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Burden of cardiovascular diseases in the Eastern Mediterranean Region, 1990–2015: findings from the Global Burden of Disease 2015 study

GBD 2015 Eastern Mediterranean Region Cardiovascular Disease Collaborators1

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Abstract
Objectives To report the burden of cardiovascular diseases (CVD) in the Eastern Mediterranean Region (EMR) during 1990–2015.
Methods We used the 2015 Global Burden of Disease study for estimates of mortality and disability-adjusted life years (DALYs) of different CVD in 22 countries of EMR.
Results A total of 1.4 million CVD deaths (95% UI: 1.3–1.5) occurred in 2015 in the EMR, with the highest number of deaths in Pakistan (465,116) and the lowest number of deaths in Qatar (723). The age-standardized DALY rate per 100,000 decreased from 10,080 in 1990 to 8606 in 2015 (14.6% decrease). Afghanistan had the highest age-standardized DALY rate of CVD in both 1990 and 2015. Kuwait and Qatar had the lowest age-standardized DALY rates of CVD in 1990 and 2015, respectively. High blood pressure, high total cholesterol, and high body mass index were the leading risk factors for CVD.
Conclusions The age-standardized DALY rates in the EMR are considerably higher than the global average. These findings call for a comprehensive approach to prevent and control the burden of CVD in the region.

Keywords Cardiovascular disease · Burden of disease · Eastern Mediterranean Region

Introduction

The Global Burden of Disease (GBD) study documented that cardiovascular diseases (CVD) have been the leading cause of global mortality since 1980 (Institute for Health Metrics and Evaluation 2017; Mortality and Causes of Death 2016). CVD accounted for nearly one-third of all deaths worldwide in 2015. Meanwhile, the principal components of CVD, namely stroke and ischemic heart disease, accounted for 85.1% (95% uncertainty interval (UI): 84.7–85.5) of all deaths in the CVD category in 2015 (Mortality and Causes of Death 2016). CVD accounted for nearly one-third of all deaths worldwide in 2015. Meanwhile, the principal components of CVD, namely stroke and ischemic heart disease, accounted for 85.1% (95% uncertainty interval (UI): 84.7–85.5) of all deaths in the CVD category in 2015 (Mortality and Causes of Death 2016).

Although the age-standardized mortality rates of CVD have fallen by 27.3% in the last 25 years, the absolute number of deaths due to CVD increased globally by 42.4% between 1990 and 2015 (2017). Most CVD deaths occur in low- and middle-income countries (Mensah et al. 2015). The decline in age-standardized rates is mainly due to preventive interventions and better access to quality treatment for acute cardiovascular conditions such as myocardial infarction and stroke (Smith 2011). CVD also impose a high economic burden on health systems and society. For instance, CVD personal spending in the United States was estimated to be 231.1 billion USD in 2013 and was the largest disease category of personal health care spending (Dieleman et al. 2016).
The Eastern Mediterranean Region (EMR) comprises 22 countries with a population of nearly 580 million people, with a diverse range in per capita gross national product (maximum 83,990 USD for Qatar, minimum 610 USD for Afghanistan) (World Development Indicators database 2017). To the best of our knowledge, there is no comprehensive report on the burden and mortality of CVD in the EMR.

This study aimed to report findings on cardiovascular diseases between 1990 and 2015, from the Global Burden of Diseases, Injuries and Risk Factors Study (GBD 2015) in the 22 countries of the EMR. This would help us better understand the burden of CVD and interventions needed to control these diseases.

**Methods**

GBD 2015 covers 195 countries, 21 regions, and seven super-regions from 1990 to 2015 for 315 diseases and injuries, 2619 unique sequelae, and 79 risk factors by age and sex. Detailed descriptions of the general methodological approach of GBD 2015 and specific methodology used for CVD have been provided elsewhere (GBD 2015 DALYs and Collaborators 2016; GBD 2015 Disease and Injury Prevalence Collaborators 2016; GBD 2015 Mortality and Causes of Death Collaborators 2016).

We evaluated the burden of CVD in the Eastern Mediterranean Region (EMR), which contains 22 countries: Afghanistan, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestine, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, the United Arab Emirates (UAE), and Yemen.

The category of CVD includes the ten most common global causes of CVD-related death: rheumatic heart disease, ischemic heart disease, cerebrovascular disease (ischemic stroke and hemorrhagic stroke), hypertensive heart disease, cardiomyopathy and myocarditis, atrial fibrillation and flutter, aortic aneurysm, peripheral vascular disease, endocarditis, and “other cardiovascular and circulatory diseases.” Electronic supplementary table S1 shows the International Classification of Diseases (ICD-10) codes for each of the cardiovascular causes.

To estimate the number of deaths due to CVD, we estimated all-cause mortality envelopes (total number of deaths) for each country-year during 1990–2015; we used all accessible data such as vital registration systems, sample registration data, and household recall of deaths. These sources were used as inputs for cause of death models. We used cause of death ensemble modeling (CODEm) to estimate the number of deaths for each CVD by age, sex, country, and year. The number of deaths for each cause and life tables for all-cause mortality were used to calculate years of life lost (YLLs) (GBD 2015 Mortality and Causes of Death Collaborators 2016; Roth et al. 2015a, b).

We updated our previous systematic reviews for the GBD study separately for each of the non-fatal sequelae of CVD. Data on epidemiologic measures (incidence, prevalence, and case fatality) were extracted from 170 data sources. List of all sources (by cause and location) are available at the Institute for Health Metrics and Evaluation’s website (IHME 2016).

Bayesian meta-regression analysis through DisMod-MR 2.1 was used for disease modeling. Model-based prevalence estimates, in combination with disability weights, were used to calculate cause-specific years lived with disability (YLDs) for each age, sex, location, and year. Disability-adjusted life years (DALYs) were calculated through summation of YLLs and YLDs (DALYs and Collaborators 2016; Disease et al. 2016).

We report 95% uncertainty intervals (UI) for each estimate, including rates, numbers of deaths, and DALYs. We estimated UIs by taking 1000 samples from the posterior distribution of each quantity and using the 25th- and 975th-ordered draws of the uncertainty distribution.

**Results**

**Mortality**

The CVD death rate per 100,000 population in the EMR decreased from 515.1 (95% UI: 491.7–541.5) in 1990 to 456.5 (95% UI: 431.5–484.2) in 2015 (Table 1). A total of 1,373,329 CVD deaths (95% UI: 1,290,959–1,465,047) occurred in 2015 in the EMR, 54.8% of which were among males. These deaths accounted for 34.1% (95% UI: 33.1–35.1) of all deaths in the region in 2015, compared to 30.2% (95% UI: 29.5–30.9) of all deaths in 1990.

The number of men dying from CVD was consistently higher than the number of women during 1990–2015 (Fig. 1).

The total number of deaths from ischemic heart disease (IHD) was 802,078 in 2015, which accounted for 58.4% of the total number of deaths due to CVD in the EMR. There were 637,640 additional deaths in 2015 compared to 1990, out of which 62.5% was contributed by IHD.

Table 2 provides the total number of deaths and the age-standardized death rates from CVD in 1990 and 2015 for all EMR countries. In 2015, Afghanistan had the highest age-standardized death rate from CVD, followed by Iraq and Yemen. In most of the EMR countries, age-standardized death rates for CVD decreased between 1990 and 2015, with the highest decreases in Bahrain, Qatar, Lebanon, and Jordan.
| Cause                                      | 1990 Number of deaths | 2015 Number of deaths | % Change | 1990 Age-standardized death rate per 100,000 | 2015 Age-standardized death rate per 100,000 | % Change |
|-------------------------------------------|----------------------|-----------------------|----------|---------------------------------------------|---------------------------------------------|----------|
| Cardiovascular diseases                   | 735,689              | 700,875–773,593       | 86.7     | 515.1                                       | 491.7–541.5                                 | 456.5    | 431.5–484.2 | −11.4 |
| Rheumatic heart disease                   | 18,350               | 16,029–21,037         | 47.4     | 9.1                                         | 7.8–10.7                                    | 6.8      | 5.7–7.8     | −25.5 |
| Ischemic heart disease                    | 403,355              | 379,184–425,913       | 98.9     | 294.0                                       | 276.9–310.3                                 | 269.1    | 252.5–286.9 | −8.5 |
| Ischemic stroke                           | 92,230               | 79,786–106,780        | 89.5     | 75.5                                        | 65.5–87.8                                   | 65.6     | 59.7–71.2   | −13.1 |
| Hemorrhagic stroke                        | 117,813              | 105,731–133,751       | 69.9     | 71.5                                        | 61–82.5                                     | 60.6     | 55.4–69.6   | −15.3 |
| Hypertensive heart disease                | 36,179               | 30,771–46,101         | 73.2     | 27.0                                        | 22.7–35.2                                   | 21.4     | 19–24.1     | −20.7 |
| Cardiomyopathy and myocarditis            | 18,025               | 15,031–20,571         | 50.5     | 8.7                                         | 7.2–10                                      | 7.3      | 6.5–7.9     | −16.6 |
| Atrial fibrillation and flutter           | 3513                 | 2654–4487             | 114.5    | 3.9                                         | 2.9–5.1                                     | 3.5      | 2.6–4.5     | −11.0 |
| Aortic aneurysm                           | 2694                 | 2163–3414             | 157.6    | 2.0                                         | 1.6–2.5                                     | 2.3      | 2.1–2.5     | 14.9  |
| Peripheral artery disease                 | 114                  | 68–151                | 272.4    | 0.1                                         | 0.1–0.1                                     | 0.2      | 0.1–0.2     | 65.9  |
| Endocarditis                              | 5172                 | 4167–7067             | 74.3     | 2.9                                         | 2.3–4.2                                     | 2.6      | 2.3–3.9     | −8.3  |
| Other cardiovascular and circulatory      | 38,243               | 34,519–42,477         | 45.5     | 20.3                                        | 18.5–22.2                                   | 17.1     | 15.9–18.6   | −15.7 |
Electronic supplementary figure S1 shows the top-ranked death rates for different CVD in EMR countries. Ischemic heart disease was the leading cause of CVD mortality in 20 countries of the EMR; the exceptions were Djibouti and Somalia, where cerebrovascular disease (both hemorrhagic and ischemic stroke) was the leading cause of cardiovascular-related death.

**YLLs**

The age-standardized YLL rate decreased 15.3%, from 9618.7 (9148.6–10,141.7) per 100,000 in 1990–8145.0 (7628.6–8744.3) per 100,000 in 2015 (Electronic supplementary table S2). In the region, Afghanistan had the highest age-standardized YLL rate at 21,426.2 (17,105.2–26,544.7), followed by Yemen and Iraq (Electronic supplementary table S2). In all countries of the EMR except Pakistan, age-standardized YLL rates decreased from 1990 to 2015 (Electronic supplementary table S2).

**YLDs**

The years lived with disability caused by CVD in the EMR increased from 1,058,839 (95% UI: 746,613–1409,913) in 1990 to 1,966,111 (95% UI: 1398,373–2597,819) in 2015. The rate of YLD increased by 85.7% during 1990–2015 in the EMR.

The age-standardized YLD rate in the EMR was 460.6 (329.2–603.6) per 100,000 in 2015, which showed very little decrease compared to 1990 (461.1 per 100,000) (Electronic supplementary table S2). Oman had the highest age-standardized YLD rate in the region in both 1990 and 2015: it was 1261 (874.6–1722.1) per 100,000 in 2015, which was about 2.7 times higher than the regional average. United Arab Emirates had the lowest age-standardized YLD rate in the EMR, 296.8 per 100,000 in 1990 and 285.8 per 100,000 in 2015. Age-standardized YLD rates of CVD decreased between 1990 and 2015 in six countries of the region: Iran, United Arab Emirates, Jordan, Djibouti, Somalia, and Afghanistan. The biggest decline was seen in Iran (4.6%), and the smallest reduction was in Afghanistan (0.5%). Among the remaining 16 countries of the region that showed increases in age-standardized YLD rates of CVD, Syria’s was the greatest, at 9.1%.

**DALYs**

The rate of DALYs from CVD per 100,000 population decreased from 5447.8 (95% UI: 5168.2–5739.0) in 1990–5109.8 (95% UI: 4771.3–5511.1) in 2015, a 6.2% decrease—compared to an 8.4% reduction in the DALY rate for all other non-communicable diseases in the EMR. The age-standardized DALY rate also decreased 14.6% during 1990–2015 (Table 3). Table 3 reports numbers and age-standardized rates of DALYs for different CVD in the EMR in 1990 and 2015. The age-standardized DALY rate of CVD for men and women in the EMR in 2015 was higher than in other WHO regions. It was 1.51 times the global rate for males and 1.86 times the global rate for females. Electronic supplementary figure S2 shows the age-standardized rates of DALYs for different CVD in men and women. As shown, ischemic heart disease caused the highest number of DALYs both in men (5771.9 per 100,000) and women (3931.2 per 100,000), followed by hemorrhagic stroke and ischemic stroke.

Electronic supplementary figure S3 shows DALY rates for each CVD in different age groups. As shown, the highest DALY rates for IHD, hemorrhagic stroke, ischemic stroke, and hypertensive heart disease were observed in people aged 50–69 years. IHD, hemorrhagic stroke, and rheumatic heart disease showed the highest number of DALYs in the 15–49 years age group.
Table 2: Total number of deaths and age-standardized mortality rates for cardiovascular disease causes of death in 1990 and 2015, and percent change, Global Burden of Disease study, Eastern Mediterranean Region, 1990–2015

| Country      | Number of deaths | Age-standardized death rate per 100,000 |
|--------------|------------------|----------------------------------------|
|              | 1990             | 2015                                   |
|              | Number 95% UI    | Number 95% UI                          |
| EMR          | 735,689          | 700,875–773,593                        | 1,373,329 | 1,290,959–1,465,047 | 86.7 |
| Afghanistan  | 34,755           | 27,217–42,776                          | 10,1572  | 81,113–125,962      | 192.2 |
| Bahrain      | 614              | 547–681                                | 792     | 671–933             | 29.0  |
| Djibouti     | 683              | 434–1025                               | 1402    | 762–2395            | 105.3 |
| Egypt        | 153,214          | 147,677–157,026                        | 226,457 | 219,738–234,235     | 47.8  |
| Iran         | 96,775           | 86,347–107,587                         | 176,299 | 148,576–203,480     | 82.2  |
| Iraq         | 44,476           | 38,326–51,342                          | 75,604  | 61,673–91,552       | 70.0  |
| Jordan       | 4,869            | 4319–5684                              | 6788    | 6108–7611           | 39.4  |
| Kuwait       | 1262             | 1192–1324                              | 2367    | 2040–2747           | 87.6  |
| Lebanon      | 7,397            | 6206–8674                              | 11,632  | 8967–14,195         | 57.3  |
| Libya        | 4,864            | 4354–5397                              | 9301    | 8130–10,535         | 91.2  |
| Morocco      | 36,293           | 32,487–40,581                          | 59,824  | 47,641–75,972       | 64.8  |
| Oman         | 2,108            | 1688–2552                              | 4000    | 3336–4583           | 89.7  |
| Pakistan     | 216,936          | 191,002–247,476                        | 465,116 | 407,279–528,666     | 114.4 |
| Palestine    | 2333             | 1902–2925                              | 5805    | 4683–6954           | 148.8 |
| Qatar        | 338              | 297–383                                | 723     | 568–924             | 114.3 |
| Saudi Arabia | 13,222           | 11,931–14,651                          | 25,845  | 23,532–28,503       | 95.5  |
| Somalia      | 11,706           | 3957–22,825                            | 15,080  | 5270–31,505         | 28.8  |
| Sudan        | 42,922           | 35,852–51,825                          | 74,648  | 56,697–97,015       | 73.9  |
| Syria        | 23,049           | 20,307–26,719                          | 33,044  | 28,488–36,934       | 43.4  |
| Tunisia      | 10,747           | 9970–11,633                            | 18,423  | 14,973–21,952       | 71.4  |
| UAE          | 1641             | 1260–2230                              | 8563    | 6337–11,314         | 421.9 |
| Yemen        | 25,485           | 16,534–36,647                          | 50,043  | 30,637–78,838       | 96.4  |

% Change: 1990–2015

| Country      | Number of deaths | Age-standardized death rate per 100,000 |
|--------------|------------------|----------------------------------------|
|              | 1990             | 2015                                   |
|              | Rate 95% UI      | Rate 95% UI                            |
| EMR          | 515.1            | 491.7–541.5                           | 456.5   | 431.5–484.2         | –11.4 |
| Afghanistan  | 1048.1           | 860.6–1235.4                          | 1042.5  | 865–1227.9          | –0.5  |
| Bahrain      | 414.1            | 371.4–456.9                           | 186.1   | 162.1–210.2         | –55.1 |
| Djibouti     | 393.4            | 265.8–568.8                           | 360.9   | 212.6–590.1         | –8.3  |
| Egypt        | 544.9            | 530.1–556.7                           | 465.2   | 451.7–479.2         | –14.6 |
| Iran         | 499.2            | 451.4–547.5                           | 402.2   | 344–456.9           | –19.4 |
| Iraq         | 657.6            | 569.1–755.1                           | 604.4   | 503.7–715.3         | –8.1  |
| Jordan       | 416.0            | 370.2–481.4                           | 236.9   | 214.1–264.4         | –43.1 |
| Kuwait       | 258.5            | 245–371.3                             | 209.7   | 185–237             | –18.9 |
| Lebanon      | 464.2            | 391.3–540.9                           | 252.1   | 196–305.1           | –45.7 |
| Libya        | 310.3            | 276.6–344                             | 299.7   | 263.3–393.3         | –3.4  |
| Morocco      | 362.1            | 327.5–400.4                           | 268.3   | 216.5–336.6         | –25.9 |
| Oman         | 378.8            | 300.7–461.2                           | 300.3   | 255.4–336.8         | –20.7 |
| Pakistan     | 513.1            | 454.9–578                             | 530.9   | 469–599.1           | 3.5   |
| Palestine    | 443.1            | 366.5–452                             | 394.9   | 326.3–462.4         | –10.9 |
| Qatar        | 342.4            | 303.1–380.4                           | 180.6   | 149.6–221.8         | –47.3 |
| Saudi Arabia | 288.0            | 260.4–317.9                           | 231.6   | 213.2–253.4         | –19.6 |
| Somalia      | 508.9            | 192.7–890.2                           | 439.7   | 172.6–813.3         | –13.6 |
| Sudan        | 611.3            | 512.7–738.5                           | 501.9   | 388.7–634.1         | –17.9 |
| Syria        | 554.8            | 494.8–634.9                           | 401.0   | 348.7–446.9         | –27.7 |
| Tunisia      | 285.3            | 263.3–308.9                           | 204.0   | 166.5–242.6         | –28.5 |
| UAE          | 406.5            | 327.3–501.8                           | 333.4   | 279.6–403.7         | –18.0 |
| Yemen        | 700.0            | 461.6–991.9                           | 592.1   | 383–888.5           | –15.4 |
Table 3 Total disability-adjusted life years (DALY) and age-standardized disability-adjusted life years rates for component cardiovascular causes of death in 1990 and 2015, and percent change, Global Burden of Disease study, Eastern Mediterranean Region, 1990–2015

| Cause                        | Number of DALYs | Age-standardized DALY rate per 100,000 |
|------------------------------|-----------------|---------------------------------------|
|                              | 1990            | 2015                                  | % Change |
|                              | Number 95% UI   | Number 95% UI Rate 95% UI            |          |
| Cardiovascular diseases      | 20,164,206 19,129,504–21,242,151 | 10,079.8 9594.7–10,603.6 | −14.6 |
| Rheumatic heart disease      | 876,838 770,813–986,361 | 302.1 265.1–344.5 | −28.5 |
| Ischemic heart disease       | 932,318 8770,306–9877,741 | 5370.1 5026.2–5672.7 | −9.4 |
| Ischemic stroke              | 1879,679 1649,862–2128,711 | 1183.5 1031.4–1361 | −15.7 |
| Hemorrhagic stroke           | 394,327 365,523–433,670 | 1649.0 1485.2–1870.5 | −21.0 |
| Hypertensive heart disease   | 822,728 711,712–1011,157 | 479.4 411.3–603 | −22.6 |
| Cardiomyopathy and myocarditis | 833,292 693,153–982,453 | 247.2 206.1–281.7 | −24.0 |
| Atrial fibrillation and flutter | 77,777 61,867–94,926 | 63.3 51.4–77 | −8.0 |
| Aortic aneurysm              | 63,221 50,928–80,451 | 35.4 28.5–45 | 17.6 |
| Peripheral artery disease    | 13,954 7359–24,367 | 10.1 5.3–17.9 | 11.3 |
| Endocarditis                 | 217,347 160,723–291,718 | 68.4 55.9–92.5 | −14.4 |
| Other CVD                    | 2114,855 1844,679–2463,667 | 671.3 599.3–755.3 | −26.2 |

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Table 4  Total number of disability-adjusted life years and age-standardized disability-adjusted life years rates for cardiovascular diseases in 1990 and 2015, and percent change, 1990–2015, in Eastern Mediterranean Region countries

| Country       | Number of DALYs | Age-standardized DALY rate per 100,000 |
|---------------|-----------------|---------------------------------------|
|               | 1990 Number     | 2015 Number                             |
|               | 95% UI          | 95% UI                                 |
| 1990 % Change | Rate 95% UI     | Rate 95% UI                             |
| 2015 % Change | Rate 95% UI     | Rate 95% UI                             |
|----------------|-----------------|---------------------------------------|
| EMR            | 20,164,206      | 33,131,948                             |
|                | 19,129,504–21,242,151 | 30,937,166–35,734,353                  |
|                | 64.3            | 10,079.8                               |
|                | 9594.7–10,603.6 | 8605.6                                 |
|                | 30.5            | 8074.6                                 |
|                | 6–9219.3        | -14.6                                  |
| Afghanistan    | 1,019,023       | 2,865,062                              |
|                | 7,93,590–1,278,676 | 2,239,466–3,635,800                    |
|                | 181.2           | 22,258.2                               |
|                | 17,615.6–27,186.7 | 17,591.4–27,024.5                     |
|                | 21.8            | 1.8                                    |
| Bahrain        | 18,578          | 8086.5                                 |
|                | 16,524–20,639   | 7206.4                                 |
|                | 25.8            | 2832.6                                 |
|                | 11,863.9        | 3769.2                                 |
| Djibouti       | 19,979          | 7891.5                                 |
|                | 13,027–29,586   | 5171.4                                 |
|                | 79.8            | 4021.2                                 |
|                | 8605.6          | -9.9                                   |
| Egypt          | 4,373,017       | 11,230.6                               |
|                | 4,109,349–4,595,897 | 10,762.9–11,583.1                     |
|                | 24.3            | 8826.2                                 |
|                | 8074.6          | -21.4                                  |
| Iran           | 2,941,466       | 9,849.9                                |
|                | 2,610,284–3,291,417 | 8776.8–10,950.2                      |
|                | 31.8            | 7179.6                                 |
|                | 6090.9–9,340.9  | 27.1                                   |
| Iraq           | 1,070,614       | 12,513.4                               |
|                | 917,957–1248,583 | 10,676.3–14,669.9                     |
|                | 75.2            | 11,244.0                               |
|                | 9,989.1–13,679.3 | 10.1                                   |
| Jordan         | 109,195         | 8792.8                                 |
|                | 95,903–127,032  | 6771.4                                 |
|                | 41.3            | 3071.5                                 |
|                | 4077.5          | -47.0                                  |
| Kuwait         | 40,918          | 6384.4                                 |
|                | 38,315–43,123   | 5714.7                                 |
|                | 84.2            | 4957.2                                 |
|                | 5683.4          | -11.7                                  |
| Lebanon        | 167,913         | 1103.4                                 |
|                | 154,797–199,183 | 7050.6                                 |
|                | 25.8            | 5071–6713.2                            |
| Libya          | 176,223         | 304.3                                 |
|                | 154,977–198,183 | 1010.2                                 |
|                | 33.1            | 992.4                                  |
|                | 5071–6713.2     | -31.1                                  |
| Morocco        | 1,103,861       | 1,332,750                              |
|                | 980,405–1,235,540 | 1,078,637–1,670,227                   |
|                | 20.7            | 7222.4                                 |
| Oman           | 93,965          | 853.6                                 |
|                | 76,349–115,695  | 6511.3                                 |
|                | 44.0            | 4977.5                                 |
|                | 7692.8          | -31.1                                  |
| Pakistan       | 5,069,303       | 1,301.4                                |
|                | 4,422,395–5,880,731 | 1,236,078–1,830,492                  |
|                | 111.5           | 9928.0                                 |
|                | 8,904.3         | 5.1                                    |
| Palestine      | 68,438          | 8263.4                                 |
|                | 55,953–85,314   | 6749.8                                 |
|                | 119.9           | 5868.1                                 |
| Qatar          | 10,556          | 24.791                                |
|                | 9283–12,017     | 19,932                                 |
|                | 134.8           | 7280.6                                 |
|                | 5071–6713.2     | -11.9                                  |
| Saudi Arabia   | 359,601         | 663,879                               |
|                | 320,837–401,588 | 600,438–732,764                      |
|                | 84.6            | 4039.5                                 |
| Somalia        | 329,146         | 528,500                               |
|                | 120,719–676,354 | 7472.5–8561.6                       |
|                | 24.6            | 36520.2                                |
| Sudan          | 1,359,599       | 10,762.8                               |
|                | 1,129,865–1,596,275 | 120,719–21,078.4                   |
|                | 50.6            | 10062.4                                |
| Syria          | 668,927         | 12,814.4                               |
|                | 579,151–779,665 | 10,687.4–15,522.9                   |
|                | 14.6            | 7923.7                                 |
| Tunisia        | 282,490         | 11,211.5                               |
|                | 259,822–306,247 | 9876.4–13,008.3                      |
|                | 31.3            | 7277.4                                 |
| UAE            | 56,629          | 5367.9                                 |
|                | 42,431–80,907   | 9928.2                                 |
|                | 438.2           | 6184.6                                 |
| Yemen          | 824,766         | 7978.3                                 |
|                | 550,243–1,143,803 | 620,130–901,976                    |
|                | 71.9            | 6090.9                                 |
|                | 14,715.3        | -22.5                                  |

**Burden of cardiovascular diseases in the Eastern Mediterranean Region...**
Table 4 summarizes age-standardized DALY rates for CVD in the EMR countries in 1990 and 2015. As shown, DALY rates decreased in all EMR countries except Pakistan from 1990 to 2015; the greatest reductions in DALY rates were seen in Bahrain (59.4%), Qatar (48.7%), and Jordan (47%). Afghanistan had the highest age-standardized CVD DALY rate in both 1990 and 2015. Kuwait had the lowest age-standardized DALY rate of CVD in 1990, and Qatar had the lowest in 2015.

Analyzing the components of DALYs, CVD had a higher YLL rate compared to YLD rate: on average, YLLs were 17.7 times higher than YLDs in the EMR. The YLL/YLD ratio in the countries of the region showed a wide range of variation, from 48.9 in Afghanistan to 3.7 in Oman (Electronic supplementary table S2).

Risk factors

Figure 2 shows the contribution, in DALYs, of different risk factors to different CVD. High blood pressure, high total cholesterol, and high body mass index were the leading risk factors for CVD, accounting for 17,159,331 DALYs, 9,852,820 DALYs, and 8,427,021 DALYs, respectively.

The cluster of all dietary risk factors accounts for 19,803,725 DALYs, making it the leading risk factor for CVD, higher than even high blood pressure. Low whole grains, low fruit, low vegetables, and high sodium intake were the most important dietary risk factors.

Discussion

This study shows that CVD are the leading cause of disease burden in the EMR as a whole and in most of the countries of the region. Close to 33 million years of life were lost due to premature mortality or disability from CVD, and more than 1.3 million people died in the EMR in 2015, accounting for around one-third of all deaths in the region. Previous studies have also reported CVD deaths as the main cause of death, for instance, 45% in the West Bank (Palestine), 45% in Aleppo (Syria), 35% in Jordan, and 25% in UAE (Barakat et al. 2012; Loney et al. 2013; Shara 2010). A study in Europe has reported CVD mortality as making up half of all deaths (Nichols et al. 2014).

CVD age-standardized mortality was considerably higher than the global average (456 compared to 286 per 100,000); however it shows a declining trend over the past 25 years in most of the EMR countries. Countries with higher declines (Bahrain, Qatar, Lebanon, and Jordan) were among the countries in the fourth Socio-demographic Index quartile category. In another GBD study, we estimated an index for healthcare access and quality which is a composite index based on estimates of mortality amenable to healthcare.
to personal health care and varies between 0 (worst) and 100 (best). The index showed substantial heterogeneity with a range between 32 (Afghanistan) and 85 (Qatar) in 2015 in the EMR. Linking these results to the findings of our study showed that the countries with lower age-standardized DALY rates due to CVD had a higher index for healthcare access and quality, and vice versa. This restates the importance of increasing access to and quality of health care to reduce CVD burden (Barber et al. 2017).

In the EMR, YLLs are the main component of CVD burden. A global-level assessment showed that for overall CVD, YLL rates were lowest in both the lowest and highest socio-demographic groups, with an increase for those in the middle of the socio-demographic rankings. It has been suggested that medical care in countries with the highest Socio-demographic Index might have increased life expectancy to the point where CVD is most prevalent, while people in the lowest socio-demographic group are dying from other competing conditions before reaching the common age for developing ischemic heart disease and stroke. Based on this hypothesis, people living in countries in the middle range of the socio-demographic rankings are surviving long enough to develop ischemic heart disease but do not have access to optimal medical or surgical treatment (GBD 2015 Mortality and Causes of Death Collaborators 2016).

These findings call for a comprehensive approach to prevent and control the burden of CVD in the region. This approach should include a road map for better monitoring of the burden in EMR countries, with a focus on potential variations in risk and care by regions within the countries. It should also include programs for increasing awareness among the general population of the importance of controlling CVD risk factors.

The United Nations has set targets to decrease mortality from non-communicable diseases (Sustainable Development Goals, target 3.4.1), and CVD is at the center of this target (GBD 2015 SDGs Collaborators 2016). The World Health Organization has suggested a package of essential non-communicable disease interventions for primary health care in low-resource settings (PEN). These interventions include a mixture of cost-effective population-wide and individual approaches to reduce the burden of major non-communicable diseases, such as methods for early detection and diagnosis using inexpensive technologies, non-pharmacological and pharmacological approaches for modification of risk factors, and affordable medications for prevention and treatment of heart attacks and strokes, diabetes, cancer, and asthma (World-Health-Organization 2010).

Our study showed that increased blood pressure is the most important risk factor for CVD in the EMR, followed by high total cholesterol and high body mass index. A Cochrane systematic review showed that multiple risk factor interventions may lower systolic and diastolic blood pressure, body mass index, and waist circumference in low- and middle-income countries (Uthman et al. 2015).

Previous studies show a high percentage of undiagnosed CVD risk factors, such as diabetes and hypertension, in the region (Abd El-Aty et al. 2015; El Bcheraoui et al. 2014a, b; Najafipour et al. 2014). The evidence shows that delayed detection and undiagnosed risk factors, especially diabetes, are strong predictors of fatal CVDs (Nakagami et al. 2006). Based on reports from the region, required care and services (such as medications) are underutilized in diagnosed cases, even in high-income countries like Saudi Arabia (Moradi-Lakeh et al. 2016). Underutilization of medications is a function of availability, accessibility, affordability, acceptability, and quality of medicines (and care), as well as adherence to medical recommendations (Behnood-Rod et al. 2016; Najafipour et al. 2014; van Mourik et al. 2010; Wirtz et al. 2016). The Prospective Urban Rural Epidemiology (PURE) study showed great variation in availability, affordability, and use of medications for CVD, between and within countries. Countries with less control over production, importation, distribution chains, and retail outlets are specifically at risk of sub-standard quality and falsification of medicines (Khatib et al. 2016). All these factors are important to achieve desired health outcomes in the field of CVD. CVD prevention and control programs should improve the perceived need and demand of the population for early detection and use of the prevention/control services. The study on CVD mortality forecast in 2015 has shown that the MENA region will not achieve the target of 25% reduction of CVD mortality by 2025 without achieving all major targets for risk factor reduction (i.e., reducing the prevalence of elevated systolic blood pressure by 25%, reducing the prevalence of smoking by 30%, halting the rise in elevated body mass index, and halting the rise in fasting plasma glucose). Moreover, reports of health system challenges in controlling and managing CVD in some of the EMR countries reemphasize the need for significant investment and improvement of access (Roth et al. 2015a, b; Romdhane et al. 2015; Ahmad et al. 2015).

Our study has some limitations; accurate data on cardiovascular events (especially non-fatal outcomes) are limited in many countries, including the EMR countries. We used the standard GBD methodology by using study- and country-level covariates for adjustment and estimation of epidemiologic measures. Our study does not account for variation within countries.
Conclusion

Most of the EMR countries have launched programs to reduce the burden of non-communicable disease, but they generally do not have widespread programs to combat CVD. This study calls for strengthening efforts to design and launch comprehensive programs to cover all aspects of prevention and control of CVDs through evidence-informed, efficient interventions. The countries should establish or improve information systems such as surveillance systems to provide valid and accurate information for policymaking and monitoring of the situation.
writing of the paper. The study did not involve human participants and/or animals; therefore, no informed consent was needed.

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Conflict of interest The authors declare that they have no conflicts of interest at this time.

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