

Aminorroaya, Arya et al.

Article — Published Version

Burden of Ischemic Heart Disease and Its Attributable Risk Factors in North Africa and the Middle East, 1990 to 2019: Results From the GBD Study 2019

Journal of the American Heart Association

Provided in Cooperation with:

Kiel Institute for the World Economy – Leibniz Center for Research on Global Economic Challenges

Suggested Citation: Aminorroaya, Arya et al. (2024) : Burden of Ischemic Heart Disease and Its Attributable Risk Factors in North Africa and the Middle East, 1990 to 2019: Results From the GBD Study 2019, Journal of the American Heart Association, ISSN 2047-9980, Ovid Technologies (Wolters Kluwer Health), Philadelphia, Vol. 13, Iss. 2, <https://doi.org/10.1161/JAHA.123.030165>

This Version is available at:

<https://hdl.handle.net/10419/301880>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.












If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<http://creativecommons.org/licenses/by-nc-nd/4.0/>

ORIGINAL RESEARCH

Burden of Ischemic Heart Disease and Its Attributable Risk Factors in North Africa and the Middle East, 1990 to 2019: Results From the GBD Study 2019

Arya Aminorroaya , MD, MPH*; Sahar Saeedi Moghaddam , MSc*; Hamed Tavolinejad , MD; Zahra Aryan, MD, MPH; Behnam Heidari, MD, MPH; Hedyeh Ebrahimi , MD, MPH; Mohammadreza Naderian , MD, MPH; Parnian Shobeiri , MD, MPH; Ali Ghanbari, MSc; Nazila Rezaei , MD; Mohammad-Reza Malekpour , MD; Rosa Haghshenas , BSc; Negar Rezaei , MD, PhD; Bagher Larijani , MD; Farshad Farzadfar , MD, MPH, DSc

BACKGROUND: The North Africa and Middle East (NAME) region has one of the highest burdens of ischemic heart disease (IHD) worldwide. This study reports the contemporary epidemiology of IHD in NAME.

METHODS AND RESULTS: We estimated the incidence, prevalence, deaths, years of life lost, years lived with disability, disability-adjusted life years (DALYs), and premature mortality of IHD, and its attributable risk factors in NAME from 1990 to 2019 using the results of the GBD (Global Burden of Disease study 2019). In 2019, 0.8 million lives and 18.0 million DALYs were lost due to IHD in NAME. From 1990 to 2019, the age-standardized DALY rate of IHD significantly decreased by 33.3%, mostly due to the reduction of years of life lost rather than years lived with disability. In 2019, the proportion of premature death attributable to IHD was higher in NAME compared with global measures: 26.8% versus 16.9% for women and 18.4% versus 14.8% for men, respectively. The age-standardized DALY rate of IHD attributed to metabolic risks, behavioral risks, and environmental/occupational risks significantly decreased by 28.7%, 37.8%, and 36.4%, respectively. Dietary risk factors, high systolic blood pressure, and high low-density lipoprotein cholesterol were the top 3 risks contributing to the IHD burden in most countries of NAME in 2019.

CONCLUSIONS: In 2019, IHD was the leading cause of death and lost DALYs in NAME, where premature death due to IHD was greater than the global average. Despite the great reduction in the age-standardized DALYs of IHD in NAME from 1990 to 2019, this region still had the second-highest burden of IHD in 2019 globally.

Key Words: coronary artery disease ■ epidemiology ■ global burden of disease ■ ischemic heart disease ■ mortality ■ North Africa and Middle East

Cardiovascular diseases have been the leading cause of death worldwide for decades.¹⁻³ Ischemic heart disease (IHD) remains the most prevalent cardiovascular disease and accounts for 16% of total global deaths.^{1,2,4,5} Although the global IHD burden is increasing, there are considerable

Correspondence to: Farshad Farzadfar, MD, MPH, DSc, Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, No. 10, Al-e-Ahmad and Chamran Highway intersection, Tehran, Iran. Email: f-farzadfar@tums.ac.ir

*A. Aminorroaya and S. Saeedi Moghaddam contributed equally as co-first authors.

This work was presented at AHA Scientific Sessions, November 11 to 13, 2023, in Philadelphia, PA.

This manuscript was sent to Mahasin S. Mujahid, PhD, MS, FAHA, Associate Editor, for review by expert referees, editorial decision, and final disposition.

Supplemental Material is available at <https://www.ahajournals.org/doi/suppl/10.1161/JAHA.123.030165>

For Sources of Funding and Disclosures, see page 11.

© 2024 The Authors. Published on behalf of the American Heart Association, Inc., by Wiley. This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

JAHA is available at: www.ahajournals.org/journal/jaha

CLINICAL PERSPECTIVE

What Is New?

- In 2019, ischemic heart disease (IHD) was the leading cause of burden of disease and death in NAME, where premature death due to IHD was greater than the global average.
- The age-standardized disability-adjusted life year rate of IHD decreased by >30% in NAME from 1990 to 2019; however, NAME still has the second rank in the burden of IHD globally with major health inequalities.
- From 1990 to 2019, the age-standardized rates of disability-adjusted life years, years of life lost, and years lived with disability due to IHD significantly decreased; however, the reduction of disability-adjusted life years arises mostly from a decrease in years of life lost or death, rather than years lived with disability or morbidity, of IHD.

What Are the Clinical Implications?

- There are some control plans for IHD in place in some NAME countries, including multisectoral and interdisciplinary committees for control of noncommunicable diseases and their risk factors, and expansion of catheterization laboratories and fibrinolytic injection facilities for the acute management of IHD; although some of them proved effective in reducing the IHD burden according to this study, they are yet to be adopted and evaluated by other countries in the region.
- The management of dietary risk factors, high systolic blood pressure, and high low-density lipoprotein cholesterol should be the focus of IHD control plans in NAME.

Nonstandard Abbreviations and Acronyms

GBD	Global Burden of Diseases, Injuries, and Risk Factors study 2019
NAME	North Africa and Middle East
NCD	noncommunicable disease
SDI	sociodemographic index

regional and national variations.⁶ One of the highest age-standardized IHD prevalence and incidence rates is observed in the North Africa and Middle East (NAME) region.^{2,4,6}

NAME is an economically diverse region, where countries are at different stages of development with a diverse distribution of wealth and resources, and remarkable socioeconomic disparities. Besides the ongoing

epidemiologic transition in NAME with evolving patterns of fertility, death, life expectancy, and leading causes of death, socioeconomic disparities worsen the access to preventive measures to control noncommunicable diseases (NCDs).^{7,8} The prevalence of major atherosclerosis risk factors, including hypertension, diabetes, and obesity has significantly increased in the NAME region over the past 2 decades.⁸⁻¹⁰ IHD seems to affect younger individuals across NAME countries compared with other regions.^{8,10} Consequently, the age-standardized disability-adjusted life year (DALY) rates for IHD are considerably higher than the global picture, and IHD is estimated to cause 26% of all deaths in NAME.^{4,6,11}

Prevention and control of atherosclerotic cardiovascular diseases are one of the public health challenges in the NAME region.⁷⁻⁹ Therefore, updated estimates of regional and national IHD burdens are essential in establishing benchmarks for decisions in policy making and resource allocation. It is also important to evaluate the role of demographic changes, sex differences, risk factor patterns, and national trends to inform timely and effective strategies. Nevertheless, to the best of our knowledge, no updated study has reported detailed epidemiologic estimates with time comparisons for IHD within countries in this region.^{8,11,12} As part of the GBD (Global Burden of Diseases, Injuries, and Risk Factors study 2019), this investigation was conducted to provide an update on the imposed burden of IHD-related death and morbidity in NAME.

METHODS

Data Source

Epidemiological data from the GBD was obtained from the Institute for Health Metrics and Evaluation to evaluate the epidemiology of the Institute for Health Metrics and Evaluation and its attributable risk factors in NAME between 1990 and 2019. The GBD is a multinational collaboration that reports comprehensive and systematic estimations for 369 diseases and injuries in 204 countries. The study was initiated in 1990 and has been updated regularly ever since with the addition of new data sources and methodological revisions to enable comparisons across time. Detailed methods of the GBD have been published elsewhere.¹⁻⁴ The GBD study is approved by the University of Washington Institutional Review Board (STUDY00009060). Informed consent forms were not deemed necessary as the GBD uses deidentified collective data. The data used in this study are accessible via the Global Health Data Exchange (<http://ghdx.healthdata.org/gbd-2019>) and the GBD Compare webpage (<https://vizhub.healthdata.org/gbd-compare/>). The reporting of the present study complies with Guidelines for Accurate and Transparent Health Estimates Reporting.¹³

Definitions

In the GBD, diseases and injuries are classified into 4 levels of causes. IHD is a level 3 cause (coded as B.2.2) under noncommunicable diseases (level 1) and cardiovascular diseases (level 2). IHD itself cannot be subdivided into level 4 causes. The standard definition of IHD used in the GBD included acute myocardial infarctions, determined on the basis of the Fourth Universal Definition of Myocardial Infarction and adjusted to account for out-of-hospital sudden cardiac death, chronic IHD, and chronic stable angina, determined on the basis of the Rose angina questionnaire, and heart failure due to IHD.^{4,14} Premature death due to IHD was defined as age <55 years in men and <65 years in women according to international guidelines and regional studies.^{15–18} The Institute for Health Metrics and Evaluation uses a 4-level hierarchy to classify risk factors.³ Level 1 risk factors include broad categories of metabolic risks, behavioral risks, and environmental/occupational risks. Level 2 risk factors comprise 20 risk factors, and level 3 risk factors consist of 25 more granular risk factors, while level 4 risk factors represent the most detailed classification with 29 risk factors.^{1–3} The sociodemographic index (SDI) is a summary measure of country development that incorporates income per capita, educational attainment level, and the total fertility rate, and is presented in quintiles.¹⁹

Definition of the NAME region is ambiguous and varies between institutions and studies. GBD defines 7 super-regions on the basis of epidemiologic similarity and geographic closeness, including high income; Latin America and Caribbean; sub-Saharan Africa; NAME; South East Asia, East Asia, and Oceania; Central Europe, Eastern Europe, and Central Asia; and South Asia. This analysis focused on the GBD NAME region, composed of 21 countries: Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, Turkey, United Arab Emirates, and Yemen.^{20,21}

Estimation Framework

The burden of IHD was determined via standard epidemiologic measures including prevalence, incidence, death rates, years of life lost (YLLs), years lived with disability (YLDs), and DALYs measured with regard to age, sex, country, and SDI, with comparisons over time. Incidence and prevalence were based on a broad range of population-representative data. GBD employs a highly standardized method to estimate death due to different causes, which uses vital registration based on *International Classification of Disease (ICD)* codes^{1,22} and verbal autopsy data as inputs to the Cause of Death Ensemble Model to produce time trends.^{1,2,23} YLLs were calculated as the difference between the

maximum country-specific life expectancy and the age at death. YLDs were the product of the prevalence and disability weights of IHD. DALYs were produced as the sum of YLLs and YLDs.

Statistical Analysis

In this study, we reported incidence, prevalence, deaths, premature deaths, YLLs, YLDs, and DALYs of IHD for NAME and its countries from 1990 to 2019. Moreover, we explored the impact of changes in age structure, population growth, and variations in incidence rate on the incidence of IHD using decomposition analysis. Briefly, expected IHD cases in 2019 were estimated using 2 hypothetical scenarios: first, applying the 1990 age-specific IHD incidence rates to the 2019 population size; and second, applying the 1990 age structure and age-specific IHD incidence rates to the 2019 population size. The difference between the 2 scenarios was considered as the contribution of population aging. Differences between the second scenario and the actual IHD incidence in 2019 were considered as the contribution of population growth. Finally, any remaining changes in IHD incidence were attributed to alterations in age-specific IHD incidence rates.²⁴ Data are reported as point estimates (95% uncertainty interval). All statistical analyses and visualizations were done using R software version 4.0.4 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Disability-Adjusted Life Years

In 2019, 18.0 million DALYs (61.3% men) were lost due to IHD in NAME. From 1990 to 2019, the age-standardized DALY rate of IHD significantly decreased by 33.3% (95% uncertainty interval, –41.4 to –25.0) and reached 4158.9 per 100 000 population (3650.7–4751.7) in NAME (Table 1; Figure 1). The corresponding worldwide figure was –28.6% (–33.3 to –24.2) and 2243.5 (2098.7–2385.0), respectively. Although NAME had the highest worldwide age-standardized DALY rate of IHD in 1990, the steady decrease of this measure in the study period resulted in convergence with the global average. Noticeably, this decreasing trend was consistent across all 21 countries of NAME ranging from a 10.5% reduction (–30.2 to 16.8) in Libya to a 69.1% decrease (–75.1 to –60.7) in Bahrain; nevertheless, it did not reach statistical significance for Egypt, Libya, Saudi Arabia, Syrian Arab Republic, Tunisia, and Yemen (Table S1; Figure S1). Egypt had the highest and Turkey had the lowest age-standardized DALY rate of IHD in NAME in 2019 (Figure 2). The decreasing trend of age-standardized DALYs mostly arises from the reduction of YLLs rather than YLDs. From 1990 to 2019, the contribution of YLDs to the age-standardized DALY

Downloaded from https://ahajournals.org by on August 15, 2024

Table 1. Age-Standardized Incidence, Prevalence, Death, DALY, YLL, and YLD Rates of IHD and Their Percentage Change From 1990 to 2019 in NAME

Measure	Metric	1990						2019						% Change (1990–2019)					
		Both	Female	Male	Both	Female	Male	Both	Female	Male	Both	Female	Male	Both	Female	Male			
Incidence	All ages number	1084677 (972 520 to 1 201 363)	430454 (384 869 to 477 644)	654223 (587 044 to 723 621)	2550432 (2 287 730 to 2 826 390)	1 015 618 (911 178 to 1 122 474)	1 534 814 (1 375 053 to 1 709 606)	135.1 (131.3 to 139.3)	135.9 (130.9 to 141.1)	134.6 (130.1 to 140)									
	Age-standardized rate (per 100 000)	674.5 (612.2 to 740.5)	555 (502.1 to 612.8)	791.2 (718.7 to 870)	613.9 (555.8 to 675.2)	514.4 (465.3 to 567)	708.1 (639.6 to 780.7)	-9 (-10.3 to -7.5)	-7.3 (-9.2 to -5.2)	-10.5 (-12.1 to -8.7)									
Prevalence	All ages number	8049364 (7 457 890 to 8 705 147)	3 168 596 (2 926 883 to 3 420 699)	4 880 767 (4 524 621 to 5 266 870)	19 979 927 (18 501 725 to 21 563 635)	7 695 285 (7 141 891 to 8 313 322)	12 284 642 (11 368 062 to 13 247 357)	148.2 (145.5 to 151.3)	142.9 (139.9 to 146.3)	151.7 (148.1 to 155.7)									
	Age-standardized rate (per 100 000)	5087.4 (4736.7 to 5477.9)	4098.7 (3804.9 to 4411.4)	6069.4 (5647.5 to 6537.7)	4911.1 (4552.7 to 5295.1)	3908.3 (3632.5 to 4218.2)	5882.7 (5457.5 to 6353.1)	-3.5 (-4.5 to -2.2)	-4.6 (-5.8 to -3.3)	-3.1 (-4.4 to -1.6)									
Deaths	All ages number	444 690 (411 688 to 478 245)	186 919 (172 234 to 202 900)	257 772 (237 189 to 279 881)	799 484 (706 349 to 909 787)	339 325 (295 245 to 381 948)	460 160 (404 384 to 528 543)	79.8 (58.2 to 100.5)	81.5 (58.6 to 104.2)	78.5 (57 to 101.6)									
	Age-standardized rate (per 100 000)	309.3 (284.3 to 332.1)	268.6 (244.3 to 292.9)	349.1 (318.9 to 378.1)	219 (194.2 to 246.8)	195.2 (169.4 to 218.8)	241.7 (213.8 to 274.7)	-29.2 (-36.9 to -21.8)	-27.3 (-35.6 to -19.4)	-30.8 (-38.5 to -22.6)									
DALYs	All ages number	10 861 907 (10 042 741 to 11 729 607)	4 206 912 (3 889 351 to 4 587 269)	6 654 995 (6 133 099 to 7 284 506)	17 994 822 (15 580 582 to 20 811 862)	6 961 313 (5 988 107 to 8 025 462)	11 033 509 (9 511 629 to 12 905 430)	65.7 (43.4 to 87.5)	65.5 (41.2 to 89.3)	65.8 (43.8 to 89.9)									
	Age-standardized rate (per 100 000)	6232.4 (5783.4 to 6705.7)	5038.4 (4639.8 to 5470.6)	7376.1 (6798.6 to 8043.7)	4158.9 (3650.7 to 4751.7)	3420.3 (2963.1 to 3899.4)	4853 (4240.3 to 5611.2)	-33.3 (-41.4 to -25)	-32.1 (-41.1 to -23.1)	-34.2 (-42.5 to -25.4)									
YLLs	All ages number	107 19 667 (99 217 16 to 11 566 815)	4 154 023 (3 839 383 to 4 531 616)	6 565 644 (6 052 849 to 7 184 630)	17 643 805 (15 257 317 to 20 451 537)	6 834 223 (5 874 507 to 7 891 828)	10 809 582 (9 295 861 to 12 683 788)	64.6 (42.3 to 86.6)	64.5 (39.9 to 88.7)	64.6 (42.3 to 89)									
	Age-standardized rate (per 100 000)	6145 (5692.6 to 6621.4)	4972 (4575 to 5398)	7267.8 (6684 to 7913.1)	4075.1 (3561.3 to 4675)	3357.4 (2905.2 to 3842.2)	4748.9 (4132.7 to 5496.1)	-33.7 (-42.1 to -25.3)	-32.5 (-41.6 to -23.4)	-34.7 (-43.1 to -25.7)									
YLDs	All ages number	142 240 (94 617 to 201 761)	52 889 (35 329 to 74 579)	89 351 (69 292 to 127 739)	351 017 (234 240 to 494 898)	127 090 (85 093 to 179 956)	223 927 (148 743 to 316 962)	146.8 (141.1 to 152.9)	140.3 (132.9 to 148)	150.6 (143.9 to 157.6)									
	Age-standardized rate (per 100 000)	87.4 (58.5 to 122.9)	66.4 (45 to 93.3)	108.4 (72.8 to 152.2)	83.8 (56.5 to 117.2)	62.9 (42.3 to 87.8)	104.1 (70 to 145.8)	-4 (-6.1 to -2.1)	-5.3 (-8.1 to -2.3)	-4 (-6.4 to -1.8)									

Data in parentheses are 95% uncertainty intervals. DALYs, indicates disability-adjusted life years; IHD, ischemic heart disease; NAME, North Africa and Middle East; YLDs, years lived with disability; and YLLs, years of life lost.

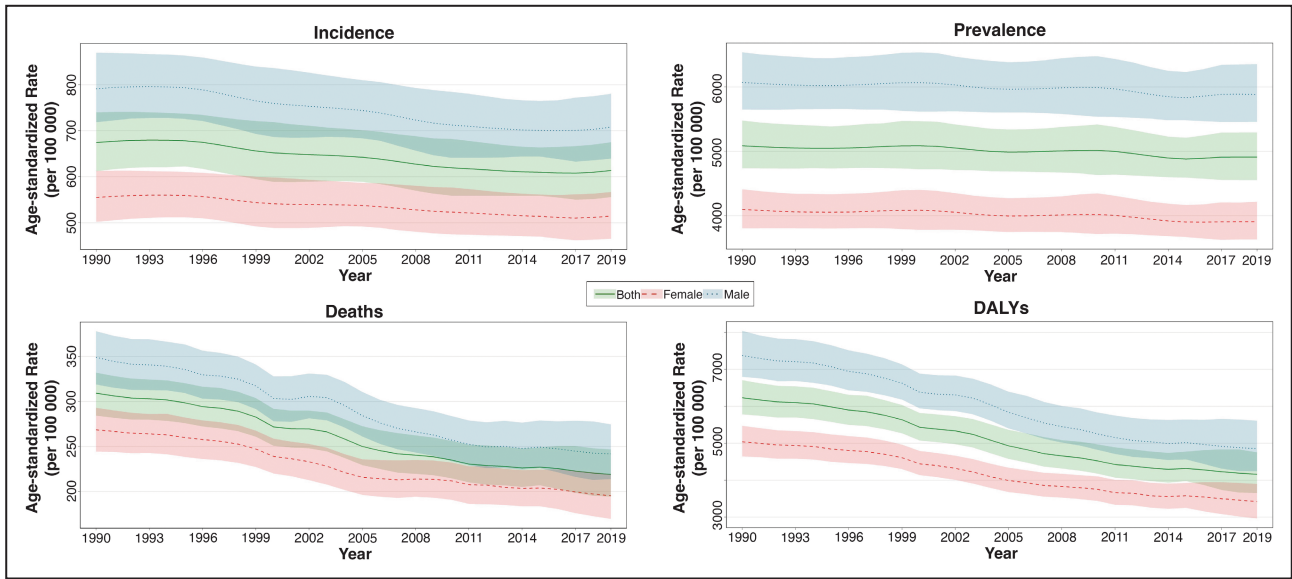


Figure 1. Time trend of age-standardized incidence, prevalence, death, and DALY rates of IHD in NAME from 1990 to 2019. DALY indicates disability-adjusted life years; IHD, ischemic heart disease; and NAME, North Africa and Middle East.

rate attributed to IHD was <4% for all NAME countries (Figure 3).

Mortality Rate

In 2019, 799000.5 people (57.6% men) died of IHD, corresponding to 17.6million YLLs (61.3% men), in the NAME region. The NAME region age-standardized death and YLL rates of IHD remarkably decreased by

29.2% (–36.9% to –21.8%) and –33.7% (–42.1% to –25.3%) during the study period and reached 219.0 (194.2–246.8) for death and 4075.1 (3561.3–4675.0) for YLLs in 2019 (Table 1; Figure 1). The corresponding worldwide figure was –30.8% (–34.8% to –27.2%) and –24.6% and 2177.0 (2034.0–2321.5) for YLLs, respectively. From 1990 to 2019, all countries in NAME demonstrated a decreasing trend for age-standardized death

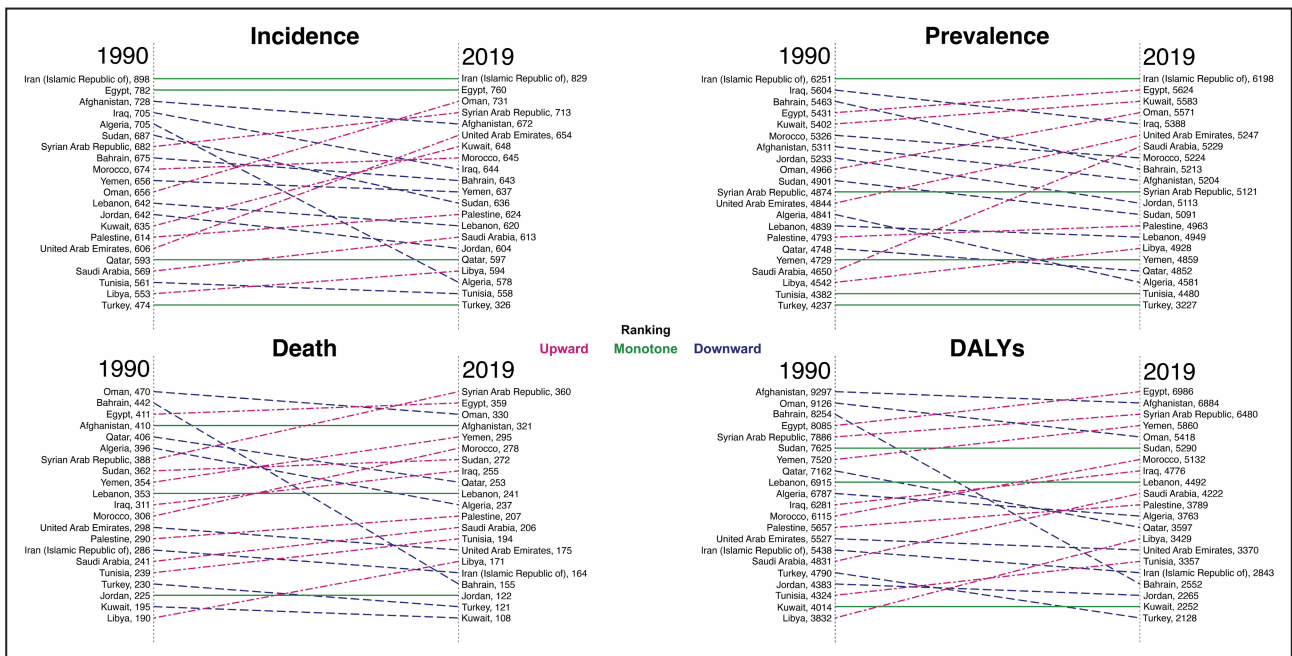


Figure 2. Ranking of NAME countries in terms of age-standardized incidence, prevalence, death, and DALY rates of IHD from 1990 to 2019.

DALY indicates disability-adjusted life years; IHD, ischemic heart disease; and NAME, North Africa and Middle East.

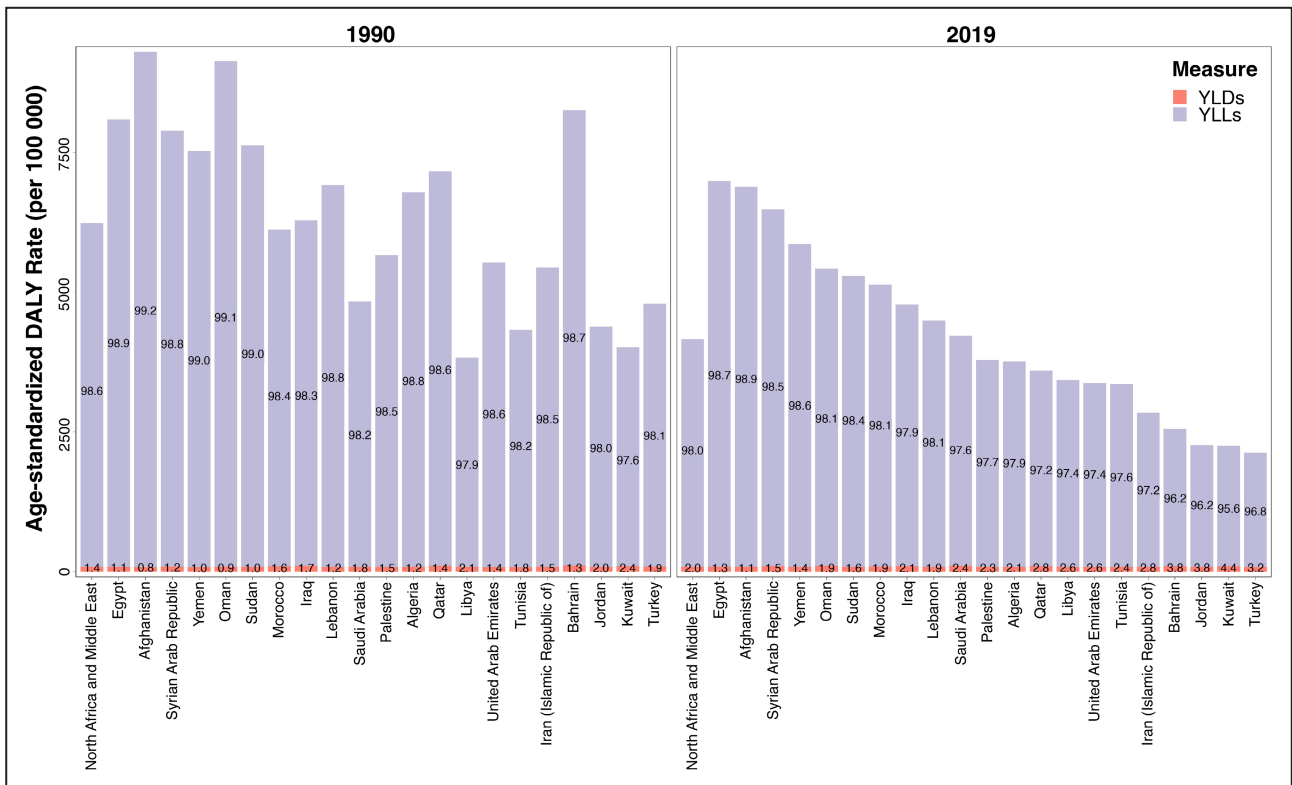


Figure 3. Age-standardized DALY rate of IHD and the contribution of YLLs and YLDs in NAME countries from 1990 to 2019. DALY indicates disability-adjusted life year; IHD, ischemic heart disease; NAME, North Africa and Middle East; YLDs, years lived with disability; and YLLs, years of life lost.

rates varying from a 7.2% (–28.4% to 22.9%) decrement in the Syrian Arab Republic to a 64.9% (–71.4% to –55.9%) decrease in Bahrain; however, the decreasing trend was not statistically significant for Egypt, Libya, Morocco, Saudi Arabia, Syrian Arab Republic, Tunisia, and Yemen. Similarly, the decrease in age-standardized YLL rate ranged from 11.0% (–31.1% to 16.9%) in Libya to 69.9% (–76.0% to –61.3%) in Bahrain with no statistically significant difference in Egypt, Libya, Saudi Arabia, Syrian Arab Republic, Tunisia, and Yemen (Table S1; Figure S1). Syrian Arab Republic had the highest and Kuwait had the lowest age-standardized death rate of IHD in NAME in 2019 (Figure 2).

Premature Death

In 2019, the share of premature IHD death was 26.8% and 18.4% for women and men, respectively, in the NAME region, compared with 16.9% and 14.8%, accordingly, at the global level (Table 2). The greatest reduction of IHD premature death from 1990 to 2019 was recorded by Turkey (55.6% for women and 37.8% for men) followed by Iran (48.3% for women and 21.6% for men) and Lebanon (39.0% for women and 33.5% for men) in NAME. In contrast, the United Arab Emirates (64.8% for women and 14.9% for men) and Saudi Arabia (60.4% for women and 48.7% for men)

showed a dramatic increase in the share of IHD premature deaths. A similar pattern was observed considering premature YLLs due to IHD (Table 2). From 1990 to 2019, Afghanistan demonstrated the widest sex inequality in IHD premature death, with 102.6% and 3.4% increase in the share of IHD premature death in men and women, respectively. In Palestine, the share of IHD premature death decreased by 10.1% in women from 1990 to 2019, while it increased by 31.5% in men (Table 2).

Morbidity

In 2019, 351 000 YLDs (63.8% men) were lost due to IHD, one-third of YLDs of stroke, in NAME. Moreover, there were 20.0million prevalent cases (61.5% men) of IHD in this year. The age-standardized YLD rate of IHD significantly decreased by 4.0% (–6.1% to –2.1%) from 1990 to 2019 and reached 83.8 (56.5–117.2) in NAME in 2019. The respective figures were –3.5% (–4.5% to –2.2%) and 4911.1 (4552.7–5295.1) for prevalence (Table 1; Figure 1). The variation of age-standardized YLD rate during the study period ranged from a 26.9% (–32.7% to –21%) significant decrease in Turkey to a significant 23.4% (15.3%–32.4%) increase in Oman. Comparably, the percentage change in the age-standardized prevalence rate from 1990 to 2019 varied

Downloaded from http://ahajournals.org by on August 15, 2024

Table 2. Share of Premature Deaths and YLLs due to IHD and Their Percentage Change From 1990 to 2019 in the World, NAME, and NAME Countries

Measure	Location	1990		2019		% Change (1990–2019)	
		Female, %	Male, %	Female, %	Male, %	Female, %	Male, %
Deaths	Global	18.6	16.7	16.9	14.8	-9.1	-11.4
	North Africa and Middle East	32	20.1	26.8	18.4	-16.3	-8.5
	Afghanistan	47.3	19.2	48.9	38.9	3.4	102.6
	Algeria	31.5	17.9	21	13.9	-33.3	-22.3
	Bahrain	36	30.3	29.8	28.5	-17.2	-5.9
	Egypt	31.9	20.4	32.8	18.6	2.8	-8.8
	Iran (Islamic Republic of)	33.1	19	17.1	14.9	-48.3	-21.6
	Iraq	28.2	19.1	27.9	17.9	-1.1	-6.3
	Jordan	29.8	26.6	22.9	23.9	-23.2	-10.2
	Kuwait	33.2	37.4	30.9	34.4	-6.9	-8.0
	Lebanon	25.4	17.6	15.5	11.7	-39.0	-33.5
	Libya	30.4	21	32.1	22.1	5.6	5.2
	Morocco	31.6	17.9	28.4	12.2	-10.1	-31.8
	Oman	30.1	26.1	26.6	23	-11.6	-11.9
	Palestine	24.8	14.3	22.3	18.8	-10.1	31.5
	Qatar	34.9	32.1	35.1	31.6	0.6	-1.6
	Saudi Arabia	33.8	23.8	54.2	35.4	60.4	48.7
	Sudan	34.9	21.1	32.1	20	-8.0	-5.2
	Syrian Arab Republic	34.5	22.9	28.5	16.6	-17.4	-27.5
	Tunisia	25.4	13.3	16.2	10.4	-36.2	-21.8
Turkey	25.9	20.1	11.5	12.5	-55.6	-37.8	
United Arab Emirates	33.8	49.6	55.7	57	64.8	14.9	
Yemen	35.7	26.7	35	23.3	-2.0	-12.7	
YLLs	Global	37.6	31.5	36.3	29.8	-3.5	-5.4
	North Africa and Middle East	52.9	34.9	47.8	34.2	-9.6	-2.0
	Afghanistan	65.9	31.7	69.9	58.2	6.1	83.6
	Algeria	52.7	34	42.3	29.6	-19.7	-12.9
	Bahrain	54.2	47.8	48.1	44.2	-11.3	-7.5
	Egypt	52.5	35.9	51	32.9	-2.9	-8.4
	Iran (Islamic Republic of)	53.9	32.3	36.1	31.3	-33.0	-3.1
	Iraq	49.5	34.5	48.6	31.7	-1.8	-8.1
	Jordan	49.2	42.6	40.6	40.7	-17.5	-4.5
	Kuwait	57.3	54.9	57.1	54.5	-0.3	-0.7
	Lebanon	45	31.7	32.9	26	-26.9	-18.0
	Libya	53.7	40.8	56	41.8	4.3	2.5
	Morocco	51.4	32.4	48.4	23.7	-5.8	-26.9
	Oman	47.4	41.2	44.3	40.7	-6.5	-1.2
	Palestine	43.2	27.3	41	32.8	-5.1	20.1
	Qatar	57.1	47.4	52	47.6	-8.9	0.4
	Saudi Arabia	55.6	39.9	74.3	51.3	33.6	28.6
	Sudan	55.9	36.7	55.5	37.3	-0.7	1.6
	Syrian Arab Republic	60.3	41.6	49.4	30.5	-18.1	-26.7
	Tunisia	44.3	26.1	33.5	22.4	-24.4	-14.2
Turkey	45.5	33.8	25.9	25.6	-43.1	-24.3	
United Arab Emirates	52.2	65.7	71.9	69.1	37.7	5.2	
Yemen	55.5	40.9	56.1	40.1	1.1	-2.0	

IHD indicates ischemic heart disease; NAME, North Africa and Middle East; and YLLs, years of life lost.

from a significant 23.8% (–26.8% to –20.3%) decrease in Turkey to a significant 12.4% (8.7%–16.4%) increase in Saudi Arabia (Table S1; Figure S1). In 2019, Iran had the highest and Turkey had the lowest age-standardized prevalence rate of IHD in NAME (Figure 2).

Incidence and Decomposition Analysis

In 2019, 2.6 million incident cases (60.2% men) of IHD occurred in NAME. From 1990 to 2019, the age-standardized incidence rate of IHD remarkably decreased by 9.0% (–10.3% to –7.5%) and reached 613.9 (555.8–675.2) in NAME in 2019 (Table 1, Figure 1). The variation of this measure during the study period ranged from a significant 31.4% (–34.9% to –27.4%) decrease in Turkey to a significant 11.4% (6.1%–17.4%) increase in Oman (Table S1). In 2019, Iran had the highest and Turkey had the lowest age-standardized incidence rate of IHD in NAME (Figure 2).

The number of incident cases of IHD grew by 135.1% in NAME from 1990 to 2019. According to the decomposition analysis, this increase was attributed to population growth (76.4%), age structure change (80.4%), and incidence rate change (–21.7%). Population growth and age structure change contributed to the increased number of incident cases of IHD in all NAME countries except for Afghanistan and Sudan; nonetheless, the incidence rate change varied from –80.3% in Turkey to 65.7% in the United Arab Emirates from 1990 to 2019 (Table S2).

Risk Factors

From 1990 to 2019, metabolic risk factors, followed by behavioral and environmental/occupational risks, contributed the most to the number of IHD DALYs attributed to risk factors in the NAME region. In 2019, 15.9 (13.7–18.6), 12.3 (10.5–14.4), and 6.9 (5.7–8.2) million IHD DALYs were attributed to metabolic, behavioral, and environmental/occupational risks, respectively, in NAME region (Table S3). The age-standardized DALY rate of IHD attributed to risk factors significantly decreased for combined all risk factors by 32.5% (–40.7% to –24.2%), metabolic risks by 28.7% (–37.1% to –18.9%), behavioral risks by 37.8% (–45.6% to –29.6%), and environmental/occupational risks by 36.4% (–44.7% to –27.7%) (Table S4). Considering the age-standardized DALY rate of IHD attributable to level 4 of risk factors, high systolic blood pressure, high low-density lipoprotein cholesterol, and high body mass index remained among the top 5 risk factors of IHD in NAME from 1990 to 2019. Although the age-standardized DALY rate attributable to high systolic blood pressure and high low-density lipoprotein cholesterol decreased by –28.9% (–38.3% to –18.7%) and –32.9% (–41.4% to –24.0%), respectively, the age-standardized DALY rate attributable to high fasting plasma glucose increased by

31.0% (9.1%–55.6%). Notably, the attributable burden of smoking significantly decreased by 41.5% (–49.6% to –32.6%) during the study period. Considering level 2 of risk factors, dietary risks, high systolic blood pressure, and high low-density lipoprotein cholesterol were the top 3 risks contributing to age-standardized DALYs and death rates in most countries of NAME in 2019 (Figure S2).

DISCUSSION

In 2019, IHD was the leading cause of burden of disease and death in NAME and accounted for 18 million DALYs and 0.8 million deaths in this region. Noticeably, people in the NAME region were more likely to die prematurely due to IHD compared with the rest of the world. Although NAME had the greatest age-standardized DALY rate of IHD in the world in 1990, the burden of IHD remarkably decreased from 1990 to 2019. Despite this great reduction, NAME still has the second rank of the burden of IHD globally, after Central Europe, Eastern Europe, and the Central Asia super-region. From 1990 to 2019, the age-standardized rates of DALYs, YLLs, and YLDs due to IHD significantly decreased; however, the reduction of DALYs arise mostly from a decrease in YLLs or death, rather than YLDs or morbidity of IHD. The decomposition analysis of the IHD incidence revealed that the inherent incidence change accounted for a >20% reduction in the incidence of IHD. Despite major reductions in the DALYs attributed to risk factors in NAME, metabolic risk factors and dietary risks remained to be addressed in IHD control.

NAME had the greatest burden of IHD in 1990, and despite a considerable reduction of its burden, NAME remained as one of the most alarming regions for IHD compared with others. In this study, we found that the reduction in death is the main driver for the decrease in DALYs of IHD in NAME, and YLDs of IHD decreased significantly but far less than YLLs of IHD. Generally, this finding underscores the greater importance of preventive and therapeutic measures rather than rehabilitation facilities in the region; nevertheless, each country should tailor this recommendation on the basis of its resources and epidemiologic profile of IHD such as YLLs/YLDs ratio and trend.²⁵

There are 2 widely accepted strategies to prevent IHD, population-based and individual-based.^{26,27} The presence of an extensive primary health care network enables the health system to implement population-based measures for risk factor control and, consequently, a more equal reduction of the IHD burden. The Individual-based approach, however, depends on sophisticated costly health care personnel and results in a more diverse reduction of the IHD burden.²⁸ Although each of these policies requires certain infrastructures and human resources, they can be adopted

by NAME countries on the basis of their health system profile. For instance, the extensive primary health care network of Iran can be leveraged for expanding primary and secondary preventive measures to control IHD risk factors.⁹ However, tackling NCDs, including IHD, requires multilevel approaches to implement tailored action plans for the control of these conditions. Some NAME countries, including Iran,^{29,30} Turkey,^{31,32} and the United Arab Emirates,³³ developed customized strategies to tackle NCDs, which may have lessons for other countries in the region. These strategies included the establishment of NCD monitoring programs as well as multisectoral collaboration between government, ministries of education and health, municipalities, and academia.³⁴ Moreover, tax implementation on tobacco products in some NAME countries might lead to the observed significant reduction of the attributable burden of smoking in the study.³⁴ Finally, the World Health Organization's best buys for control of NCDs should be evaluated in terms of cost-effectiveness and adopted on the basis of health system priorities, especially in low- and middle-income countries.³⁵

The proportion of IHD premature death decreased in NAME from 1990 to 2019; however, this reduction was not consistent across NAME countries. Furthermore, premature mortality rates in NAME are still higher than the global measure and high-SDI regions.^{36–38} Adoption of premature death as part of the Sustainable Development Goal target 3.4 by the United Nations highlights its public health priority.³⁹ It should be noted that we defined sex-specific premature death for IHD in this study, and this definition is not the same as the definition of the United Nations for NCDs, albeit both definitions share mutual concepts. Given the higher mortality rate of young adults, especially women, in the setting of acute IHD,^{40–43} improved health care access and quality of care,^{5,44} particularly in the acute setting, along with enhancement of medical education and health care workers' awareness on unusual signs and symptoms of IHD in the young population may address the high rate of IHD premature death in the NAME region. Although the establishment of modern therapeutic facilities including catheterization laboratories and fibrinolytic administration facilities may diminish the IHD premature death and burden, the successful implementation of these advanced therapeutic interventions should be ensured.^{45–47} In addition, access to coronary artery bypass grafting procedures, which showed cost-effectiveness in NAME countries, should be improved to diminish the IHD burden.^{48,49} However, the establishment of these treatment facilities is resource-intensive, imposing a financial burden on the health system. This should be factored into public health policymaking and tailored on the basis of the health priorities and health expenditures of each country. Notably, expanding therapeutic infrastructures may cut the burden of IHD in the short term; nevertheless, implementing

nationwide preventive programs, especially for high-risk patients such as those with a family history of IHD or patients with hereditary dyslipidemia, may be more cost-effective as a long-term policy.^{26,27}

The NAME region demonstrated a remarkable improvement in the age-standardized DALY rate of IHD attributed to risk factors, which is comparable with the global measure, 32.5% versus 28.8%.^{1,2} This decrease might play an important role in the significant reduction of the IHD burden in this region; however, much remains to be done. Metabolic risks remained the major contributor to IHD in NAME. These risks need to be reduced by multiple risk factor interventions that have shown effectiveness in low- and middle-income countries.⁵⁰ Another strategy should focus on enhancing awareness and effective treatment of cardiovascular risk factors. This is while regional studies showed suboptimal awareness of diabetes and hypertension, and also underuse of medications to control NCD risk factors.^{51–53} The predominance of metabolic and dietary risks contributing to IHD calls for expanding social media campaigns, a cost-effective tool, to encourage people to adopt a more healthy lifestyle, including a healthy diet and increased physical activity.³⁵ Introduction of polypills in recent years may also depict new horizons in the primary and secondary prevention of IHD.^{54–56}

Our findings provide a general epidemiologic picture of IHD in NAME countries. These data inform public health policymakers to adopt customized and cost-effective strategies according to their available infrastructure and resources to control IHD; nonetheless, disparities across demographic subgroups of age, sex, race, and ethnicity should be addressed.⁵ Between 1990 and 2019, we found a remarkably greater increase in IHD premature death in Afghan men (>100%) compared with women (<5%), and an increase in IHD premature death in men compared with a decrease in women in Palestine. These sex disparities may arise from poor quality of data sources including vital registrations, which in turn introduces uncertainty into epidemiologic modeling. However, they may imply a true inequality that should be further delineated and addressed. The lack of data on these health inequalities in NAME, in contrast with high-SDI countries, necessitates further studies in this region.^{41–43} The Quality of Care Index has been recently introduced and adopted to assess the quality of care and health inequalities for different diseases including IHD using the GBD results.^{5,57–61} This method involves dimension reduction strategies to combine death, DALYs, YLLs, YLDs, incidence, and prevalence to provide an epidemiologically plausible index representing the care quality of IHD.⁵ Therefore, the Quality of Care Index holds promise to assess the disparities in the quality of care of IHD across demographic subgroups in NAME and other regions using GBD.

Among NAME countries, Turkey had one of the lowest burdens of IHD in the region from 1990 to 2019 and successfully managed to cut the IHD burden by >50%. This achievement correlates and may originate from the successive growth of the gross domestic product per capita and SDI of Turkey during the study period.^{19,62} In addition to the control of NCDs,^{31,32} Turkey established percutaneous coronary intervention facilities across the country and is actively monitoring the management of IHD by conducting nationwide studies and acute myocardial infarction registries.⁶³ Reforming the national health system of Turkey may also be a factor in the significant reduction of the IHD burden. While Iran had the highest incidence and prevalence of IHD in NAME from 1990 to 2019, its DALYs and death rates due to IHD were far less than other NAME countries. Although the higher prevalence of IHD in this country might be the result of higher-quality screening and diagnostic strategies resulting in identifying more cases, it may also reflect inadequate primary prevention strategies for controlling risk factors before they result in a clinically identifiable IHD.⁶⁴ The significantly lower DALYs and death rate might also partially arise from better diagnosis strategies, resulting in diagnosis in earlier stages and therefore milder IHD, although it might be partially a reflection of better secondary prevention of IHD in Iran.^{9,25} In this country, availability and affordability of acute care for IHD were improved in recent years,⁴⁵ and national efforts were directed at a multisectoral approach to address NCDs^{29,30}; nevertheless, these efforts aimed at the primary prevention of IHD should be strengthened to reduce the incidence of IHD in future years.⁶⁴ The dramatic increase in the share of IHD premature death in the United Arab Emirates and Saudi Arabia is alarming and necessitates an appropriate public health response. These increases may be due to their increase in gross domestic product and the bell-shaped association between SDI and IHD death.^{4,11,62}

Limitations

GBD is a global effort to depict the epidemiologic picture of diseases worldwide using the available data and a complex analytic framework; however, it has some inherent limitations.¹⁻⁴ Incompleteness or even lack of vital registrations, verbal autopsy, and other health data sources are major drawbacks for the estimation of IHD burden in NAME. These limitations may be more exaggerated in this region due to the ongoing wars and conflicts in NAME. Investment in health data management systems and other infrastructures is highly encouraged to improve the quality of input data for IHD modeling. While we interpreted the trends of the IHD burden in the context of current IHD control plans in NAME countries to highlight the possibly successful health policies,

we cannot establish causal relationships between the policies and trends in this study. Future studies are warranted to evaluate the downstream effects of specific IHD control policies.

CONCLUSIONS

IHD was the leading cause of death and lost DALYs, accounting for 0.8 million deaths and 18 million DALYs in NAME in 2019. The age-standardized DALY rate of IHD decreased by >30% in NAME from 1990 to 2019; however, NAME still has the second rank in the burden of IHD globally. People in NAME were more likely to die prematurely due to IHD compared with the global average. While the age-standardized DALY rate of IHD attributed to risk factors significantly decreased from 1990 to 2019, metabolic and dietary risks are still major setbacks for the control of IHD. There are some control plans for IHD in place in some NAME countries, including multisectoral and interdisciplinary committees for control of NCDs and their risk factors, and expansion of catheterization labs and fibrinolytic injection facilities for the acute management of IHD. Although some of them proved effective in reducing the IHD burden according to this study, they are yet to be adopted and evaluated by other countries in the region. Health inequalities, and sex, ethnicity, and age disparities should be on the agenda of future research in NAME to ensure uniform improvement of the IHD burden in the region.

ARTICLE INFORMATION

Received May 1, 2023; accepted October 30, 2023.

Affiliations

Section of Cardiovascular Medicine, Department of Internal Medicine, Yale School of Medicine, New Haven, CT (A.A.); Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute (A.A., S.S.M., H.T., H.E., M.N., P.S., A.G., Nazila Rezaei, M.-R.M., R.H., Negar Rezaei, F.F.) and Tehran Heart Center, Cardiovascular Diseases Research Institute (A.A., H.T., M.N.), Tehran University of Medical Sciences, Tehran, Iran; Kiel Institute for the World Economy, Kiel, Germany (S.S.M.); Department of Medicine, Rutgers New Jersey Medical School, Newark, NJ (Z.A.); Endocrinology and Metabolism Research Center (EMRC), Vali-Asr Hospital, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran (B.H.); Department of Cardiovascular Medicine, Mayo Clinic, Rochester, MN (M.N.); and Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran (B.L., F.F.).

Sources of Funding

This study was not funded; however, the GBD study 2019 was supported by the Bill and Melinda Gates Foundation. The funder had no roles in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or final approval of the manuscript; and decision to submit the manuscript for publication.

Disclosures

None.

Supplemental Material

Tables S1–S4

Figures S1–S2

REFERENCES

- GBD 2019 Diseases and Injuries Collaborators. 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. *Lancet*. 2020;396:1204–1222. doi: [10.1016/s0140-6736\(20\)30925-9](https://doi.org/10.1016/s0140-6736(20)30925-9)
- GBD 2019 Demographics Collaborators. Global age-sex-specific fertility, mortality, healthy life expectancy (HALE), and population estimates in 204 countries and territories, 1950–2019: a comprehensive demographic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396:1160–1203. doi: [10.1016/s0140-6736\(20\)30977-6](https://doi.org/10.1016/s0140-6736(20)30977-6)
- GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2020;396:1223–1249. doi: [10.1016/s0140-6736\(20\)30752-2](https://doi.org/10.1016/s0140-6736(20)30752-2)
- Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, Barengo NC, Beaton AZ, Benjamin EJ, Benziger CP, et al. Global burden of cardiovascular diseases and risk factors, 1990–2019. *J Am Coll Cardiol*. 2020;76:2982–3021. doi: [10.1016/j.jacc.2020.11.010](https://doi.org/10.1016/j.jacc.2020.11.010)
- Aminorroaya A, Yousefi M, Rezaei N, Shabani M, Mohammadi E, Fattahi N, Azadnajafabad S, Nasserinejad M, Rezaei N, Naderimaghani S, et al. Global, regional, and national quality of care of ischaemic heart disease from 1990 to 2017: a systematic analysis for the Global Burden of Disease Study 2017. *Eur J Prev Cardiol*. 2022;29:371–379. doi: [10.1093/eurjpc/zwab066](https://doi.org/10.1093/eurjpc/zwab066)
- Dai H, Much AA, Maor E, Asher E, Younis A, Xu Y, Lu Y, Liu X, Shu J, Bragazzi NL. Global, regional, and national burden of ischemic heart disease and its attributable risk factors, 1990–2017: results from the Global Burden of Disease Study 2017. *Eur Heart J Qual Care Clin Outcomes*. 2020;8:50–60. doi: [10.1093/EHJQCCO/QCAA076](https://doi.org/10.1093/EHJQCCO/QCAA076)
- Akala FA, El-Saharty S. Public-health challenges in the Middle East and North Africa. *Lancet*. 2006;367:961–964. doi: [10.1016/S0140-6736\(06\)68402-X](https://doi.org/10.1016/S0140-6736(06)68402-X)
- Traina MI, Almahmeed W, Edris A, Murat TE. Coronary heart disease in the Middle East and North Africa: current status and future goals. *Curr Atheroscler Rep*. 2017;19:24. doi: [10.1007/s11883-017-0659-9](https://doi.org/10.1007/s11883-017-0659-9)
- Farzadfar F, Naghavi M, Sepanlou SG, Saeedi Moghaddam S, Dangel WJ, Davis Weaver N, Aminorroaya A, Azadnajafabad S, Koolaji S, Mohammadi E, et al. Health system performance in Iran: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2022;399:1625–1645. doi: [10.1016/S0140-6736\(21\)02751-3](https://doi.org/10.1016/S0140-6736(21)02751-3)
- Gehani AA, Al-Hinai AT, Zubaid M, Almahmeed W, Hasani MRM, Yusufali AH, Hassan MO, Lewis BS, Islam S, Rangarajan S, et al. Association of risk factors with acute myocardial infarction in Middle Eastern countries: the INTERHEART Middle East study. *Eur J Prev Cardiol*. 2014;21:400–410. doi: [10.1177/2047487312465525](https://doi.org/10.1177/2047487312465525)
- GBD 2015 Eastern Mediterranean Region Cardiovascular Disease Collaborators. Burden of cardiovascular diseases in the eastern Mediterranean region, 1990–2015: findings from the Global Burden of Disease 2015 Study. *Int J Public Health*. 2018;63 (Suppl 1):S137–S149. doi: [10.1007/s00038-017-1012-3](https://doi.org/10.1007/s00038-017-1012-3)
- Khan MAB, Hashim MJ, Mustafa H, Baniyas MY, Al Suwaidi S, Alkathheeri R, Alblooshi FMK, Almatrooshi M, Alzaabi MEH, Al Darmaki RS, et al. Global epidemiology of ischemic heart disease: results from the Global Burden of Disease Study. *Cureus*. 2020;12:12. doi: [10.7759/CUREUS.9349](https://doi.org/10.7759/CUREUS.9349)
- Stevens GA, Alkema L, Black RE, Boerma JT, Collins GS, Ezzati M, Grove JT, Hogan DR, Hogan MC, Horton R, et al. Guidelines for accurate and transparent health estimates reporting: the GATHER statement. *Lancet*. 2016;388:e19–e23. doi: [10.1016/S0140-6736\(16\)30388-9](https://doi.org/10.1016/S0140-6736(16)30388-9)
- Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, White HD; Executive Group on behalf of the Joint European Society of Cardiology (ESC)/American College of Cardiology (ACC)/American Heart Association (AHA)/World Heart Federation (WHF) Task Force for the Universal Definition of Myocardial Infarction. Fourth universal definition of myocardial infarction (2018). *J Am Coll Cardiol*. 2018;72:2231–2264. doi: [10.1016/j.jacc.2018.08.1038](https://doi.org/10.1016/j.jacc.2018.08.1038)
- Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, Himmelfarb CD, Khera A, Lloyd-Jones D, McEvoy JW, et al. 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation*. 2019;140:e596–e646. doi: [10.1161/CIR.0000000000000678](https://doi.org/10.1161/CIR.0000000000000678)
- Visseren FLJ, Mach F, Smulders YM, Carballo D, Koskinas KC, Bäck M, Benetos A, Biffi A, Boavida JM, Capodanno D, et al. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. *Eur Heart J*. 2021;42:3227–3337. doi: [10.1093/eurheartj/ehab484](https://doi.org/10.1093/eurheartj/ehab484)
- Dugani SB, Murad W, Damilig K, Atos J, Mohamed E, Callachan E, Farukhi Z, Shaikh A, Elfatih A, Yusef S, et al. Premature myocardial infarction in the Middle East and North Africa: rationale for the Gulf PREVENT study. *Angiology*. 2020;71:17–26. doi: [10.1177/0003319719849737](https://doi.org/10.1177/0003319719849737)
- Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, McQueen M, Budaj A, Pais P, Varigos J, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet*. 2004;364:937–952. doi: [10.1016/s0140-6736\(04\)17018-9](https://doi.org/10.1016/s0140-6736(04)17018-9)
- Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (GBD 2019) socio-demographic index (SDI) 1950–2019. Institute for Health Metrics and Evaluation (IHME). Updated on March 3, 2023. Accessed on August 19, 2023. <https://ghdx.healthdata.org/record/ihme-data/gbd-2019-socio-demographic-index-sdi-1950-2019>
- Global Burden of Disease (GBD). Institute for Health Metrics and Evaluation (IHME). Accessed on August 19, 2023. <https://www.healthdata.org/research-analysis/about-gbd>
- Global Burden of Disease data and tools guide, Appendix 1: Full list of locations, diseases, injuries, and risk factors. Institute for Health Metrics and Evaluation (IHME). Accessed on August 19, 2023. <https://www.healthdata.org/research-analysis/about-gbd/gbd-data-and-tools-guide>
- Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2019 (GBD 2019) cause list mapped to ICD codes. Institute for Health Metrics and Evaluation (IHME). Updated on March 3, 2023. Accessed on August 19, 2023. <https://ghdx.healthdata.org/record/ihme-data/gbd-2019-cause-icd-code-mappings>
- GBD 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet*. 2017;390:1151–1210. doi: [10.1016/S0140-6736\(17\)32152-9](https://doi.org/10.1016/S0140-6736(17)32152-9)
- Fitzmaurice C, Dicker D, Pain A, Hamavid H, Moradi-Lakeh M, MacIntyre MF, Allen C, Hansen G, Woodbrook R, Wolfe C, et al. The global burden of cancer 2013. *JAMA Oncol*. 2015;1:505–527. doi: [10.1001/jamaoncol.2015.0735](https://doi.org/10.1001/jamaoncol.2015.0735)
- Aminorroaya A, Fattahi N, Azadnajafabad S, Mohammadi E, Jamshidi K, Rouhifard Khalilabad M, Mohammadi Fateh S, Naderimaghani S, Rezaei N, Larjani B, et al. Burden of non-communicable diseases in Iran: past, present, and future. *J Diabetes Metab Disord*. 2020;1–7. doi: [10.1007/s40200-020-00669-z](https://doi.org/10.1007/s40200-020-00669-z)
- Rose GA. *The Strategy of Preventive Medicine*. Oxford University Press; 1992.
- Manuel DG, Lim J, Tanuseputro P, Anderson GM, Alter DA, Laupacis A, Mustard CA. Revisiting Rose: strategies for reducing coronary heart disease. *BMJ*. 2006;332:659–662. doi: [10.1136/bmj.332.7542.659](https://doi.org/10.1136/bmj.332.7542.659)
- Capewell S, Graham H. Will cardiovascular disease prevention widen health inequalities? *PLoS Med*. 2010;7:e1000320. doi: [10.1371/journal.pmed.1000320](https://doi.org/10.1371/journal.pmed.1000320)
- Peykari N, Hashemi H, Dinarvand R, Haji-Aghajani M, Malekzadeh R, Sadrolsadat A, Sayyari AA, Asadi-Lari M, Delavari A, Farzadfar F, et al. National action plan for non-communicable diseases prevention and control in Iran; a response to emerging epidemic. *J Diabetes Metab Disord*. 2017;16:3. doi: [10.1186/s40200-017-0288-4](https://doi.org/10.1186/s40200-017-0288-4)
- Amerzadeh M, Salavati S, Takian A, Namaki S, Asadi-Lari M, Delpisheh A, Farzadfar F, Ghanei M, Haghdoost AA, Haji-Aghajani M, et al. Proactive agenda setting in creation and approval of national action plan for prevention and control of non-communicable diseases in Iran: the use of multiple streams model. *J Diab Metab Disord*. 2020. doi: [10.1007/s40200-020-00591-4](https://doi.org/10.1007/s40200-020-00591-4)
- Breda J, Allen LN, Tibet B, Erguder T, Karabulut E, Yildirim HH, Mok A, Wickramasinghe K. Estimating the impact of achieving Turkey's non-communicable disease policy targets: a macro-simulation modelling study. *Lancet Reg Health Eur*. 2021;100018. doi: [10.1016/j.lanep.2020.100018](https://doi.org/10.1016/j.lanep.2020.100018)
- Republic of Turkey Ministry of Health, Department of chronic diseases elderly health and disabled people of the public health institution. Multisectoral action plan of Turkey for noncommunicable diseases, 2017–2025. 2017. Accessed on August 19, 2023. <https://cdn.who.int/media/docs/librariesprovider2/country-sites/multisecto>

- ral-action-plan-of-turkey-for-noncommunicable-diseases-2017-2025-(english-and-turkish)9718061-5d52-4d6f-adab-f21d292c48f9.pdf?sfvrsn=377621a3_1&download=true
33. Fadhil I, Belaila B, Razzak H. National accountability and response for noncommunicable diseases in The United Arab Emirates. *Int J Noncommun Dis*. 2019;4:4–9. doi: [10.4103/jncd.jncd_55_18](https://doi.org/10.4103/jncd.jncd_55_18)
 34. Fadhil I, Ali R, Al-Raisi SS, Bin Belaila BA, Galadri S, Javed A, Sulaiman K, Saeed K, Arifeen S. Review of national healthcare systems in the Gulf Cooperation Council Countries for noncommunicable diseases management. *Oman Med J*. 2022;37:e370. doi: [10.5001/omj.2021.96](https://doi.org/10.5001/omj.2021.96)
 35. Bakhtiari A, Takian A, Majdzadeh R, Haghdoost AA. Assessment and prioritization of the WHO “best buys” and other recommended interventions for the prevention and control of non-communicable diseases in Iran. *BMC Public Health*. 2020;20:333. doi: [10.1186/s12889-020-8446-x](https://doi.org/10.1186/s12889-020-8446-x)
 36. Hervella MI, Carratalá-Munuera C, Orozco-Beltrán D, López-Pineda A, Bertomeu-González V, Gil-Guillén VF, Pascual R, Quesada JA. Trends in premature mortality due to ischemic heart disease in Spain from 1998 to 2018. *Rev Esp Cardiol (Engl Ed)*. 2021;74:838–845. doi: [10.1016/j.rec.2020.09.034](https://doi.org/10.1016/j.rec.2020.09.034)
 37. Chen Y, Freedman ND, Albert PS, Huxley RR, Shiels MS, Withrow DR, Spillane S, Powell-Wiley TM, Berrington de González A. Association of cardiovascular disease with premature mortality in the United States. *JAMA Cardiol*. 2019;4:1230–1238. doi: [10.1001/jamacardio.2019.3891](https://doi.org/10.1001/jamacardio.2019.3891)
 38. Ordunez P, Prieto-Lara E, Pinheiro Gawryszewski V, Hennis AJ, Cooper RS. Premature mortality from cardiovascular disease in the Americas—will the goal of a decline of “25% by 2025” be met? *PLoS One*. 2015;10:e0141685. doi: [10.1371/journal.pone.0141685](https://doi.org/10.1371/journal.pone.0141685)
 39. Department of Economic and Social Affairs of United Nations. Sustainable Development Goal 3. United Nations. Accessed on August 19, 2023. <https://sdgs.un.org/goals/goal3>
 40. Ford ES, Capewell S. Coronary heart disease mortality among young adults in the U.S. from 1980 through 2002: concealed leveling of mortality rates. *J Am Coll Cardiol*. 2007;50:2128–2132. doi: [10.1016/j.jacc.2007.05.056](https://doi.org/10.1016/j.jacc.2007.05.056)
 41. Smilowitz NR, Maduro GA Jr, Lobach IV, Chen Y, Reynolds HR. Adverse trends in ischemic heart disease mortality among young New Yorkers, particularly young Black women. *PLoS One*. 2016;11:e0149015. doi: [10.1371/journal.pone.0149015](https://doi.org/10.1371/journal.pone.0149015)
 42. Khara S, Kolte D, Gupta T, Subramanian KS, Khanna N, Aronow WS, Ahn C, Timmermans RJ, Cooper HA, Fonarow GC, et al. Temporal trends and sex differences in revascularization and outcomes of ST-segment elevation myocardial infarction in younger adults in the United States. *J Am Coll Cardiol*. 2015;66:1961–1972. doi: [10.1016/j.jacc.2015.08.865](https://doi.org/10.1016/j.jacc.2015.08.865)
 43. Alabas OA, Gale CP, Hall M, Rutherford MJ, Szummer K, Lawesson SS, Alfredsson J, Lindahl B, Jernberg T. Sex differences in treatments, relative survival, and excess mortality following acute myocardial infarction: national cohort study using the SWEDEHEART registry. *J Am Heart Assoc*. 2017;6:e007123. doi: [10.1161/JAHA.117.007123](https://doi.org/10.1161/JAHA.117.007123)
 44. GBD 2015 Healthcare Access and Quality Collaborators. Healthcare access and quality index based on mortality from causes amenable to personal health care in 195 countries and territories, 1990–2015: a novel analysis from the Global Burden of Disease Study 2015. *Lancet*. 2017;390:231–266. doi: [10.1016/s0140-6736\(17\)30818-8](https://doi.org/10.1016/s0140-6736(17)30818-8)
 45. Abdi S, Haji Aghajani M, Janbabaie G, Noohi F, Kermanchi J, Salarifar M, Geraiely B, Sadeghipour P, Kazemi-Saleh D, Firouzi A, et al. 24/7 Primary percutaneous coronary intervention as a national program. *Crit Pathw Cardiol*. 2021;20:81–87. doi: [10.1097/hpc.0000000000000244](https://doi.org/10.1097/hpc.0000000000000244)
 46. Shehab A, Al-Habib K, Hersi A, Al-Faleh H, Alsheikh-Ali A, Almahmeed W, Suleiman KJ, Al-Motarrab A, Suwaidy JA, Asaad N, et al. Quality of care in primary percutaneous coronary intervention for acute ST-segment-elevation myocardial infarction: Gulf RACE 2 experience. *Ann Saudi Med*. 2014;34:482–487. doi: [10.5144/0256-4947.2014.482](https://doi.org/10.5144/0256-4947.2014.482)
 47. Alhabib KF, Kinsara AJ, Alghamdi S, Al-Murayeh M, Hussein GA, AlSaif S, Khalaf H, Alfaleh H, Hersi A, Kashour T, et al. The first survey of the Saudi Acute Myocardial Infarction Registry Program: main results and long-term outcomes (STARS-1 program). *PLoS One*. 2019;14:e0216551. doi: [10.1371/journal.pone.0216551](https://doi.org/10.1371/journal.pone.0216551)
 48. Fakhrazad N, Barouni M, Goudarzi R, Kojuri J, Jahani Y, Tasavon Gholamhoseini M. Cost-effectiveness analysis of coronary arteries bypass grafting (CABG) and percutaneous coronary intervention (PCI) through drug stent in Iran: a comparative study. *Cost Eff Resour Alloc*. 2023;21:16. doi: [10.1186/s12962-023-00426-y](https://doi.org/10.1186/s12962-023-00426-y)
 49. Baser O, Burkan A, Baser E, Koselerli R, Ertugay E, Altinbas A. High cost patients for cardiac surgery and hospital quality in Turkey. *Health Policy*. 2013;109:143–149. doi: [10.1016/j.healthpol.2012.09.015](https://doi.org/10.1016/j.healthpol.2012.09.015)
 50. Uthman OA, Hartley L, Rees K, Taylor F, Ebrahim S, Clarke A. Multiple risk factor interventions for primary prevention of cardiovascular disease in low- and middle-income countries. *Cochrane Database Syst Rev*. 2015;2015:CD011163. doi: [10.1002/14651858.CD011163.pub2](https://doi.org/10.1002/14651858.CD011163.pub2)
 51. Aryan Z, Mahmoudi N, Sheidaei A, Rezaei S, Mahmoudi Z, Gohari K, Rezaei N, Hajipour MJ, Dilmaghani-Marand A, Razi F, et al. The prevalence, awareness, and treatment of lipid abnormalities in Iranian adults: surveillance of risk factors of noncommunicable diseases in Iran 2016. *J Clin Lipidol*. 2018;12:1471–1481.e1474. doi: [10.1016/j.jacl.2018.08.001](https://doi.org/10.1016/j.jacl.2018.08.001)
 52. Moradi-Lakeh M, El Bcheraoui C, Daoud F, Tuffaha M, Wilson S, Al Saeedi M, Basulaiman M, Memish ZA, AlMazroa MA, Al Rabeeah AA, et al. Medication use for chronic health conditions among adults in Saudi Arabia: findings from a national household survey. *Pharmacoepidemiol Drug Saf*. 2016;25:73–81. doi: [10.1002/pds.3904](https://doi.org/10.1002/pds.3904)
 53. El Bcheraoui C, Basulaiman M, Tuffaha M, Daoud F, Robinson M, Jaber S, Mikhitarian S, Memish ZA, Al Saeedi M, AlMazroa MA, et al. Status of the diabetes epidemic in the Kingdom of Saudi Arabia, 2013. *Int J Public Health*. 2014;59:1011–1021. doi: [10.1007/s00038-014-0612-4](https://doi.org/10.1007/s00038-014-0612-4)
 54. Roshandel G, Khoshnia M, Poustchi H, Hemming K, Kamangar F, Gharavi A, Ostovaneh MR, Nateghi A, Majed M, Navabakhsh B, et al. Effectiveness of poly pill for primary and secondary prevention of cardiovascular diseases (PolyIran): a pragmatic, cluster-randomised trial. *Lancet*. 2019;394:672–683. doi: [10.1016/S0140-6736\(19\)31791-X](https://doi.org/10.1016/S0140-6736(19)31791-X)
 55. Muñoz D, Uzoije P, Reynolds C, Miller R, Walkley D, Pappalardo S, Tousey P, Munro H, Gonzales H, Song W, et al. Poly pill for cardiovascular disease prevention in an underserved population. *N Engl J Med*. 2019;381:1114–1123. doi: [10.1056/NEJMoa1815359](https://doi.org/10.1056/NEJMoa1815359)
 56. Chow CK, Meng Q. Poly pills for primary prevention of cardiovascular disease. *Nat Rev Cardiol*. 2019;16:602–611. doi: [10.1038/s41569-019-0209-y](https://doi.org/10.1038/s41569-019-0209-y)
 57. Azadnajafabad S, Saeedi Moghaddam S, Mohammadi E, Rezaei N, Ghasemi E, Fattahi N, Aminorroaya A, Azadnajafabad R, Aryannejad A, Rezaei N, et al. Global, regional, and national burden and quality of care index (QCI) of thyroid cancer: a systematic analysis of the Global Burden of Disease Study 1990–2017. *Cancer Med*. 2021;10:2496–2508. doi: [10.1002/cam4.3823](https://doi.org/10.1002/cam4.3823)
 58. Keykhaei M, Masinaei M, Mohammadi E, Azadnajafabad S, Rezaei N, Saeedi Moghaddam S, Rezaei N, Nasserinejad M, Abbasi-Kangevari M, Malekpour MR, et al. A global, regional, and national survey on burden and quality of care index (QCI) of hematologic malignancies: global burden of disease systematic analysis 1990–2017. *Exp Hematol Oncol*. 2021;10:11. doi: [10.1186/s40164-021-00198-2](https://doi.org/10.1186/s40164-021-00198-2)
 59. Nejad M, Ahmadi N, Mohammadi E, Shabani M, Sherafati A, Aryannejad A, Rezaei N, Ghanbari A, Yoosefi M, Aminorroaya A, et al. Global and regional burden and quality of care of non-rheumatic valvular heart diseases: a systematic analysis of Global Burden of Disease 1990–2017. *Int J Qual Health Care*. 2022;34:mzac026. doi: [10.1093/intqhc/mzac026](https://doi.org/10.1093/intqhc/mzac026)
 60. Momtazmanesh S, Saeedi Moghaddam S, Malakan Rad E, Azadnajafabad S, Ebrahimi N, Mohammadi E, Rouhifard M, Rezaei N, Masinaei M, Rezaei N, et al. Global, regional, and national burden and quality of care index of endocarditis: the Global Burden of Disease Study 1990–2019. *Eur J Prev Cardiol*. 2022;29:1287–1297. doi: [10.1093/eurjpc/zwab211](https://doi.org/10.1093/eurjpc/zwab211)
 61. Fattahi N, Ghanbari A, Djalalinia S, Rezaei N, Mohammadi E, Azadnajafabad S, Abbasi-Kangevari M, Aryannejad A, Aminorroaya A, Rezaei N, et al. Global, regional, and national quality of care index (QCI) of gastric cancer: a systematic analysis for the Global Burden of Disease Study 1990–2017. *J Gastrointest Cancer*. 2023. doi: [10.1007/s12029-023-00950-3](https://doi.org/10.1007/s12029-023-00950-3)
 62. GDP per capita (current US\$). The World Bank. 2021. Accessed on August 19, 2023. <https://data.worldbank.org/indicator/NY.GDP.PCAP.CD>
 63. Erol MK, Kayıkçıoğlu M, Kılıçkap M. Rationale and design of the Turkish acute myocardial infarction registry: the TURKMI study. *Anatol J Cardiol*. 2020;23:169–175. doi: [10.14744/AnatolJCardiol.2019.57522](https://doi.org/10.14744/AnatolJCardiol.2019.57522)
 64. Ebrahimi H, Masinaei M, Aminorroaya A, Aryan Z, Mehdi-pour P, Rostam-Abadi Y, Ahmadi N, Saeedi Moghaddam S, Pishgar F, Ghanbari A, et al. Risk of incident cardiovascular diseases at national and subnational levels in Iran from 2000 to 2016 and projection through 2030: insights from Iran STEPS surveys. *PLoS One*. 2023;18:e0290006. doi: [10.1371/journal.pone.0290006](https://doi.org/10.1371/journal.pone.0290006)