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Original Article

Burden of Cardiovascular Diseases Among Older Adults in Iran, 1990-2023

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Abstract

Objectives: This study aimed to assess the burden and temporal trends of cardiovascular diseases (CVDs) among adults aged ≥60 years in Iran from 1990 to 2023.

Design: Systematic analysis.

Setting(s): Iran.

Participants: Adults aged 60 years and older.

Outcome Measures: Data were obtained from the Global Burden of Disease (GBD) 2023 study. Using GBD methods, prevalence, mortality, and disability-adjusted life year (DALY) rates for CVDs from 1990 to 2023 were estimated for Iran to allow comparisons across time. Then, analyses were conducted based on age, gender, province, and cause of CVDs, and 95% uncertainty intervals (UIs) were reported.

Results: In 2023, approximately 3.4 million (95% UI: 3.0–3.8) CVD cases were estimated among individuals aged ≥60 years in Iran, corresponding to a rate of 34,612.8 per 100,000 population. The number of deaths rose from around 81,000 in 1990 to 113,000 in 2023, yet the death rate fell by 54.9% over this period, and the DALY rate declined by 61.1%. The burden of CVD increased markedly with age and was consistently higher among males. Ischaemic heart disease remained the leading contributor to CVD prevalence, mortality, and DALYs, followed by stroke. Considerable provincial variations were also observed, with a higher burden in several western and northern provinces.

Conclusion: Although the mortality and DALY rates for CVD among older adults in Iran declined substantially between 1990 and 2023, the absolute burden has continued to rise as a result of population ageing and demographic growth. Strengthening prevention strategies aimed at the major metabolic and behavioural risk factors, improving long-term cardiovascular care, and addressing regional disparities will therefore be essential to mitigate the future burden of CVD in Iran's ageing population.

Keywords: Cardiovascular diseases, Aged, Iran, Burden of disease, Disability-adjusted life years

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Introduction

Cardiovascular diseases (CVDs) remain the leading cause of morbidity and mortality worldwide, and the absolute burden they impose is projected to increase over the coming decades.[1] Although the prevalence and mortality rates of CVD are expected to decline, the total number of cases and deaths is anticipated to rise substantially, driven mainly by population growth and rapid population ageing.[2] The population aged 60 years and older is of particular relevance, as its marked expansion in the coming decades is expected to further amplify the burden of atherosclerotic CVDs, such as ischaemic heart disease (IHD) and stroke.[3] Understanding cardiovascular health among older adults is therefore becoming increasingly important.

Older adults experience a particularly high burden of CVD, owing to the cumulative exposure to metabolic, behavioural, and environmental risk factors over the life course, together with the coexistence of multiple chronic conditions. Cardiovascular outcomes in this age group therefore tend to reflect both long-term risk accumulation and age-related physiological vulnerability. Within

the Global Burden of Disease (GBD) framework, the burden of disease in older populations has been assessed using standardised metrics, including years lived with disability (YLDs), years of life lost (YLLs), and disability-adjusted life years (DALYs), allowing both fatal and non-fatal health outcomes to be evaluated together.[4] These measures provide an essential basis for understanding how an ageing population may reshape the overall burden of CVD.

The growing impact of CVD on ageing populations is particularly evident in the Middle East and North Africa (MENA) region, where CVDs are a leading cause of mortality and morbidity across countries. Analyses based on GBD data have shown that the regional burden of CVD remains substantial.[5] Although age-specific rates of mortality and DALYs have stabilised or declined in recent decades, the total number of cases and deaths has continued to increase, largely as a result of demographic change, namely population growth and ageing. CVD-related mortality also rises sharply with age and reaches its highest levels in older age groups, which reflects the concentration of cardiovascular burden among older adults in this region.[6]

Similar epidemiological patterns have been observed in Iran, where the burden of CVD has shifted substantially over recent decades. Between 1990 and 2021, the all-age prevalence of CVD increased by approximately 182.6%, rising from 2.9 to 8.3 million cases, while the number of incident cases increased by 159.6%, largely as a result of demographic expansion and population ageing. [6]Over the same period, the mortality and DALY rates declined considerably, which suggests improvements in cardiovascular prevention and clinical management.[6] Nevertheless, the total number of deaths and DALYs attributable to CVD increased substantially, reflecting the growing and ageing population. Throughout this period, ischaemic heart disease and stroke have remained the two leading contributors to cardiovascular DALYs in Iran.[6]

However, comprehensive evidence on the burden and temporal trends of CVDs among older adults in Iran remains limited. Using the most recent estimates from the latest round of the GBD study, this study aims to assess the burden and temporal trends of CVDs among older adults (aged ≥60 years) in Iran from 1990 to 2023.

Methods

Overview

The GBD 2023 study, coordinated by the Institute for Health Metrics and Evaluation, provides comprehensive estimates for 375 diseases and injuries across 204 countries and territories from 1990 to 2023. Countries were grouped into several geographic regions to facilitate comparative analyses. Considering that detailed descriptions of the GBD analytical framework and methodological developments have been previously published, only a concise summary relevant to CVDs has been presented in this study.[7 8] Additional information regarding fatal and non-fatal estimates is publicly available through the Global Health Data Exchange and the GBD visualisation tools (http://ghdx.healthdata.org/gbd-results-tool).

Estimates incorporated multiple sources of uncertainty, including sampling variability, adjustments for incomplete or biased data, heterogeneity across studies, and weighting procedures used in ensemble models.

Case Definition

CVDs are included in the non-communicable disease category and encompass multiple conditions affecting the heart and circulatory system. Within the GBD study, CVDs include IHD, stroke (including subarachnoid haemorrhage, intracerebral haemorrhage, and ischaemic stroke), hypertensive heart disease, rheumatic heart disease, and non-rheumatic valvular heart disease. The other CVDs are aortic aneurysm, pulmonary arterial hypertension, atrial fibrillation and flutter, infective endocarditis, cardiomyopathy and myocarditis, peripheral arterial disease (PAD), and other circulatory disorders.[7] Standardised diagnostic definitions were applied whenever possible. These definitions relied on physician diagnosis, clinical symptoms, imaging findings, or established clinical guidelines, such as the World Health Organization criteria for stroke and internationally recognised definitions for myocardial infarction and heart failure.

Mortality Estimation

Cause-specific mortality estimates were generated using data from verbal autopsy studies and vital registration systems. Moreover, mortality records coded with intermediate, implausible, or ill-defined causes, often referred to as "garbage codes", were reassigned to valid underlying causes using standardised redistribution algorithms. This procedure was implemented to improve the comparability of mortality estimates across countries and time periods. Furthermore, empirical Bayesian noise-reduction methods were applied to reduce random variations in mortality data. In addition, the potential misclassification of causes of death during the coronavirus disease 2019 pandemic was addressed using a counterfactual modelling approach based on mortality patterns observed between 2014 and 2019.[8]

Additionally, cause-specific mortality for CVDs was estimated using the Cause of Death Ensemble model. This modelling framework generates multiple statistical sub-models that incorporate biological, demographic, and environmental covariates. Each sub-model is evaluated through out-of-sample predictive validity testing, and weights are assigned according to predictive performance. Final mortality estimates are produced as the weighted combinations of these models. The resulting cause-specific deaths are then adjusted using the CoDCorrect algorithm in order to ensure that the sum of all causes does not exceed total all-cause mortality. Subsequently, years of life lost (YLLs) are calculated by multiplying the number of deaths at each age by the remaining life expectancy derived from the GBD standard life table.

Morbidity Estimation

Non-fatal disease burden was estimated using information obtained from population-based studies, administrative health records, and national health surveys. Published studies were systematically reviewed to identify epidemiological data representative of the general population. Then, administrative datasets were adjusted to account for potential biases, such as hospital readmissions, incomplete diagnostic records, or the absence of outpatient data for certain conditions.[7]

Updated systematic reviews were performed for several causes included in GBD 2023 following the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-analyses, and they were registered in the PROSPERO database. When studies used case definitions that differed from the reference definitions applied in GBD, statistical adjustments were implemented using Bayesian network meta-regression techniques to correct for systematic differences.

Afterward, incidence, prevalence, remission, and mortality for non-fatal outcomes were estimated using DisMod-MR 2.1, which is a Bayesian meta-regression modelling tool. This model ensures internal consistency across epidemiological parameters while producing estimates stratified by age, gender, location, and year. In regions with limited data availability, predictions were informed by location-specific covariates and hierarchical geographic modelling in which global estimates were sequentially refined for super-regions, regions, and countries.[7]

Compilation of Results

Three summary indicators (i.e., YLLs, YLDs, and DALYs) were used to describe the overall burden of CVDs. YLLs, which reflect premature mortality, were calculated by multiplying the number of deaths in each age group by the remaining life expectancy. In addition, YLDs were estimated by combining disease prevalence with disability weights assigned to specific health states. These weights were derived from population-based surveys designed to quantify the impact of health conditions on daily functioning. Further, DALYs were computed as the sum of YLDs and YLLs, representing the overall loss of health due to both premature mortality and non-fatal disease outcomes.

Socio-demographic development was measured using the socio-demographic index (SDI), a composite indicator that combines the total fertility rate among those under 25 years of age, the mean educational attainment of adults aged 15 years and older, and lag-distributed income per capita. The SDI ranges from 0 to 100, with higher values reflecting greater socio-demographic development. All analyses were conducted in R (version 4.2.1), with the final estimates derived from the mean of 250 posterior draws, and the 95% uncertainty intervals (UIs) calculated from the 2.5th and 97.5th percentiles of these draws.

Results

National Level

In 2023, there were approximately 3.4 million (95% UI: 3.0 to 3.8) prevalent cases of CVD among individuals aged 60 years and older, with a rate of 34,612.8 per 100,000 population (Table 1). This represented a 1.8% (95% UI: -3.5 to 8) increase in the prevalence rate since 1990, when there were around one million cases and the rate stood at 33,985.3 per 100,000 (Table S1). In contrast, although the total number of deaths from CVD rose from nearly 81 thousand in 1990 to 113 thousand in 2023, the age-standardised death rate decreased substantially by 54.9% (95% UI: -62.6 to -45.8) across this period, falling from 2,549.6 to 1,149.2 per 100,000 (Table S2). A similar pattern was found for the overall disease burden, with CVD accounting for 1.9 million (95% UI: 1.6 to 2.2) DALYs in 2023, at a rate of 19,965.7 (95% UI: 17,147.1 to 22,703.1) per 100,000. This represented a 61.1% (95% UI: -67.4 to -53.6) decrease in the DALY rate since 1990 (Table S3).

Provincial Level

The highest prevalence estimates were observed in Khuzestan [42428.1 (95% UI: 38307.2 to 47953.2)], Ardebil [41885 (95% UI: 37503.5 to 47190.3)], and Golestan [39880.5 (95% UI: 35744.7 to 44892.4)] in 2023. However, the lowest cases were reported in Tehran [30248.9 (95% UI: 27239.1 to 33814.2)], Qom [31496.7 (95% UI: 28438.3 to 35742.6)], and Semnan [33232.7 (95% UI: 29986 to 37855.5)]. Related data are shown in Figure 1A and Table S1. Figure S1 presents the gender-specific prevalence rates for adults aged 60 and older at the provincial level. In 2023, the highest death rates were found in Zanjan [1991.5 (95% UI: 1656.6 to 2274.1)], West Azarbayejan [1575.5 (95% UI: 1326.9 to 1820.7)], and Ardebil [1554.6 (95% UI: 1290.6 to 1777.1)]. In contrast, the lowest rates belonged to Tehran [737.4 (95% UI: 600.5 to 870.6)], Mazandaran [975.3 (95% UI: 787.9 to 1141.7)], and Fars [989.9 (95% UI: 786.7 to 1151.8)], as illustrated in Figure 1B and Table S2. Figure S2 displays the gender-specific death rates for adults aged 60 and older at the provincial level. Regarding DALYs, the highest rates in 2023 were related to Zanjan [32759.3 (95% UI: 27958.9 to 37142.6)], Khuzestan [28178.6 (95% UI: 24125.4 to 31953)], and West Azarbayejan [27222.1 (95% UI: 23310.9 to 30884.8)]. Conversely, the lowest DALY rates were observed in Tehran [13328 (95% UI: 11290.9 to 15508.1)], Mazandaran [16804.4 (95% UI: 14013.9 to 19145.4)], and Fars [16816.7 (95% UI: 13627.5 to 19451.9)], the details of which are depicted in Figure 1C and Table S3. Moreover, the 2023 gender-specific DALY rates are represented at the provincial level in Figure S3. Between 1990 and 2023, Zanjan experienced the greatest increase in prevalence [13.7% (95% UI: 4.7 to 23.8)], followed by Golestan [12.6% (95% UI: 5.7 to 19.6)] and Kurdistan [9.6% (95% UI: 2.4 to 18.6)]. Conversely, the largest decreases (Table 1) were reported in Tehran [-5.9% (95% UI: -11 to -0.8)], Qom [-5.5% (95% UI: -10 to -1.1)], and Khuzestan [-4.8% (95% UI: -9.2 to -1.1)]. Figure S4 illustrates the gender-specific estimates at the

Table 1. Prevalent Cases, Deaths, and DALYs Due to Cardiovascular Diseases for Adults 60 Years and Older in 1990 and 2023 for Both Genders and Percentage Changes in Rates per 100,000 in Iran

	Prevalence (95% UI)			Deaths (95% UI)			DALYs (95% UI)		
	Counts (2023)	Rate (2023)	Pcs in Rate 1990-2023	Counts (2023)	Rate (2023)	Pcs in Rate 1990-2023	Counts (2023)	Rate (2023)	Pcs in Rate 1990-2023
Iran	3,416,479 (3091920, 3826367)	34612.8 (31324.7, 38765.5)	1.8 (-3.5, 8)	113,430 (94576, 130224)	1149.2 (958.2, 1319.3)	-54.9 (-62.6, -45.8)	1,970,725 (1692508, 2240916)	19965.7 (17147.1, 22703.1)	-61.1 (-67.4, -53.6)
Alborz	122,614 (109008, 138854)	34157.4 (30367, 38681.5)	-3.9 (-8.8, 1.2)	3,962 (3056, 4619)	1103.6 (851.5, 1286.7)	-45.4 (-54.3, -33.4)	71,653 (57476, 81825)	19960.9 (16011.4, 22794.6)	-49.2 (-56.7, -38.8)
Ardebil	62,878 (56300, 70842)	41885 (37503.5, 47190.3)	5.7 (-0.1, 11.8)	2,334 (1937, 2668)	1554.6 (1290.6, 1777.1)	-33.2 (-44.4, -19.9)	40,065 (34093, 45177)	26688.6 (22710.5, 30094.1)	-44.4 (-53.3, -33.5)
Bushehr	37,406 (33655, 42575)	34249 (30814.7, 38981.6)	4.1 (-3.1, 12.6)	1,281 (1047, 1467)	1173.2 (958.8, 1343.2)	-52.7 (-61.2, -44.5)	23,459 (19489, 26613)	21479.7 (17844.1, 24366.8)	-56.5 (-63.7, -48.9)
Chahar Mahaal and Bakhtiari	40,368 (35960, 45764)	35503.4 (31626.7, 40249.2)	5.2 (-3, 14.7)	1,683 (1344, 1931)	1480.1 (1182.1, 1698.4)	-34.1 (-43.9, -21.8)	27,639 (22752, 31491)	24308.4 (20010.4, 27696.4)	-45.5 (-53.3, -34.7)
East Azarbayejan	17,9810 (161806, 203055)	34303.7 (30868.8, 38738.4)	9.3 (0.5, 19.9)	7,587 (6427, 8744)	1447.4 (1226.1, 1668.1)	-39.2 (-50, -25.1)	128,439 (109210, 146282)	24503.2 (20834.8, 27907.3)	-47.2 (-56.5, -35.2)
Fars	226,198 (203539, 256077)	35795 (32209.3, 40523.2)	6 (-2.2, 14.9)	6,256 (4971, 7279)	989.9 (786.7, 1151.8)	-62.7 (-69.5, -55.2)	106,269 (86116, 122921)	16816.7 (13627.5, 19451.9)	-69.8 (-74.3, -64.2)
Gilan	149,826 (134680, 170221)	35351.1 (31777.3, 40163.1)	6.3 (-0.9, 14.4)	4,786 (3700, 5578)	1129.1 (873.1, 1316.2)	-65.4 (-71.2, -58.6)	81,220 (66299, 93876)	19163.5 (15643.1, 22149.8)	-70.1 (-75, -64.6)
Golestan	81,598 (73136, 91853)	39880.5 (35744.7, 44892.4)	12.6 (5.7, 19.6)	2,596 (2149, 2957)	1269 (1050.5, 1445.4)	-54.3 (-62.4, -45.4)	50,331 (42304, 56652)	24598.8 (20675.6, 27688.1)	-59.8 (-66.3, -52.7)
Hamadan	81,652 (73246, 91854)	35245.4 (31616.7, 39649.1)	7.6 (1.4, 15.2)	3,372 (2776, 3924)	1455.5 (1198.1, 1693.7)	-46.1 (-55.2, -35.4)	56,131 (46537, 63902)	24229.2 (20087.8, 27583.6)	-56 (-62.8, -47.5)
Hormozgan	56,852 (50897, 63965)	37193.1 (33297.4, 41846.7)	2.7 (-4.1, 9.7)	1,860 (1537, 2114)	1216.6 (1005.5, 1382.9)	-51.3 (-59.6, -41.2)	33,245 (28325, 37472)	21749 (18530.5, 24514.6)	-57.8 (-64.5, -49.1)
Ilam	24,387 (22025, 27660)	36201.1 (32695, 41060)	5.9 (-1.6, 14.1)	709 (591, 826)	1052.5 (877.8, 1225.5)	-48.1 (-56.7, -38.1)	12,549 (10713, 14268)	18628.8 (15903.6, 21180.4)	-52.6 (-60, -44)
Isfahan	239,261 (212339, 270170)	33707.9 (29915.1, 38062.6)	2.6 (-5.3, 11.4)	7,674 (6186, 8965)	1081.1 (871.5, 1263)	-62.3 (-69.1, -54)	127,996 (105537, 146600)	18032.5 (14868.4, 20653.5)	-66.5 (-72.2, -60.1)
Kerman	121,170 (107655, 137733)	36298.4 (32249.9, 41260.2)	3.8 (-4.5, 14)	3,488 (2908, 4045)	1045 (871.1, 1211.6)	-52.4 (-60.9, -42.2)	59,992 (50973, 68024)	17971.6 (15269.8, 20377.6)	-60.1 (-67.3, -52.1)
Kermanshah	95,711 (86288, 109165)	36339.8 (32762.2, 41448.1)	7.4 (0.5, 15.9)	3,521 (2877, 4029)	1336.7 (1092.4, 1529.7)	-52.3 (-61, -40.2)	61,109 (51333, 69946)	23202.1 (19490.3, 26557.4)	-60.3 (-66.8, -50.3)
Khorasan-e-Razavi	246,735 (223190, 277623)	35806.7 (32389.7, 40289.2)	6.5 (-1.4, 15.2)	8,479 (7029, 9822)	1230.4 (1020, 1425.4)	-53.2 (-62.5, -41.6)	146,435 (125509, 166523)	21251 (18214.1, 24166.1)	-60.7 (-68.3, -51.8)
Khuzestan	198,421 (179149, 224260)	42428.1 (38307.2, 47953.2)	-4.8 (-9.2, -1.1)	7,009 (5846, 7991)	1498.7 (1250, 1708.8)	-53.2 (-60.1, -44.7)	131,782 (112826, 149433)	28178.6 (24125.4, 31953)	-55.9 (-62.5, -48.4)

Table 1. Continued.

	Prevalence (95% UI)			Deaths (95% UI)			DALYs (95% UI)		
	Counts (2023)	**Rate (2023)**	**Pcs in Rate 1990-2023**	**Counts (2023)**	**Rate (2023)**	**Pcs in Rate 1990-2023**	**Counts (2023)**	**Rate (2023)**	**Pcs in Rate 1990-2023**
Kohgiluyeh and Boyer-Ahmad	23,253 (21023, 26084)	35434.6 (32036, 39749.5)	1.1 (-3.6, 6.5)	827 (646, 961)	1259.9 (984.3, 1464.7)	-39.6 (-50.1, -28.1)	14,024 (11401, 16114)	21370.8 (17373.5, 24555.2)	-49.3 (-57.3, -39.6)
Kurdistan	72,579 (65005, 81561)	35940.4 (32190, 40388.4)	9.6 (2.4, 18.6)	2,745 (2261, 3200)	1359.5 (1119.6, 1584.6)	-35 (-48.4, -15.8)	46,944 (39661, 54215)	23246.1 (19639.9, 26846.8)	-44 (-54.9, -27.9)
Lorestan	64,323 (57470, 72353)	33164.5 (29631, 37304.6)	-2.2 (-8.4, 3.6)	2,837 (2361, 3275)	1462.7 (1217.1, 1688.4)	-39.9 (-49.6, -26.5)	47,875 (40509, 54624)	24684.1 (20886.1, 28163.6)	-49.6 (-58, -38.5)
Markazi	68,457 (61745, 76751)	33599.7 (30305.1, 37670.4)	4.7 (-1.9, 12.5)	2,493 (2011, 2952)	1223.4 (987.1, 1448.9)	-52.1 (-61.7, -40.1)	39,950 (33069, 46380)	19608.3 (16230.8, 22764.1)	-60.8 (-68.1, -51.4)
Mazandaran	176,962 (159549, 201896)	34592.1 (31188.3, 39466.1)	-3.8 (-8.3, 2)	4,989 (4031, 5840)	975.3 (787.9, 1141.7)	-64.8 (-71.3, -57.7)	85,966 (71691, 97942)	16804.4 (14013.9, 19145.4)	-70.4 (-75.5, -65.1)
North Khorasan	33,214 (29931, 37651)	37643.5 (33922.7, 42672.6)	2.9 (-2.1, 8.7)	1,173 (989, 1362)	1329.6 (1120.6, 1543.4)	-48.9 (-59.2, -34.2)	21,261 (18245, 24428)	24096.9 (20678.7, 27685.7)	-57.2 (-65.4, -45.8)
Qazvin	50,494 (45286, 56960)	34345 (30802.5, 38742.5)	1.4 (-4.6, 7.6)	1,927 (1610, 2239)	1310.7 (1094.9, 1522.9)	-39 (-51.2, -24.1)	32,848 (27723, 37661)	22342.7 (18856.2, 25616.2)	-47.5 (-57.1, -35.2)
Qom	42,196 (38098, 47884)	31496.7 (28438.3, 35742.6)	-5.5 (-10, -1.1)	1,911 (1564, 2216)	1426.4 (1167.4, 1654.1)	-49.5 (-58.7, -37.5)	31,876 (26983, 36519)	23793.5 (20141.4, 27259.5)	-57.3 (-64.7, -47.3)
Semnan	30,320 (27358, 34537)	33232.7 (29986, 37855.5)	1.4 (-4.9, 7.6)	1,063 (876, 1236)	1165.4 (959.9, 1354.9)	-44.5 (-55.2, -30.8)	18,221 (15221, 21034)	19971.6 (16682.9, 23055.2)	-51.3 (-60.6, -39.5)
Sistan and Baluchistan	60,840 (55260, 67970)	35013.7 (31802.4, 39116.9)	7.4 (-0.1, 15.7)	1,963 (1611, 2352)	1129.7 (927.1, 1353.4)	-56.6 (-65.3, -46.6)	36,510 (30534, 42846)	21011.8 (17572.7, 24658.3)	-62.5 (-69.2, -54.1)
South Khorasan	33,474 (29784, 37880)	37883.1 (33706.5, 42869.4)	-1.3 (-6.4, 4.8)	1,026 (819, 1210)	1161.7 (927, 1369.6)	-43.4 (-55.3, -27.9)	16,221 (13585, 18675)	18357.6 (15374.3, 21134.4)	-55.5 (-63.5, -44.1)
Tehran	581,666 (523789, 650224)	30248.9 (27239.1, 33814.2)	-5.9 (-11, -0.8)	14,180 (11547, 16742)	737.4 (600.5, 870.6)	-67 (-73.4, -60)	256,289 (217117, 298210)	13328 (11290.9, 15508.1)	-70.4 (-75.8, -64.6)
West Azarbayejan	126,213 (114171, 142738)	34267.1 (30997.6, 38753.6)	8.8 (0.7, 17.7)	5,803 (4887, 6706)	1575.5 (1326.9, 1820.7)	-34.4 (-45.2, -19.9)	100,265 (85859, 113756)	27222.1 (23310.9, 30884.8)	-42.5 (-51.8, -30.4)
Yazd	41,894 (37703, 46490)	34429 (30984.7, 38206.3)	3.7 (-3.4, 11)	1,387 (1136, 1625)	1140.1 (933.7, 1335.8)	-50.3 (-60.7, -38.1)	22,868 (19394, 26507)	18793 (15937.9, 21783.7)	-58 (-65.7, -48.6)
Zanjan	45,708 (41529, 51185)	36262.4 (32947, 40608)	13.7 (4.7, 23.8)	2,510 (2088, 2866)	1991.5 (1656.6, 2274.1)	-24.5 (-37.7, -7.7)	41,292 (35241, 46817)	32759.3 (27958.9, 37142.6)	-39.4 (-49.7, -25)

Note. DALYs: Disability-adjusted life years; UI: Uncertainty interval; PCS: Percentage changes

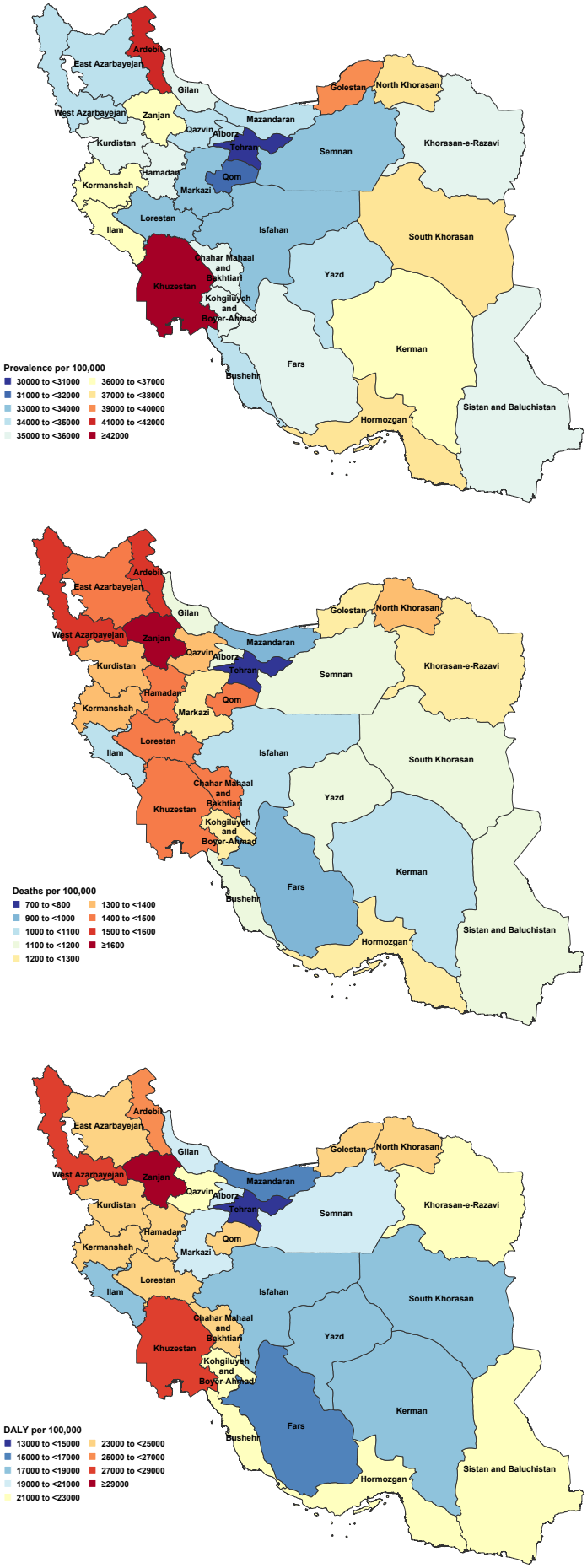

Figure 1. Prevalence (A), death rate (B), and disability-adjusted life year (DALY) rate (C) due to cardiovascular diseases among adults aged 60 years and older in Iran in 2023, by province. Rates are reported per 100,000 population. (generated from data available from http://ghdx.healthdata.org/gbd-results-tool).

provincial level for the percentage change in the point prevalence of CVDs for adults aged 60 and above in Iran from 1990 to 2023. The CVD-attributable death rate for individuals aged 60 and older in Iran decreased from 1990 to 2013 in all provinces. Based on the results (Table 1), the highest decreases were found in Tehran [-67% (95% UI: -73.4 to -60)], Gilan [-65% (95% UI: -71.2 to -58.6)], and Mazandaran [-64.8% (95% UI: -71.3 to -57.7)], while the lowest decreases belonged to Zanjan [-24.5% (95% UI: -37.7 to -7.7)], Ardebil [-33.2% (95% UI: -44.4 to -19.9)], and West Azarbayejan [-34.4% (95% UI: -45.2 to -19.9)]. Moreover, Figure S5 displays the gender-specific percentage changes in the death rates at the provincial level over the period 1990 to 2023. The trends from 1990 to 2023 revealed that the DALY rate for CVD among adults aged 60 and above did not increase in Iran. The largest decreases were reported in Tehran [-70.4% (95% UI: -75.8 to -64.6)], Mazandaran [-70.4% (95% UI: -75.5 to -65.1)], and Gilan [-70.1% (95% UI: -75 to -64.6)]. However, the lowest decreases were related to Zanjan [-39.4% (95% UI: -49.7 to -25)], West Azarbayejan [-42.5% (95% UI: -51.8 to -30.4)], and Kurdistan [-44% (95% UI: -54.9 to -27.9)] (Table 1). Furthermore, Figure S6 displays the gender-specific percentage change in the DALY rates for each province from 1990 to 2023.

Age and Gender Patterns

The prevalence of CVDs in individuals aged 60 years and older increased with advancing age in 2023, and this trend was consistent for both genders. In addition, males demonstrated higher prevalence rates than females across all age categories (Figure 2A). Additionally, the overall number of deaths in both males and females rose with age in this year, reaching a peak in the 85–89 age group before subsequently declining. Similar to prevalence rates, death rates increased with age in both genders, with consistently higher rates in males than females (Figure 2B). DALY rates likewise rose with age in both sexes during 2023, although the greatest absolute number of DALYs fell within the 65–69 age group for males and females alike (Figure 2C). When set against the wider region in that same year, the CVD-related DALY rate among Iranian adults aged 60 and older sat below the MENA rate (Iran/MENA ratio < 1) across every male age group and across the 70–94 range in females. Taken across the study period, this Iran/MENA DALY ratio was higher in 1990 than in 2023 in all age groups and for both sexes (Figure 3).

Cause-Specific Patterns

In general, the burden of CVDs increased with age from 60 years onward. Overall, IHD was the leading cause in older adults, with prevalence rising from about 450 thousand (13,416 per 100,000) at ages 60–64 to 6.8 thousand (25,751 per 100,000) at 95+ years. A second leading cause of CVDs in older adults was lower extremity PAD with the prevalence of approximately 100 thousand (2,960 per 100,000) at ages 60–64 to 87 thousand (32,939 per 100,000) at 95+ years. Among individuals aged 95 years and older, the prevalence rate of lower extremity PAD surpassed that of IHD. The prevalence of major causes of CVDs and their respective rates within each age group in 2023 are illustrated in Figure S7. Similarly, mortality from CVD notably rose with advancing age, with IHD and stroke representing the primary causes of death. In 2023, deaths from IHD started from around 6 thousand (187 per 100,000) at ages 60–64 to 2.5 thousand (9,692 per 100,000) at 95 years old and older. The prevalence of deaths from stroke was around 1.8 thousand (55 per 100,000) at ages 60–64 and 809 (3,042 per 100,000) at age 95 years old and above. The distribution of death attributable to each cause of CVD within each age group in 2023 is shown in Figure S8. Furthermore, the DALY increased substantially with age. IHD again demonstrated the highest rate, with DALYs rising from around 200 thousand (5,934 per 100,000) at ages 60–64 to 21 thousand (80,123 per 100,000) at 95+ years. Stroke contributed 66 thousand (1,975 per 100,000) DALYs at 60–64 and 6.7 thousand (25,528 per 100,000) at age 95+ years. Figure S9 depicts the DALY proportions for each cause of CVD, stratified by age group in 2023.

Discussion

In this study, we set out to characterise in detail the burden and temporal trends of CVDs among older adults in Iran from 1990 to 2023 using the latest GBD estimates, thereby extending prior national and subnational studies on CVD burden in Iran. Similar to global and regional trends, our findings indicated that, while the total number of CVD cases and deaths grew considerably, the mortality and DALY rates declined markedly during the study period. These patterns mirror GBD 2019 global estimates, where large declines in CVD mortality were observed despite sharp increases in all-age cases and deaths, largely driven by population growth and demographic ageing.[1] Further, they align with projections for 2025–2050 that anticipate continued growth in absolute CVD burden due to ageing, even under optimistic risk-factor control scenarios.[9]

The marked decline in CVD mortality and DALY rates observed in Iran over the past three decades is consistent with global and MENA-regional improvements in cardiovascular health.[1,6,10] Advances in clinical management, including the broader use of evidence-based pharmacological therapies, better acute care for myocardial infarction and stroke, and more systematic management of metabolic risk factors (e.g., hypertension, hyperglycaemia, and dyslipidaemia), have been the major drivers of reduced CVD mortality in diverse settings.[1,11] Simultaneously, the continuing rise in the number of deaths and prevalent cases observed in this study underscores the dominant influence of population ageing and improved survival into older age, a pattern repeatedly documented in global and ageing-focused GBD analyses.[4,12]

The age-specific and gender-specific analyses further highlight important epidemiological patterns. As expected, the prevalence, mortality, and DALY rates all

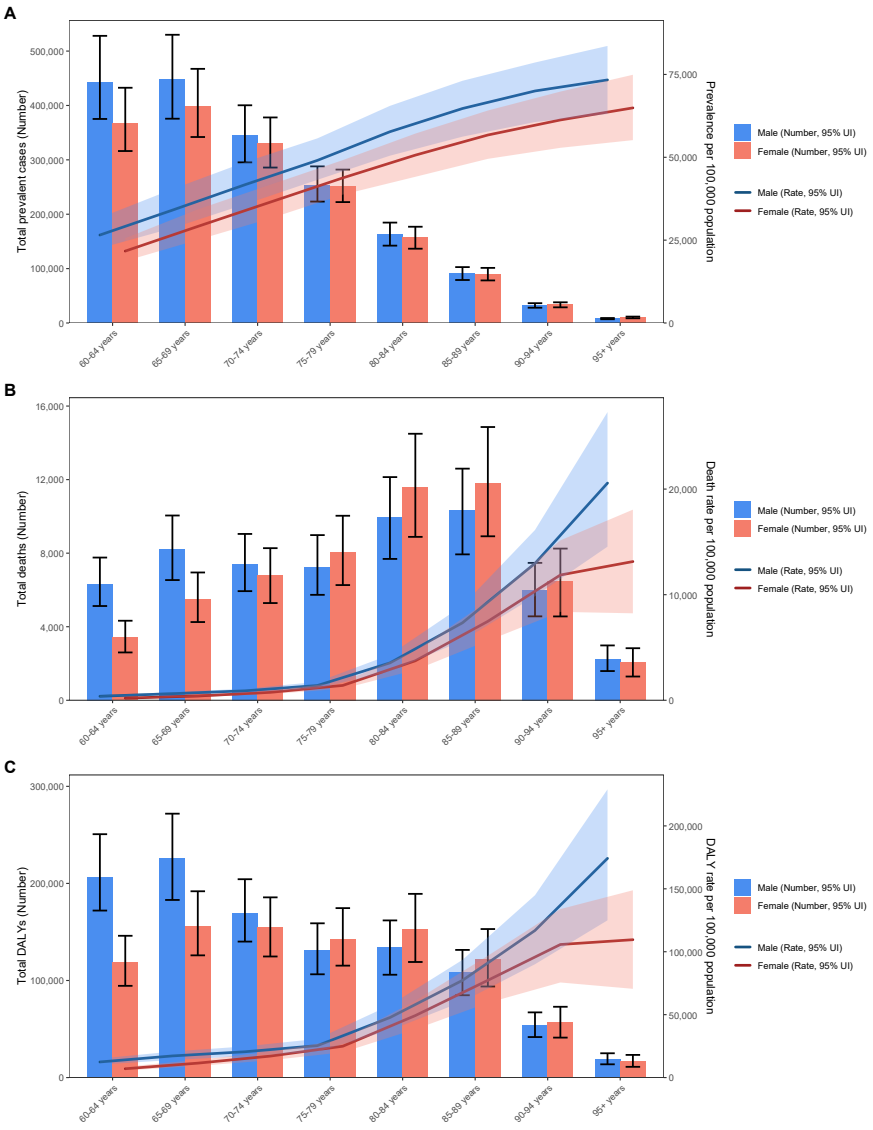

Figure 2. Number of prevalent cases and prevalence (A), number of deaths and death rate (B), and number of disability-adjusted life years (DALYs) and DALY rate (C) due to cardiovascular diseases in Iran in 2023, by age group and sex. Rates are reported per 100,000 population. Shaded areas indicate 95% uncertainty intervals (generated from data available from http://ghdx.healthdata.org/gbd-results-tool).

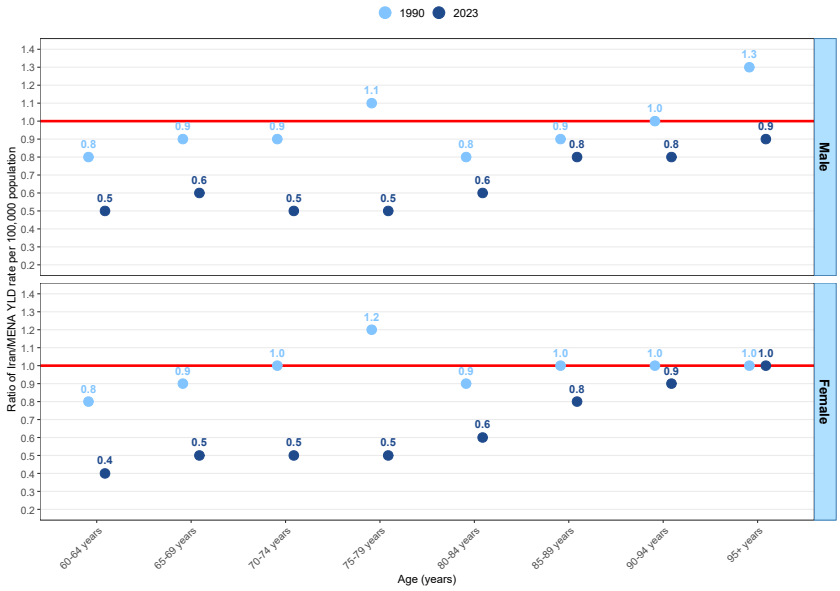

Figure 3. The ratio of Iran's national cardiovascular disease DALY rate to the MENA regional DALY rate for cardiovascular diseases, by age group and sex, from 1990 to 2023. (generated from data available from http://ghdx.healthdata.org/gbd-results-tool).

rose progressively as age advanced, reflecting cumulative exposure to risk factors and age-related declines in cardiovascular resilience. Accordingly, ageing is one of the strongest determinants of CVD risk and disability, and global GBD analyses of adults ≥70 years have shown that cardiovascular conditions, particularly IHD and stroke, remain the principal causes of death and long-term disability among older age groups.[4] Likewise, our results revealed that males experienced higher prevalence and mortality rates across most age groups, which is consistent with the findings of previous global, regional, and Iranian studies documenting higher cardiovascular risk among men at earlier ages, linked to a combination of biological influences and a greater burden of behavioural risk factors (e.g., tobacco use and occupational hazards).[1,13]

When compared with the MENA region, Iran showed lower DALY rates among older adults in most age groups in 2023, suggesting relative progress in reducing cardiovascular burden. Previous regional analyses have highlighted the fact that CVDs remain one of the leading causes of death in MENA, with demographic changes projected to substantially increase the absolute burden of CVD in coming decades.[5] The relatively lower DALY rates for older adults in Iran may reflect the earlier and wider scaling-up of primary health-care networks, improvements in hospital care, and national programmes focused on hypertension, diabetes, and lipid control.[6] Nevertheless, given the rising absolute numbers of older individuals living with CVD and its sequelae, sustaining and strengthening these efforts will be crucial to prevent a future escalation in health-care demand.

Additionally, cause-specific analyses in our study confirmed that IHD remains the dominant contributor to CVD burden among older adults, accounting for the largest share of prevalence, mortality, and DALYs, while stroke is the second leading cause. This pattern is in line with global estimates, where IHD and stroke together account for the majority of cardiovascular deaths and DALYs across age groups, particularly in older adults.[1,4,14,15] Notably, our findings demonstrated that lower extremity PAD showed a steep age-related increase in prevalence and exceeded IHD prevalence in the oldest age group.[16,17] PAD is strongly linked to ageing, diabetes, smoking, and atherosclerosis, and its prevalence is expected to rise further in ageing populations, a trend consistent with global GBD findings on vascular diseases in older adults.[4,17]

Our findings carry several important consequences for the planning and direction of health policy in Iran. The country is moving through a rapid demographic shift, in which older adults make up a steadily rising share of the population, and the pace of population ageing is projected to accelerate over the coming decades.[18] Based on our results, the demand for cardiovascular care, secondary prevention, and long-term management of chronic sequelae (e.g., heart failure, post-stroke disability, and PAD) will continue to increase. Thus, strengthening preventive strategies targeting modifiable risk factors (i.e, high body mass index, high low-density lipoprotein cholesterol, kidney dysfunction, high fasting plasma glucose, and high systolic blood pressure) remains central, as these metabolic factors account for a large share of CVD burden in Iran[1,6]. Additionally, population-based interventions focusing on blood pressure control, tobacco reduction, promotion of healthy diets and physical activity, and improved detection and management of diabetes and chronic kidney disease are essential to curb future CVD burden.[1,9]

Given the evidence suggesting that low-SDI regions within Iran may experience a somewhat higher burden of risk factor-attributable CVD, reducing these potential disparities can be an important consideration for cardiovascular health policies. Briefly, our findings demonstrated that Iran has achieved substantial progress in reducing cardiovascular mortality and disability among older adults, yet the absolute burden imposed by CVD continues to rise, driven by an ageing population and by greater survival into older age. These results are consistent with global and regional GBD analyses, reinforcing the need to sustain and intensify comprehensive CVD prevention and management strategies, particularly in high-burden provinces and low-SDI settings.[1,10] In general, addressing regional inequalities, focusing on metabolic and behavioural risk factors, and preparing health systems for the needs of an ageing population will be essential to further reduce cardiovascular burden in the coming decades.

Conclusion

Although CVD cases and deaths among older adults in Iran increased in absolute terms between 1990 and 2023, both mortality and DALY rates fell substantially. This indicates clear progress in prevention and clinical care over the past three decades. However, an ageing and growing population continues to drive up the absolute burden. Ischaemic heart disease and stroke remain the main contributors, and further reductions will require stronger risk factor control, improved long-term care, and action on regional disparities.

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Data availability statement

All data used in this study are publicly available.

Ethical approval

This study was approved by the Ethics Committee of Tabriz University of Medical Sciences, Tabriz, Iran (Ethics code: IR.TBZMED.FMD.REC.1404.418).

Consent for publication

Not applicable.

Conflict of interests

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be interpreted as a potential conflict of interest.

Supplementary File

Supplementary file contains Tables S1-S3 and Figures S1-S9.

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