republic of), Iraq, Afghanistan, Algeria, Bahrain, Egypt, Kuwait, Lebanon, Jordan, Libya, Oman, Morocco, Palestine, Qatar, Saudi Arabia, Sudan, Tunisia, Turkey, Syrian Arab Republic, United Arab Emirates (UAE), and Yemen.

This study was a systematic analysis of changes in dietary risk factors of IHD for GBD 2019 in the NAME region between 1990 and 2019 among adults aged ≥25 years. We included the 13 dietary risk factors data in the GBD 2019 due to their public availability on the Global Health Data Exchange website[15–18] (Table 1) and their sources in the supplementary table, their importance in the IHD burden, and relationship with IHD risk in 21 NAME region countries including Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, the Syrian Arab Republic, Tunisia, Turkey, the United Arab Emirates, and Yemen, and compared them with the global level.

Assessment of dietary risk factors

The dietary consumption data for GBD 2019 was obtained from various sources, including national and subnational nutrition surveys, household budget surveys available on the Global Health Data Exchange website, food balance sheets published by the United Nations Food and Agriculture Organization, and the Global Nutrient Database[9,19]. The precision of various nutrition data was different based on its source. The Global Health Data Exchange website considered the 24 h dietary recall for assessment of population mean intake and the 24 h urine collection for estimation of sodium intake. The sales data on hydrogenated vegetable oil was the source of trans fatty acid data. However, availability, sales, and household data were only available for the whole global population. To estimate age- and sex-specific dietary intake, the GBD utilized global age and sex patterns of intake.

All reported estimations in the current study were extracted from GBD 2019 data by the Institute for Health Metrics and Evaluation (IHME), which is publicly available via the Global Health Data Exchange website: http://ghdx.healthdata.org/gbd-results-tool.

Effect size of dietary risks

The extracted data from meta-analyses of prospective cohort studies were used to predict the relative risk of IHD mortality and consequently the effect size of dietary risks in GBD 2019[9]. The deficiency and excess of each dietary factor were calculated by comparing the usual intake with the midpoint of its optimal intake. The term "usual intake" refers to the country-specific level. The source of the "optimal intake" was the global guideline from WHO/FAO[9]. The details related to the effect size of dietary risks and optimal level of intake are presented in a previously published paper[9]. Thus, the effect size of dietary risks defined in previous studies, including low whole grains, fiber, vegetables, fruits, polyunsaturated fatty acids, nuts and seeds, seafood omega-3 fatty acids, and legumes, as well as high processed meat, sodium, red meat, sugar-sweetened beverages, and trans fatty acids, were predicted.

Ischemic heart disease mortality and disability-adjusted life-years

IHD in the Global Health Data Exchange (GHDx) registry has been characterized based on International Classification of Diseases (ICD)-10, including codes I20–I25.9 and I50[20]. It consists of angina pectoris (I20), acute myocardial infarction (AMI) (I21), subsequent ST elevation MI (STEMI) and non-ST elevation MI (NSTEMI) (I22), certain current complications following STEMI and NSTEMI within the 28-day period (I23), other acute ischemic heart diseases (I24), chronic ischemic heart disease (I25), and heart failure (I50), according to the medical classification suggested by the WHO. We obtained the data on IHD mortality and disability-adjusted life-years (DALYs) rate by age, sex, country, and year from GBD 2019.

The countries development status

The socio-demographic index (SDI) is a composite indicator of development status, including the geometric mean of 0 to 1 indices of total fertility rate under the age of 25, mean education for those aged 15 and older, and lag-distributed income per capita. SDI strongly correlates with health outcomes[21]. In this study, we used the 2019 SDI to classify countries along a development continuum. Based on SDI quintiles, NAME countries are categorized into five groups: Afghanistan and Yemen in the low SDI group; Morocco, Palestine, and Sudan in the low-middle SDI group; Algeria, Egypt, Iran, Iraq, Syrian Arab Republic, and Tunisia in the middle SDI group; Bahrain, Jordan, Lebanon, Libya, Oman, Saudi Arabia, and Turkey in the high-middle SDI group; and Kuwait, Qatar, and United Arab Emirates in the high SDI group[21].

The age-standardized rates of IHD mortality and DALYs attributed to dietary risk by 118 countries, sex, and year were obtained from GBD 2019 by the GBD results tool. Healthcare Access and Quality (HAQ), the index developed by GBD researchers, was also used in this study[22]. This index used risk-standardized death rates and mortality-to-incidence ratios. By excluding the drivers not connected to health systems, HAQ is a comparable index across locations[22].

We conformed to Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) recommendations to ensure the transparency and reproducibility of results. Ethics approval and consent to participate were not applicable to this study.

Statistical analysis

The age-standardized rates with their 95% uncertainty interval (UI) of IHD mortality and DALYs attributed to dietary risk by country, sex, and year were obtained from GBD 2019 by the GBD results tool[19,23,24]. Mortality data were derived from vital registration systems or autopsy surveys (household mortality surveys). Estimates were produced by the DisMod-MR (Disease Modelling Meta-Regression) software to ensure internal consistency between incidence, prevalence, mortality, and remission. For countries lacking complete data, Bayesian modeling was applied, using higher-level regional estimates as priors. Location-level covariates were incorporated to improve model accuracy and realism. Cause of Death Ensemble modeling (CODEm) was used to estimate smoothed rates across time and age by integrating multiple covariates and data sources. This process is summarized here; further discussions of these methods are available elsewhere [Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019].

IHD mortality attributable to dietary risk was estimated by multiplying overall IHD mortality by the population attributable fraction (PAF) for each diet–IHD pair[17,25]. PAFs were calculated based on the exposure level of each dietary factor, relative risk derived from meta-analyses, and the optimal level of intake recommended by global guidelines. Risk factor exposures were estimated by using population-representative surveys, surveillance data, and spatiotemporal Gaussian process regression (ST-GPR). DALYs were computed as the sum of years of life lost (YLLs) based on a reference life expectancy, and years lived with disability (YLDs) calculated using standardized disability weights for each cause.

To quantify uncertainty, 95% UIs were presented for all estimates. Monte Carlo simulations were used to generate UIs. The estimation process was repeated 1,000 times, drawing from the posterior distribution. The 2.5th and 97.5th percentiles of these simulations were reported as the 95% UI[26]. All presented rates in this article are age-standardized and per 100,000 population; rates were presented as estimate (95% UI). The detailed description of the GBD approach to estimating cause-specific mortality and DALYs was published previously[24]. All figures of this study were plotted using R software, version 4.2.1[27].

Results

Overall impact of diet on the burden of IHD

The age-standardized rate of IHD mortality attributed to dietary risk in 2019 [estimate (95% UI)] was 102.1 (81.0,121.1) in the NAME region and higher than the global rate [62.4 (51.0,73.6)] in 2019 (Figure 1 and Supplementary Table 1). In addition, dietary risk was responsible for a higher rate of IHD mortality in men than in women in both NAME [115.5 (91.7,136.9) vs. 87.9 (69.3,105.3)] and globally [78.7 (64.1,92.1) vs. 48.3 (39.0,57.9)] in 2019 (Figure 1, Supplementary Table 1). From 1990 to 2019, the IHD mortality rate attributed to dietary risk was reduced by 36.0% in the NAME region and 34.7% globally (Table 1). The dietary risk was responsible for 2060.6 (1630.7,2471.2) of the IHD DALYs rate in the NAME region and for 1271.3 (1061.3,1473.8) globally in 2019 (Figure 1 and Supplementary Table 2).

This measure was higher in men than in women in both NAME [2460.7 (1945.1,2961.3) vs. 1633.8 (1272.8,1961.7)] and globally [1688.0 (1396.9,1962.7) vs. 883.4 (725.8,1045.3)] (Figure 1, Supplementary Table 2). The trend of DALYs rate of IHD attributed to dietary risk constantly declined by 39.8% in the NAME region and 32.3% globally during 1990–2019

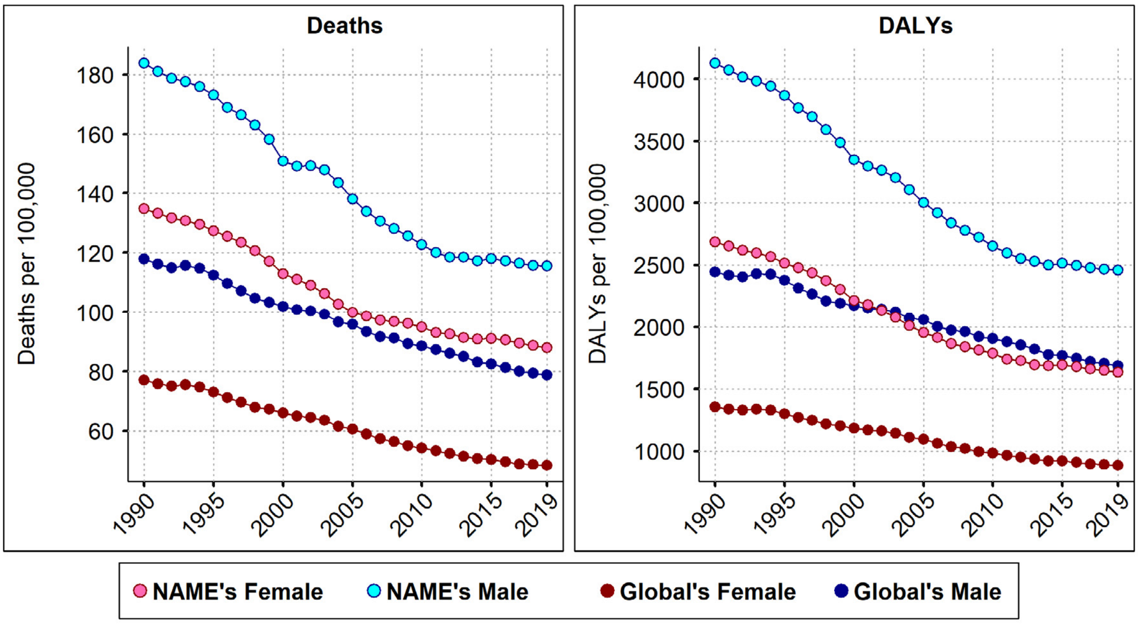

Figure 1. The ischemic heart disease death and disability-adjusted life years rates attributed to dietary risks, by sex in the NAME region and global from 1990 to 2019.
DALYs=Disability-Adjusted Life Years, NAME=North Africa and Middle East.

Table 2. The ischemic heart disease disability-adjusted life years age-standardized rates per 100,000 population (95% uncertainty interval) attributed to dietary risks in the NAME region and global in 1990 and 2019.

Risk	NAME			Global		
	1990	2019	Percentage Change, 1990-2019	1990	2019	Percentage Change, 1990-2019
Dietary risk	3422.4 (2797.8,3939.6)	2060.6 (1630.7,2471.2)	-39.8%	1876.7 (1583.3,2127.1)	1271.3 (1061.3,1473.8)	-32.3%
high processed meat	48.7 (15.0,123.1)	36.8 (9.4,100.7)	-24.4%	97.3 (17.2,180.3)	50.8 (12.2,98.3)	-47.8%
high sugar-sweetened beverages	121.7 (83.3,155.4)	83.6 (50.7,115.0)	-31.3%	73.1 (50.5,91.3)	48.9 (30.5,64.1)	-33.1%
high sodium	126.3 (19.4,510.6)	85.7 (12.8,336.2)	-32.2%	285.0 (84.3,615.0)	210.4 (56.5,449.3)	-26.2%
low fiber	151.8 (57.1,268.4)	90.3 (36.5,156.3)	-40.5%	176.8 (76.4,278.3)	97.4 (41.4,158.9)	-44.9%
low vegetables	222.6 (119.7,323.1)	109.5 (58.9,156.6)	-50.8%	171.1 (94.8,241.9)	102.1 (56.8,145.7)	-40.4%
low fruits	228.7 (80.1,362.1)	111.7 (40.3,183.9)	-51.2%	190.7 (81.7,279.8)	124.6 (51.6,184.5)	-34.6%
high red meat	196.8 (14.0,390.1)	128.3 (9.2,259.3)	-34.8%	143.9 (24.6,259.9)	94.6 (16.3,172.3)	-34.2%
low polyunsaturated fatty acids	279.5 (32.3,577.3)	161.0 (18.7,335.5)	-42.4%	138.5 (18.8,281.5)	97.6 (11.9,198.0)	-29.6%
low seafood omega-3 fatty acids	259.2 (92.0,350.7)	167.1 (76.5,224.2)	-35.5%	127.2 (58.0,164.5)	90.6 (41.5,118.4)	-28.7%
low nuts and seeds	493.6 (250.6,685.8)	245.3 (115.7,358.1)	-50.3%	248.6 (133.4,333.9)	150.0 (77.7,206.7)	-39.7%
high trans fatty acids	567.1 (80.2,774.0)	360.9 (33.1,510.6)	-36.4%	271.7 (29.6,362.7)	173.9 (19.4,237.3)	-36%
low legumes	825.0 (166.2,1356.9)	362.3 (74.5,609.6)	-56.1%	471.4 (123.2,757.1)	297.5 (64.5,483.8)	-36.9%
low whole grains	1429.6 (582.4,1786.9)	912.8 (369.7,1177.8)	-36.2%	568.2 (215.2,730.6)	393.6 (148.9,511.2)	-30.7%

NAME=North Africa and Middle East.

(Table 2). During the 1990–2019 period, there was a gradual decrease in the IHD mortality rate due to dietary risk in both sexes in the NAME region and globally. The IHD mortality rate attributed to dietary risk varied from 44.1 (30.0,57.2) in Turkey to 195.2 (149.4,239.5) in Afghanistan in 2019 (Supplementary Table 3). The proportion of IHD mortality attributed to diet was 46.6% in NAME and 52.9% globally in 2019 (Supplementary Table 3 and Figure 2). The highest rate of IHD DALYs attributed to dietary risk was 4430.5 (3317.1,5602.5) in Afghanistan, and the lowest rate was 824.2 (559.8,1086.7) in Turkey in 2019 (Supplementary Table 4). The proportion of IHD DALYs attributed to diet was 49.5% in NAME and 56.7% globally (Supplementary Table 4 and Figure 3).

Overall impact of individual components of diet on the burden of IHD

The low intake of whole grains had the most attributed risk for IHD mortality [44.5 (18.6,57.1)] and DALYs [912.8 (369.7,1177.8)] in the NAME region in 2019, which were larger than those at the global level [18.6 (7.0,24.4) and 393.6 (148.9,511.2), respectively] (Supplementary Figure 1 and Supplementary Figure 2; Table 1 and Table 2). In addition, in the NAME region, high processed meat intake had the lowest attributed risk for IHD mortality and DALYs [1.7 (0.5,4.3) and 36.8 (9.4,100.7), respectively], which is in contrast to the global level, in which data showed that high processed meat intake had a significant risk for IHD mortality and DALYs [2.5 (0.6,4.9) and 50.8 (12.2,98.3), respectively].

Compared to global, the NAME region had a lower risk of mortality [3.9 (0.7,15.5) vs. 9.8 (2.3,22.6)] and DALYs [85.7 (12.8,336.2) vs. 210.4 (56.5,449.3)] attributed to high sodium intake. The NAME region had approximately 50% higher risk of IHD mortality and DALYs rate attributed to high trans fatty acids in 2019 [17.2 (1.6,23.8) vs. 8.2 (1.0,11.3)] and [360.9 (33.1,510.6) vs. 173.9 (19.4,237.3), respectively].

From 1990 to 2019, the IHD mortality and DALY rates attributed to dietary components were reduced both globally and in the NAME region. In the NAME region, the greatest decrease in IHD mortality and DALYs rates was related to low legume intake, which caused a 51.9% and 56.1% decrease, respectively. The lowest decline in these rates in the NAME region was attributed to high processed meat, which only resulted in a 21.4% and 24.4% decrease in IHD mortality and DALYs rates, respectively, while this factor had the most impact on decreased IHD mortality and DALYs rates by 49.7% and 47.8% globally from 1990 to 2019.

Impact of individual diet components on the burden of IHD at country and sex level

Turkey had the lowest level of IHD mortality and DALYs rates attributed to overall dietary risk and each dietary component, except for low PUFA, low seafood omega-3 fatty acids, and low whole grain intake in 2019. The highest risk of IHD mortality attributed to dietary components, including low polyunsaturated fatty acids (PUFA), low fiber, low legumes, low fruits, and low vegetables, was in Afghanistan; low seafood omega-3 fatty acids, high sugar-sweetened beverage, and low nuts and seeds in Yemen; high red meat in Oman; high sodium, high trans fatty acids, low seafood omega-3 fatty acids, and high processed meat in Egypt; and low whole grain in the Syrian Arab Republic in 2019. In Afghanistan, dietary factors including low PUFA, low seafood omega-3 fatty acids, low fiber, high red meat, low whole grain, low legumes, low vegetables, and low fruits; in Yemen, high sugar-sweetened beverage and low nuts and seeds; and in Egypt, high sodium, high trans fatty acids, and high processed meat were attributing the highest IHD DALYs rate in 2019.

The IHD mortality and DALYs rate attributed to high sodium varied from 1.5 (0.3,6.7) and 31.0 (5.5,135.5) in Turkey to 6.7 (0.9,27.0) and 147.9 (16.8,587.6) in Egypt, respectively. The DALYs rate attributed to high trans fatty acids risk in Egypt was 925.2 (49.3,1415.2), which was almost twofold higher than Afghanistan, with the highest DALYs rate [529.6 (49.7,804.6)] in 2019 (Figure 2 and Figure 3; Supplementary Table 3 and Supplementary Table 4).

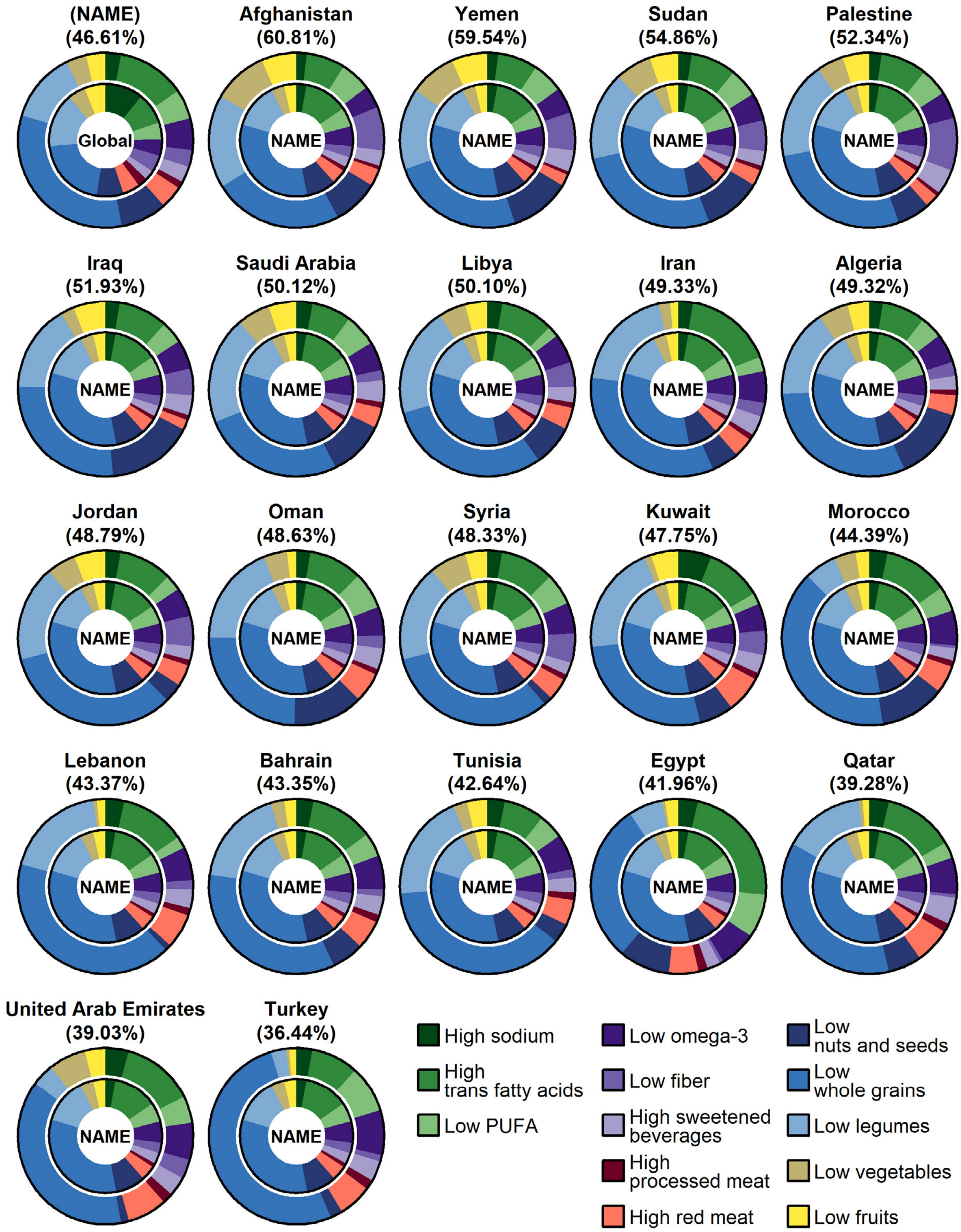

Figure 2. Portions of ischemic heart disease death rates attributed dietary risks, by the NAME countries in 2019. The location of outer pie is mentioned above of it and the location of inner pie is presented at the center. Percentages in parentheses present the portion of dietary risks from all risk factors. PUFA=Polyunsaturated Fatty Acids, NAME=North Africa and Middle East.

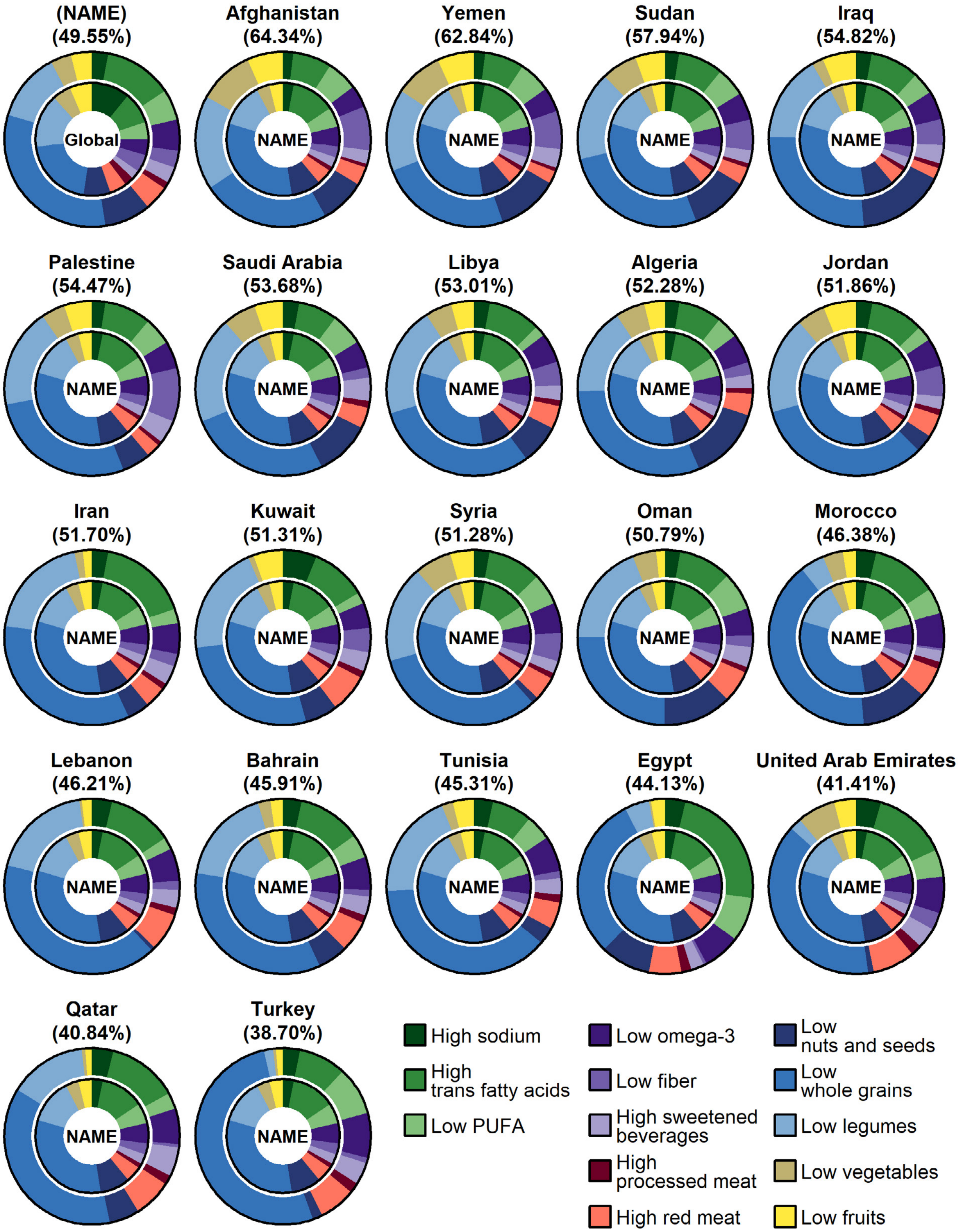

Figure 3. Portions of ischemic heart disease disability-adjusted life years rates attributed dietary risks, by the NAME countries in 2019. The location of outer pie is mentioned above of it and the location of inner pie is presented at the center. Percentages in parentheses present the portion of dietary risks from all risk factors. PUFA=Polyunsaturated Fatty Acids, NAME=North Africa and Middle East.

Libya had the lowest change in mortality rate attributed to dietary risk, from 91.5 (66.9,118.3) in 1990 to 85.8 (62.8,115.7) in 2019. In contrast, Bahrain had the greatest reduction in IHD mortality attributed to dietary risk [from 209.4 (161.8,251.5) in 1990 to 67.2 (49.7,85.1) in 2019]. Generally, the IHD mortality rates contributing to high processed meat risk had the minimum change from 1990 to 2019. In contrast, the risk associated with low whole grains and low legumes experienced the highest changes over this period (Figure 4 and Figure 5).

In general, the risk associated with high consumption of processed meat showed the

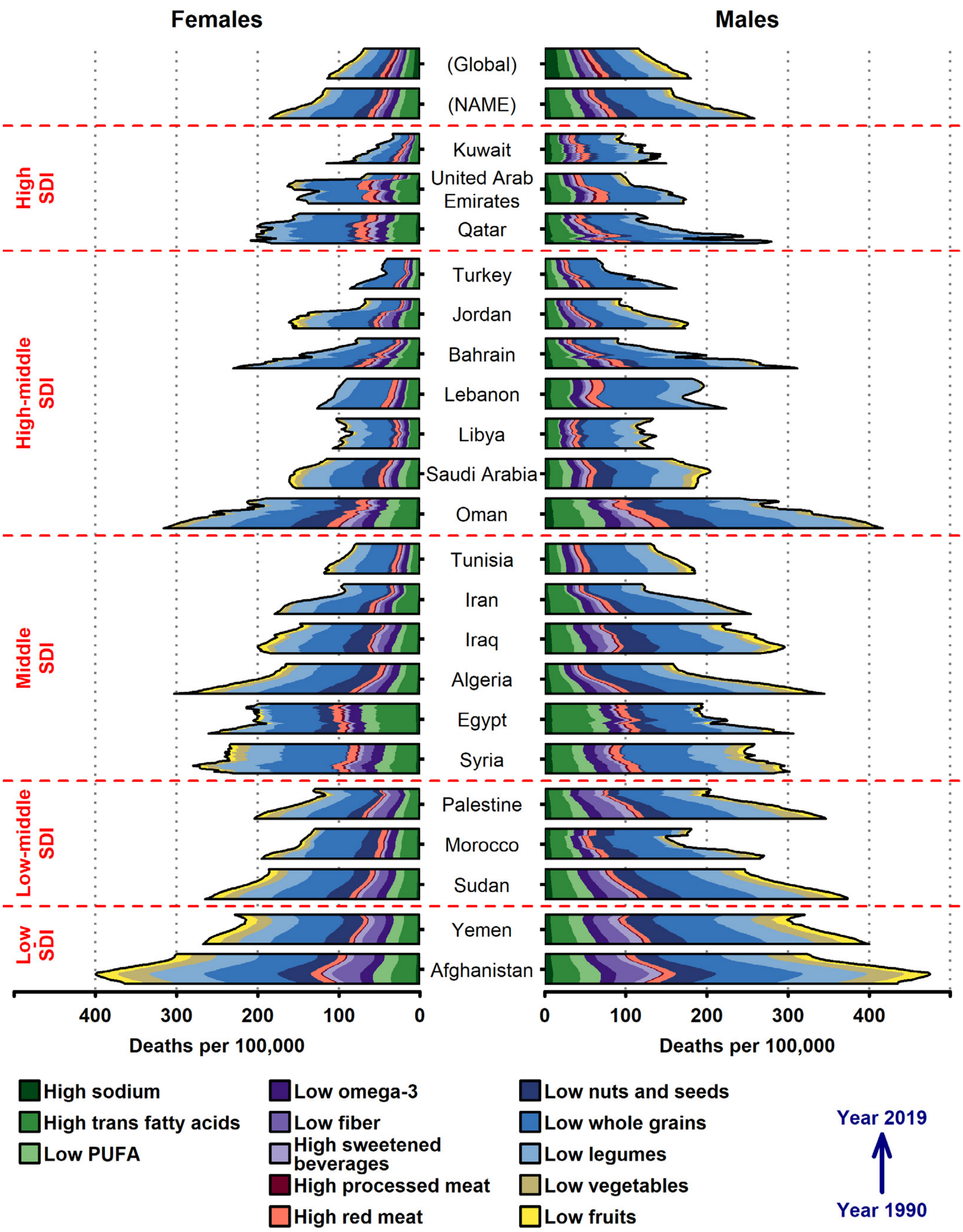

Figure 4. The ischemic heart disease deaths rates attributed to dietary risks, by the NAME countries, SDI categories and sex from 1990 to 2019.
PUFA=Polyunsaturated Fatty Acids, NAME=North Africa and Middle East, SDI=Socio-Demographic Index.

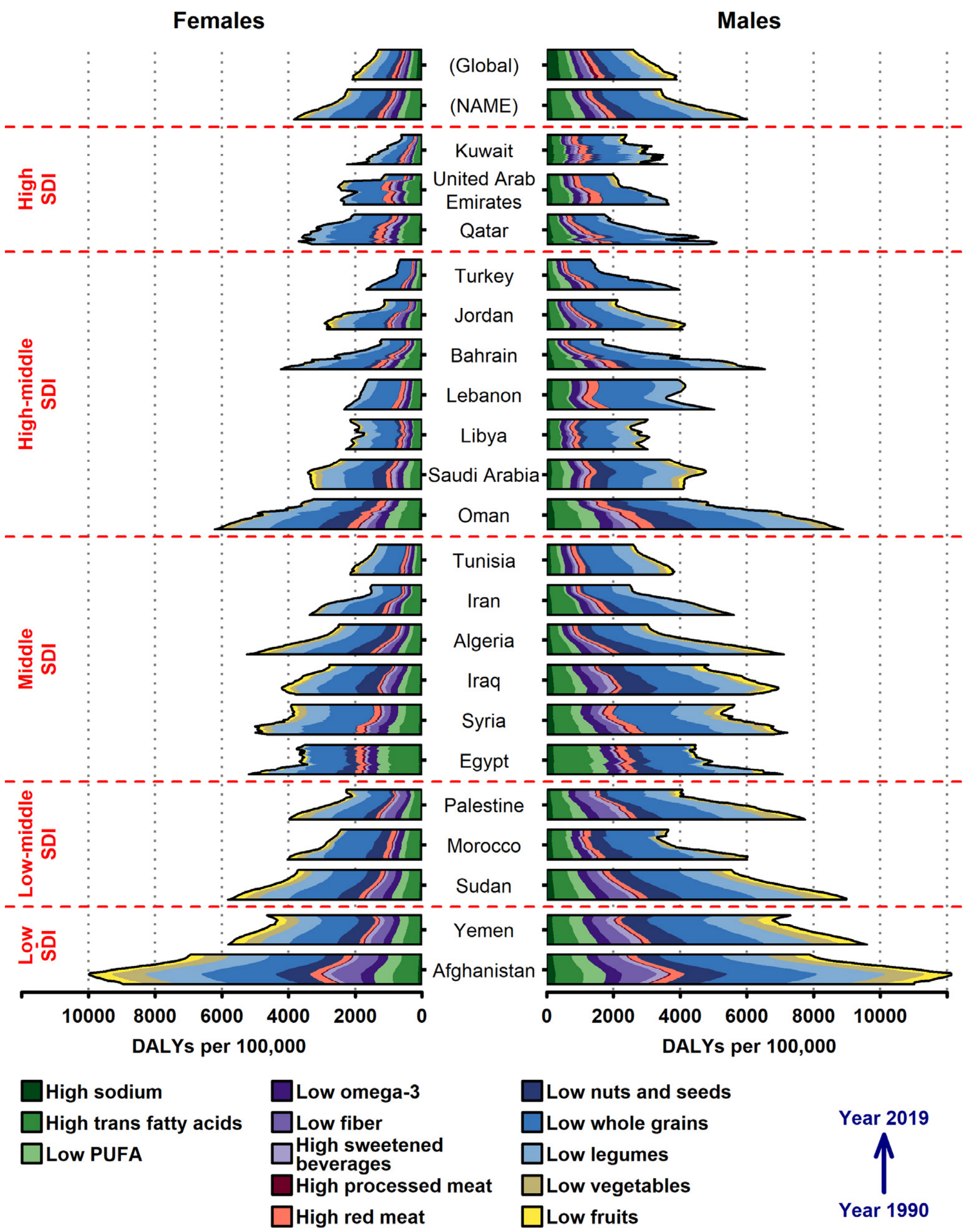

Figure 5. The ischemic heart disease disability-adjusted life years rates attributed to dietary risks, by the NAME countries, SDI categories and sex from 1990 to 2019.
PUFA=Polyunsaturated Fatty Acids, DALYs=Disability-Adjusted Life Years, NAME=North Africa and Middle East, SDI=Socio-Demographic Index.

least difference between women and men, with minimal variation between the two sexes; however, low whole grains had the most change between women and men, followed by low legumes (Figure 4 and Figure 5; Supplementary Table 5 and Supplementary Table 6).

The contribution of all components of dietary risk to IHD mortality and DALYs rates was higher in men than in women in both the NAME region and globally in 1990 and 2019 (Figure 4 and Figure 5; Supplementary Table 5 and Supplementary Table 6). The exceptions to this were Qatar [mortality: 124.1 (91.2,155.2) in women vs. 92.3 (65.3,121.0) in men and DALYs: 1398.6 (989.2,1850.8) in women vs. 1690.6 (1231.2,2152.1) in men], Algeria [mortality: 123.9

(94.3,154.7) in women vs. 116.3 (86.2,150.1) in men], and Egypt [mortality: 161.2 (110.9,209.9) in women vs. 152.9 (63.9,89.4) in men] in 2019. However, the greatest difference between women and men was in Lebanon, Yemen, and Iraq. The DALYs rate of dietary risk in Lebanon was 1286.0 (815.5,1616.3) for women and 3022.8 (2136.9,3808.4) for men. In 2019, the DALYs rate attributed to dietary risk for women in Afghanistan was 4192.3 (3030.1,5603.3), followed by Yemen [2920.8 (2225.7,3888.6)].

Relation between diet and SDI

Low SDI countries (Afghanistan and Yemen) had the greatest risk of deaths and DALYs attributed to dietary risk in the region, but there was not such a clear distinguishing relation between dietary risk and other SDI levels (Supplementary Table 5 and Supplementary Table 6). In general, in comparison with the mortality rate in NAME, high and high-middle SDI countries had lower mortality rates in both men and women. The exceptions were women in Qatar, men in Saudi Arabia, and men and women in Oman. In middle SDI countries, the mortality rate was higher than NAME in Egypt, Syria, Iraq, and Algeria in both men and women but lower in Tunisia and Iran. In both low-middle and low SDI countries, men and women had higher mortality rates compared with NAME. Findings for DALYs were almost the same except for three differences, which were observed for women in Palestine (lower than NAME), women in Algeria (higher than NAME), and men and women in Saudi Arabia (higher than NAME) (Figure 2 and Figure 3; Supplementary Table 5 and Supplementary Table 6).

Rank of dietary risk in each location

The most contributing dietary risk factor in IHD mortality and DALYs rates in all NAME countries, consistent with the global, was low whole grains (Figures 6 and 7). Low legumes were the second most contributing risk of death in almost all NAME countries except for Egypt, Morocco, Turkey, and the United Arab Emirates. The second most contributing risk of death in Morocco was low nuts and seeds intake, while in Egypt, Turkey, and the United Arab Emirates it was high trans fatty acids intake. In addition, the second dietary factor contributing to DALYs risk was low legumes except for Egypt, Iraq, Morocco, Turkey, and the United Arab Emirates. High trans fatty acids intake was the second dietary risk of DALYs in Egypt and the United Arab Emirates, low nuts and seeds intake in Iraq and Morocco, and low PUFA intake in Turkey. Globally, high consumption of sweetened beverages had the

	Global	NAME	Afghanistan	Algeria	Bahrain	Egypt	Iran	Iraq	Jordan	Kuwait	Lebanon	Libya	Morocco	Oman	Palestine	Qatar	Saudi Arabia	Sudan	Syria	Tunisia	Turkey	d Arab Emirates	Yemen
Low whole grains	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Low legumes	2	2	2	2	2	6	2	2	2	2	2	2	5	2	2	2	2	2	2	2	8	8	2
High sodium	3	12	12	12	9	8	8	10	11	6	7	11	9	10	12	8	11	12	10	9	7	7	12
High trans fatty acids	4	3	6	4	3	2	3	4	3	3	3	3	3	4	4	3	4	4	3	3	2	2	5
Low nuts and seeds	5	4	4	3	5	3	5	3	9	5	12	4	2	3	5	6	3	3	12	8	9	13	3
Low fruits	6	9	7	7	11	9	12	5	4	7	10	8	10	12	9	11	8	7	8	7	11	9	7
Low vegetables	7	8	3	5	10	13	11	11	7	13	13	6	8	8	7	12	5	5	4	11	13	4	4
High red meat	8	7	10	9	6	7	6	12	8	4	4	9	6	6	11	5	10	10	9	5	5	3	11
Low fiber	9	10	5	10	13	12	10	7	5	9	9	7	13	11	3	13	12	6	7	12	12	11	6
Low polyunsaturated fatty acids	10	6	8	8	7	4	9	8	10	11	8	12	7	5	6	9	6	8	6	6	3	6	8
Low seafood omega-3 fatty acids	11	5	9	6	4	5	4	6	6	8	5	5	4	7	8	4	7	9	5	4	4	5	9
High processed meat	12	13	13	13	12	11	13	13	13	12	11	13	12	13	13	10	13	13	13	13	10	12	13
High sugar-sweetened beverages	13	11	11	11	8	10	7	9	12	10	6	10	11	9	10	7	9	11	11	10	6	10	10

Figure 6. Heat map of ischemic heart disease death rates attributed to dietary risks, by the NAME countries. NAME=North Africa and Middle East.

	Global	NAME	Afghanistan	Algeria	Bahrain	Egypt	Iran	Iraq	Jordan	Kuwait	Lebanon	Libya	Morocco	Oman	Palestine	Qatar	Saudi Arabia	Sudan	Syria	Tunisia	Turkey	United Arab Emirates	Yemen
Low whole grains	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Low legumes	2	2	2	2	2	7	2	3	2	2	2	2	7	2	2	2	2	2	2	2	10	11	2
High sodium	3	11	12	10	9	8	8	10	10	5	6	10	9	10	12	8	11	11	10	8	7	7	12
High trans fatty acids	4	3	6	4	3	2	3	4	3	3	3	3	3	4	4	3	4	4	3	3	3	2	5
Low nuts and seeds	5	4	4	3	6	3	5	2	9	6	12	4	2	3	5	6	3	3	12	9	9	13	3
Low fruits	6	8	7	9	10	9	11	5	4	7	9	9	10	12	6	11	7	7	8	7	11	8	7
Low vegetables	7	9	3	6	11	13	12	11	6	13	13	6	8	8	9	12	5	5	4	11	13	4	4
Low polyunsaturated fatty acids	8	6	8	7	7	4	9	8	11	11	8	12	6	5	7	9	6	8	5	6	2	6	8
Low fiber	9	10	5	12	13	12	10	7	5	9	10	7	13	11	3	13	12	6	7	13	12	10	6
High red meat	10	7	10	8	5	6	6	12	8	4	4	8	5	6	11	4	10	10	9	5	5	3	11
Low seafood omega-3 fatty acids	11	5	9	5	4	5	4	6	7	8	5	5	4	7	8	5	8	9	6	4	4	5	9
High processed meat	12	13	13	13	12	11	13	13	13	12	11	13	12	13	13	10	13	13	13	12	8	12	13
High sugar-sweetened beverages	13	12	11	11	8	10	7	9	12	10	7	11	11	9	10	7	9	12	11	10	6	9	10

Figure 7. Heat map of ischemic heart disease disability-adjusted life years rates attributed to dietary risks, by the NAME countries. NAME=North Africa and Middle East.

least impact on deaths and DALYs rates as a dietary risk factor. However, in the NAME region, the consumption of high processed meat had the lowest effect on the burden of disease.

Dietary risk attributed to IHD burden and HAQ

The HAQ index varied between 28.87 in Afghanistan and 76.98 in Kuwait in 2019. Figure 8 and Supplementary Table 7 present the relation of IHD burden attributed to dietary risk with HAQ and SDI in 2019. Overall, there is an obvious relation between the increment of HAQ and SDI with a decrement in DALYs.

Discussion

This study highlights the substantial contribution of a suboptimal diet to the burden of ischemic heart disease (IHD) in the NAME region between 1990 and 2019, exceeding global averages despite overall declining trends. Specifically, dietary risks accounted for nearly half of IHD-related deaths and DALYs, with lower intake of whole grains, legumes, nuts and seeds, and seafood omega-3 fatty acids, as well as high trans-fat consumption, emerging as the most significant contributors. Notably, low whole grain intake remained the leading dietary risk across all NAME countries throughout the study period. Moreover, a clear inverse relationship was observed between countries' socio-demographic index (SDI) and diet-related IHD burden.

The higher deaths and DALYs for IHD attributable to low-quality diets in the NAME region compared with the global level warrant urgent strategies to improve dietary habits at the population level in this region. The Global Action Plan for the Prevention and Control of NCDs 2013–2020 focuses on reducing sodium/salt, sugar, calorie intake, food portion size, and energy density; the replacement of saturated and trans fatty acids with unsaturated fatty acids; and increasing fruit and vegetable availability and affordability[28]. Nevertheless, our evaluation of the NAME region suggests that among various dietary risk factors, low intake of whole grains and legumes, high intake of trans fatty acids, and low intake of nuts and seeds accounted for the highest deaths and DALYs due to IHD. The beneficial impacts of these food groups might be attributed to their bioactive compounds with anti-inflammatory properties[29–32].

In contrast, added sugar and salt made the smallest contributions after processed meat

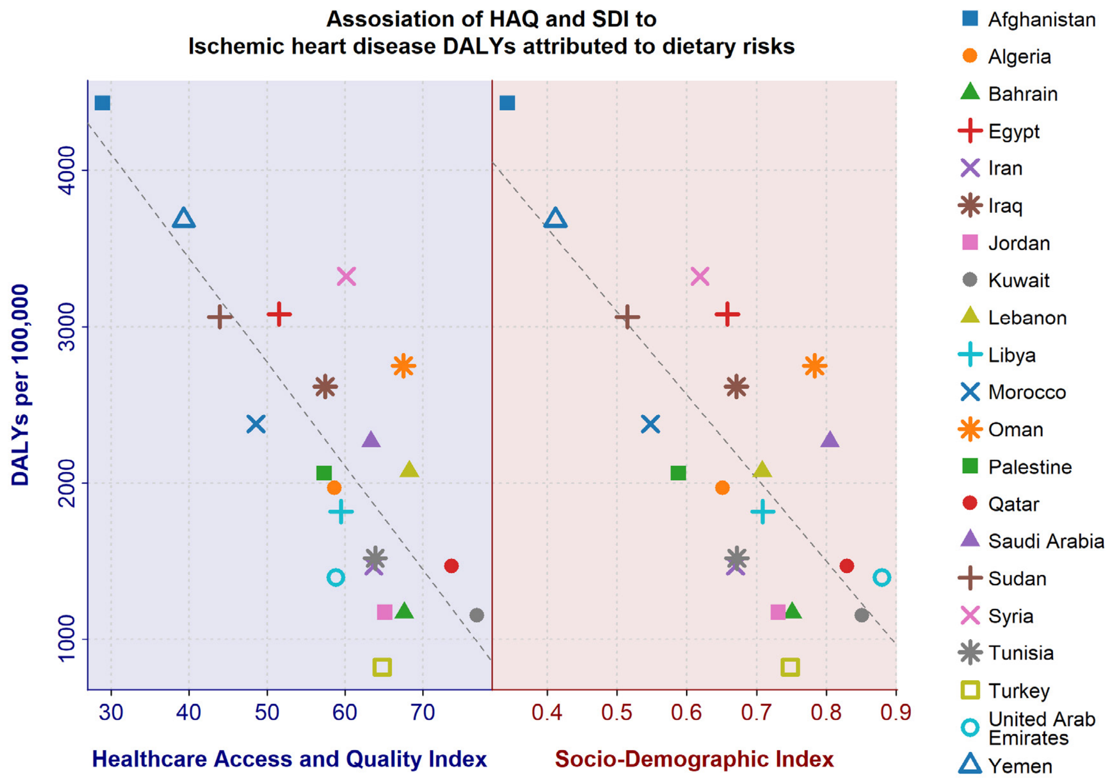

Figure 8. Relation of ischemic heart disease disability-adjusted life years rate attributed to dietary risks with healthcare access and quality and socio-demographic index by the NAME countries in 2019.
DALYs=Disability-Adjusted Life Years, HAQ=Healthcare Access and Quality Index, SDI=Socio-Demographic Index.

consumption. The first two dietary risks (low whole grain and low legume intake) were the same in the NAME region and worldwide, whereas at the global level, high sodium intake, high trans-fat, and low nuts and seeds intake ranked 3 to 5, respectively. Regarding other food groups, there were some variations between the world and the NAME region. For instance, the low intake of seafood and n-3 fatty acids in the NAME region was more important than the low intake of fruits and vegetables, while at the global level, the contribution of low fruit and vegetable intake in DALYs and deaths due to IHD exceeded the role of low seafood and n-3 fatty acids.

Therefore, emphasizing the consumption of foods that are consumed below optimal levels may be more effective in reducing the burden of IHD than recommendations to limit salt, sugar, and fat intake in NAME countries. Potential policy interventions include the development of public awareness campaigns, school-based interventions, food subsidies and incentives, food fortification, regulations on trans fats, mandatory labeling, and collaboration with the food industry. For example, one policy recommendation is to subsidize whole grain products to make them more affordable. A study in the United States modeled subsidizing healthy foods like whole grains, nuts/seeds, fruits, and vegetables, while also taxing unhealthy foods such as processed and unprocessed meats and sugar-sweetened beverages (SSB). The findings showed that both scenarios led to dietary changes and a subsequent reduction in cardiovascular disease[2]. Additionally, a study in 2021 found that subsidies for fruits and vegetables would lead to an increase in the purchase of these items[3].

In general, the trend of IHD burden was downward in all countries of the region. However, the magnitude of reduction was less significant in some countries such as Afghanistan, Yemen, Sudan, Palestine, and Iraq compared to other countries. This finding may be attributed to the impact of war and economic recession in these countries over the years. In contrast, the greater reductions in IHD burden in other countries might be a result of advancements in healthcare infrastructure and communication technology[33].

However, between-country differences in the impact of each dietary risk are another issue that should be taken into account by policymakers. In 2019, the highest burden was observed in Afghanistan, Yemen, Sudan, Palestine, and Iraq, respectively. This finding might be caused by the effect of war and economic recession in these countries over these years, which can considerably affect food availability, choices, and affordability of families, as well as mental health status, which adversely affects food choices and diet quality. The one exception to these countries is Sudan, which has one of the largest numbers of malnourished children[34]. The adverse effects of malnourishment on cardiovascular health have been well established[35].

In addition, although the first culprit of IHD burden attributed to dietary risk was the same across all countries, the second one in Egypt, Iraq, Morocco, Turkey, and the United Arab Emirates was trans fatty acids. This finding is in concordance with earlier reports, which showed Egypt had the highest consumption of trans fatty acids in the world[36,37]. It should be noted that estimates of trans fatty acid intake for countries such as the United Arab Emirates and Turkey are not based on nationally representative surveys.

For this purpose, interventions must be tailored to the unique dietary habits, cultural food preferences, availability of healthy foods, and economic constraints of each country. Iran and Iraq have high consumption of rice[4], so interventions should focus on promoting brown rice consumption rather than white rice, along with programs to promote legumes and vegetables to balance meals. Subsidizing brown rice could increase its consumption. Gulf countries have high consumption of processed foods[5].

Interventions such as imposing taxes on SSB and processed foods high in sodium and unhealthy fats, subsidizing healthier alternatives like fresh fruits and vegetables, and implementing labeling requirements to increase consumers' awareness could be effective in these countries. Countries with lower economic status, such as Yemen, Sudan, and Afghanistan, should implement programs to improve dietary habits with a focus on affordability[6] for example, promoting small home gardens that focus on growing vegetables, fruits, and legumes.

Comparing the trend of IHD burden attributed to dietary factors between countries showed a constant decrease in both sexes in all countries, either in men or in women. The greatest decline was observed in Bahrain, Iraq, and Oman, whilst Libya showed the smallest change. The unhealthy dietary pattern of the GCC countries, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates from 1970 to 2000, has been attributed to a sharp increase in income due to oil revenue[38]. Despite this, an improvement in standards of living and health services has been associated with a longer life expectancy[38]. However, improvement in educational level and sociocultural factors in these countries may have been the reasons for the great decline in the burden of disease[39].

This study also indicated that the impact of dietary risk factors on IHD burden is generally higher in men than in women. Among the factors that may explain this gender difference are the following: biological factors, dietary intake differences, specific food choices, alcohol consumption, work environment, workplace environment, and health-seeking behaviors. Men and women differ in hormonal profiles and physiology, which may influence their susceptibility to IHD independent of dietary factors. Differences in dietary patterns between men and women may explain the greater impact of dietary risk factors on the burden of IHD among men[7].

Based on our findings, men have higher consumption of red meat, processed meat, high trans-fat, and high sodium, and lower consumption of PUFA, fiber, nuts and seeds, legumes, vegetables, and fruits compared to women. In some of the NAME countries, alcohol consumption may be more prevalent among men, which could contribute to IHD risk[8]. On the other hand, men are more likely to work in physically demanding occupations and may rely on readily available, less healthy food options[9]. Finally, men may be less likely to seek preventive healthcare and adhere to dietary recommendations compared to women.

The lower attributable burden of processed meat to IHD in the NAME region compared to global levels may reflect region-specific dietary patterns. Cultural, religious, and socioeconomic factors in many NAME countries may limit the consumption of processed meats, resulting in a lower exposure level. This is captured in GBD estimates, which incorporate regionally representative dietary intake data.

In line with the earlier study, we found higher IHD burden in countries with lower income[40]. The higher incidence of IHD in lower community-level socioeconomic status (SES) may be independent of individuals' SES. Community-level SES can affect the dietary behavior of people through its influence on the neighborhood environment (e.g., accessibility to markets, food availability at local stores, and affordability) and health-care resources such as restaurants and gyms[41,42]. Moreover, people in communities with low SES are less likely to have a healthier diet[43] or share their knowledge regarding healthy lifestyles with neighbors compared with affluent communities[44,45].

At the individual level, a suboptimal diet with low public knowledge and awareness of nutritional disorders and chronic diseases can be driven by the level of education, income, and nutritional knowledge. Other factors affecting dietary behaviors include increasing pollution levels and environmental degradation[46–49], food and agricultural policies, and food marketing at the national level[46,50], internally displaced or physically constrained people (refugees)[51,52], extreme poverty[53], and the recent coronavirus pandemic in 2019[46].

Strategies such as fortification of staple foods, wheat flour fortification with folic acid, salt iodization, subsidies for healthy foods, nutrition education and behavior change communication, and addressing food security would be helpful as targeted nutritional interventions in countries with a low SDI.

The NAME region has experienced a rapid nutrition transition characterized by a shift away from traditional diets toward Westernized patterns[10]. This includes increased consumption of refined grains, which often displace whole grains. This dietary shift is driven by factors such as increased urbanization, globalization, and changing lifestyles, with processed foods becoming more available and affordable[10]. Urbanization over the last decades has also led to a shift from healthy traditional diets to Western eating patterns, which are low in whole grains, legumes, and nuts and seeds intake, but rich in trans fatty acids[54].

Furthermore, wars, inflation, recession, currency devaluation, and unemployment, which together can influence families' accessibility to healthy foods, may play a role in this context and exacerbate the current status[55]. The effect of different dietary risk factors attributable to IHD on death and DALYs was different in SDI regions. One of the main reasons for this is the health disparities between countries with different levels of IHD burden. Therefore, it may be advisable to develop health policies to reduce health inequalities in these countries.

Community-based interventions could reduce energy intake, fat, and sodium intake and increase fiber, fruit, and vegetables[25]. However, the magnitude of these effects varied substantially between different nations, and in most cases, they are still well below the recommended amount of consumption[56,57]. Moreover, due to the close interconnection between food availability and consumers, it seems that interventional programs targeting food industries would be more efficient[9]. It is worth noting that the reasons for suboptimal dietary behaviors vary from one country to another, which shows the necessity of taking different approaches to tackle the issue. Hence, where the main reason for unhealthy eating patterns is war and unrest, governments need to take actions aimed at increasing healthy food availability and affordability, while in more affluent countries different actions, such as improving people's knowledge of the benefits of healthy foods and taxing unhealthy foods, are required.

All GBD limitations are applicable to the current article, and despite GBD efforts to provide precise data, some limitations remain to be taken into account. First, GBD lacks sufficient data on diet for many NAME countries, and therefore data have been estimated based on neighboring regions or other estimations, which cannot exactly demonstrate the status of those countries. Second, the inconsistency of food group definitions, for instance whole grains, may affect the accuracy of findings. Moreover, as a common limitation in studies on dietary assessment, using different ways to prepare and cook foods influences their food content, and the same dish may contain different kinds and numbers of foods, resulting in diverse nutrient or caloric intake. Thus, it is difficult to compare dietary intake across countries.

Third, the collinearity between healthy dietary factors with each other, and vice versa, may result in an overestimation of the real effect sizes. Fourth, different dietary assessment tools have different measurement errors, which have not been corrected in most studies. Fifth, due to the lack of risk-adjusted diet impact on health, we cannot assume that diet has the same impact on health as in Western countries. On the other hand, higher accessibility to medications in affluent Western countries compared with low-income countries in the NAME region can result in different findings.

Conclusion

Finally, these results are based on observational studies, which are weaker than clinical trials in indicating causality. The main strength of this study is that it is the first comprehensive review of the NAME region, identifying the contribution of various dietary risk factors to IHD burden and comparing it with the world, which can help determine priorities for public policy establishment to reduce IHD burden.

In summary, even though the trend in IHD morbidity and mortality decreased in the region, the IHD burden remains high, particularly in regions with lower SDI. Low whole grain intake, low legume intake, and high trans fatty acid consumption were the major contributors to the burden of IHD in all NAME countries. In contrast with the global findings, processed meat, sodium, and sugar-sweetened beverages had the lowest contribution.

A collective strategy for NCDs and metabolic and lifestyle risk factors can be adopted, particularly in resource-limited countries, rather than investing in strategies that deal with many interrelated issues separately. In addition, collaborative efforts for regional strategies, investments in better surveillance, fundamental changes throughout the food system, and multi-dimensional policies targeting the food system are required to improve diet quality in this region. However, as there are no qualified data on diet for many countries in this region, to strengthen the accuracy and reliability of these findings, more dietary surveys are required in these countries.

Limitation

The limitation of data sources depends on the location and year, which vary between countries (Supplementary Table 8). Using neighborhood (regional) information to make or improve estimations is a technique to at least have and report some information for locations with no data or low-quality data. The GBD team did their best to make these estimations more realistic, but of course they have limitations that might affect our interpretation. However, it should be taken into account that GBD is the most powerful information currently available in this field, and the GBD team does their best to receive feedback and criticisms to improve the data using new reliable information.

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Conflict of interests

The authors declare no conflict of interest.

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Author's Contributions

Study Conception or Design: AM, MN, SMSI, NS
Data Acquisition: -
Data Analysis or Interpretation: KMZ
Manuscript Drafting: NM, FH, MB, NS
Critical Manuscript Revision: -

All authors have approved the final manuscript and are responsible for all aspects of the work.

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