Neuroepidemiology

Original Paper

Neuroepidemiology 2021;55:447–459
DOI: 10.1159/000519281

Received: July 12, 2021
Accepted: August 23, 2021
Published online: October 14, 2021

Disability-Adjusted Life Years and Mortality Rate Attributed to Brain and Central Nervous System Cancer in the Middle East and North Africa Countries

Hamid Reza Saeidi Borojeni[a] Farid Najafi[b] Fatemeh Khosravi Shadmani[b] Zahra Darabi[b] Mitra Darbandi[b] Khosro Farhadi[a] Sepehr Saeidi Borojeni[a] Shokofeh Maleki[a] Mehdi Naderi[a]

[a]Clinical Research Development Centre, Taleghani and Imam Ali Hospital, Kermanshah University of Medical Sciences, Kermanshah, Iran; [b]Research Center for Environmental Determinants of Health (RCEDH), Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran

Keywords
Brain and central nervous system cancer · Disease burden · Mortality · Middle East · North Africa

Abstract
Background: Primary brain tumors are among the main causes of death. This study aimed to determine the epidemiological features of the brain and central nervous system cancer in the Middle East and North Africa (MENA) region. ***Methods:*** In this study, data of the Global Burden of Disease (GBD) study were used to estimate the incidence, prevalence, deaths, disability-adjusted life years (DALYs), and mortality in 21 countries in the MENA region from 1990 to 2019 based on age and sex. The percentage of the changes of epidemiologic indicators was calculated between 1990 and 2019. ***Results:*** Palestine and Turkey had the highest rate of brain and central nervous system cancer in 2019. Saudi Arabia, Oman, Iraq, and Lebanon had the highest percentage of incidence rate changes from 1990 to 2019. The prevalence of brain and central nervous system cancer in the MENA region was increased from 7.51 (95% CI: 4.95–11.01) in 1990 to 16.45 (95% CI: 10.83–19.54) in 2019 (percentage of changes = 54.35%). The standardized age mortality rate in the MENA region was increased by 2.7% in 2019 compared to that in 1990. The rate of standardized age of DALY per 100,000 individuals in the MENA region decreased from 135.09 (95% CI: 92.57–199.92) in 1990 to 128.34 (95% CI: 87.81–151.3) in 2019. ***Conclusion:*** The incidence rate, prevalence, and standardized age mortality (per 100,000) had increased significantly in the MENA region in 2019 compared to those in 1990. Focusing on the diversity of the estimates of such indices in different countries of MENA can lead to the identification of important risk factors for brain cancer in future studies.

Introduction

Neoplasms of the brain and central nervous system (CNS) account for 1–2% of the total burden of disease, but they are a significant source of disease and mortality worldwide [1]. Primary brain tumors are among the top 10 causes of death and the second leading cause of cancer death in people under 19 years old [2]. Brain cancer ac-

Correspondence to:
Mehdi Naderi, m.naderi51@yahoo.com

counts for about 22% of all cancers, and out of 220,000 people with brain cancer, 130,000 individuals die each year [3, 4]. Malignant brain tumors account for 1.4% of all cancers and 2.4% of all cancer deaths [5]. The age-standardized incidence per 100,000 people is between 4.3 and 18.6 [5, 6]. In addition to the contribution of genetic and past family history in the development of various cancers and especially brain cancer, other factors such as lifestyle, age, occupational exposure and other exposures (exposure to lead, air pollution, pesticides, and nuclear and magnetic field exposure), and low human capital development index have been reported [7–14].

In 2016, about 330,000 cases (34,900–298,926) of CNS cancer with an age-standardized incidence rate of 4.63 per 100,000 people were reported, indicating a 17.3% (11.4–26.9) increase from 1990 to 2016 [1]. The incidence rate and the percentage of changes of cancer in the countries of the MENA region in 1990–2016 are 18,449 (15,251–20,751) and 20.5% (2–75.8), respectively. The difference between the incidence of brain cancer among geographical areas and changes over the years can be attributed to factors such as variation in diagnosis, reporting method, risk factors, and genetic background of studied populations [1, 15, 16].

Due to the industrialization of societies and lifestyle changes and the improvement of diagnostic methods, the prevalence of brain cancer is expected to be increased which requires the provision of consistent statistics for accurate planning and prevention [1]. For the purpose of this study, we decided to investigate the epidemiology of brain cancer in the MENA region as they have many characteristics in common. Some of these countries are facing war and its aftermath. Besides, they are mostly similar in terms of cultural background and lifestyle.

Materials and Methods

This study was performed using GBD data. On the IHME 2017 website (Institute for Health Metrics and Evaluation), information is reported based on countries, age, and sex. The latest update was used, which is related to the estimation of all epidemiologic indices from 1990 to 2019 (https://vizhub.healthdata.org/gbd-compare/). According to the objectives of this study, the information related to 21 countries of the Middle East and North Africa (MENA), including Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Palestine, Oman, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, and Yemen, was investigated. Generally, the epidemiological indices of the brain and CNS cancer from 1990 to 2019 were investigated in 21 countries by age group and sex. Cancer of the CNS is defined as brain and spine tumors. However, in the third edition of the international classification of diseases (ICD-O-3), tumors of the meninges, pituitary gland, pineal gland, and nerves are defined as CNS tumors [17]. In the tenth edition of ICD, CNS cancer includes all cancers, which are encoded with the codes C70.0–C72.9 (C70, malignant meninges neoplasm; C71, malignant brain neoplasm; and C72, malignant neoplasm of the spinal cord, cranial nerves, and other parts of CNS). Since the tenth edition of ICD is based on the location of cancer rather than histology, the GBD study does not currently include estimates for the subtypes of brain cancer and CNS. After cleaning the data, the incidence rate, prevalence, burden of CNS tumors, and age-standardized mortality rates were presented by country and gender. Besides, over the period of the study, the percentage of changes of the abovementioned indices was presented by each country as well as by age groups. Changes in data were analyzed and visualized by using R software version 4.0.2 (2020.06.22).

Results

The incidence rate of CNS cancer in 1990 in MENA was 4.08, 3.41, and 4.73/100,000 in the whole population, women, and men, respectively (Table 1). In 2019, Palestine with 9.42 (7.05–11.24) and Iraq with 8.53 (6.29–10.86) per 100,000 individuals had the highest incidence rate of CNS cancer, respectively. The highest incidence rate in 2019 was observed in Palestine and Iraq in the age group of 80–90 and 70–80 years, respectively. Over the period of the study, the percentage of changes of age-standardized prevalence per 100,000 people for CNS cancer in the countries under investigation was significant among the included countries. The values for Saudi Arabia, Lebanon, Oman, Qatar, Jordan, Iran, Iraq, and the MENA region were 81.64, 74, 71.84, 69.72, 59.41, 56.39, 55.3, and 54.35, respectively. The incidence of CNS cancer in the MENA region in 1990 and 2019 was higher than the global average which is not true about the prevalence of CNS tumors as it is lower than the global average. Besides, the DALY rate in MENA countries in 2019 was reported to be higher than the global average (128.34 vs. 109 per 100,000 individuals) (Table 1). The DALY rate in MENA was 137.52 (82–168.31) and 128.34 (87.81–151.3) in men and women, respectively. In both sexes in 1990, the highest DALY rate was reported in Palestine (255.22; 190.39–372.37), and the lowest DALY rate was in Tunisia (44.23; 34.66–59.2). Furthermore, in 2019, the highest DALY rate was in Palestine (232; 175.63–279.46), and the lowest DALY rate was in Tunisia (45.52; 28.5–66.36) in both sexes. In terms of the trends in changes in the DALY rate from 1990 to 2017, there were increasing trends in Iraq, Morocco, Oman, Saudi Arabia, Tunisia, and Yemen. In fact, Saudi Arabia had the highest changes (24.42%) which had more prominent changes in women

Table 1. Comparison of the burden of brain cancers in the world and MENA in 1990 and 2019

Country	Sex	Incidence rate of brain cancer according to ASR			Prevalence rate of brain cancer according to ASR			Death rate of brain cancer according to ASR			DALY rate of brain cancer according to ASR		
		1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change
Afghanistan	F	3.99 (1.18–12.98)	4.48 (1.89–12.50)	10.94	5.89 (1.54–20.88)	6.71 (2.72–18.85)	12.22	3.61 (1.11–11.26)	4.09 (1.76–11.28)	11.74	152.46 (39.81–535.75)	157.87 (63.37–444.46)	3.43
	M	3.81 (0.31–14.18)	5.72 (3.02–9.57)	33.39	8.76 (3.37–19.11)	8.50 (4.24–14.65)	−3.06	5.35 (2.47–10.55)	5.28 (2.82–8.75)	−1.33	219.87 (84.74–476.39)	195.39 (97.29–334.78)	−12.53
	Both	4.96 (2.63–10.68)	5.07 (3.02–9.26)	2.17	7.36 (3.46–17.05)	7.36 (3.46–17.05)	0	4.51 (2.49–9.40)	4.66 (2.84–8.48)	3.22	186.91 (89.39–431.50)	176.03 (99.65–323.91)	−6.18
Algeria	F	1.56 (1.12–2.08)	2.24 (1.34–2.96)	30.36	3.21 (1.99–4.46)	7.92 (4.29–11.5)	59.47	1.28 (0.96–1.74)	1.46 (0.93–1.94)	12.33	54.12 (35.44–72.73)	57.65 (33.39–77.51)	6.12
	M	2.04 (1.39–3.18)	2.37 (1.23–3.23)	13.92	4.33 (2.52–6.66)	8.56 (4.38–12.28)	49.42	1.67 (1.21–2.6)	1.53 (0.8–2.08)	−9.15	69.7 (42.89–107.71)	58.86 (29.75–81.48)	−18.42
	Both	1.8 (1.4–2.43)	2.31 (1.45–2.93)	22.08	3.78 (2.59–5.2)	8.25 (4.95–11.05)	54.18	1.48 (1.18–2.05)	1.5 (0.97–1.88)	1.33	61.96 (44.88–82.31)	58.27 (35.31–73.87)	−6.33
Bahrain	F	2.34 (1.69–3.3)	3.12 (2.11–4.09)	25	4.26 (3.07–6.04)	12.21 (8.09–16.93)	65.11	2.04 (1.47–2.9)	1.92 (1.3–2.48)	−6.25	70.09 (50.65–98.83)	65.29 (43.87–84.38)	−7.35
	M	4.08 (2.4–5.97)	3.97 (2.27–5.36)	−2.77	7.4 (4.57–10.08)	16.77 (8.84–23.13)	55.87	3.58 (2.09–5.4)	2.29 (1.36–3.13)	−56.33	119.3 (71.4–166.02)	78.5 (42.32–106.55)	−51.97
	Both	3.29 (2.31–4.48)	3.61 (2.36–4.64)	8.86	5.99 (4.28–7.94)	14.81 (9.36–19.26)	59.55	2.87 (1.99–3.99)	2.14 (1.44–2.75)	−34.11	97.32 (68.61–127.99)	72.99 (46.72–93.35)	−33.33
Egypt	F	2.4 (1.92–4.2)	3.09 (1.8–5.09)	22.33	3.94 (3.16–6.87)	7.63 (3.79–12.68)	48.36	2.13 (1.68–3.82)	2.41 (1.47–4.12)	11.62	84.29 (68.86–143.12)	89.26 (49.11–143.59)	5.57
	M	3.3 (2.53–6.29)	3.78 (2.43–6.14)	12.7	5.59 (4.23–11.24)	9.61 (5.87–14.74)	41.83	2.9 (2.19–5.53)	2.88 (1.85–4.97)	−0.69	116.49 (89.94–230.03)	107.54 (68.62–166.43)	−8.32
	Both	2.86 (2.29–4.9)	3.45 (2.37–5.11)	17.1	4.78 (3.87–8.77)	8.67 (5.86–12.02)	44.87	2.52 (1.99–4.31)	2.66 (1.82–4.09)	5.26	100.67 (82.49–178.23)	98.82 (68.1–141.13)	−1.87
Iran	F	4.73 (2.39–7.63)	6.75 (3.45–8.57)	29.93	10.24 (4.58–17.94)	25.4 (12.92–34.85)	59.69	3.9 (2.04–6.05)	4.3 (2.16–5.29)	9.3	150.64 (70.39–246.81)	146.99 (76.04–184.89)	−2.48
	M	6.44 (3.4–8.84)	7.8 (3.28–10.1)	17.44	13.8 (6.76–20.08)	29.98 (13.01–41.38)	53.97	5.31 (2.87–7.2)	4.85 (2.01–6.19)	−9.48	197.64 (104– 275.63)	165.75 (72.86–213.07)	−19.24
	Both	5.61 (3.31–7.33)	7.28 (3.66–8.77)	22.94	12.08 (6.67–16.2)	27.7 (14.43–35.07)	56.39	4.62 (2.81–5.93)	4.57 (2.26–5.47)	−1.09	175.03 (102.02–223.69)	156.38 (81.96–187.04)	−11.93
Iraq	F	6.8 (4.38–12.73)	8.4 (5.79–11.02)	19.05	8.83 (5.21–16.74)	23.55 (15.2–32.75)	62.51	4.25 (2.56–8.2)	6.22 (4.36–8.06)	31.67	166.21 (100.47–310.82)	228.65 (155.36–301.09)	27.31
	M	4.93 (2.94–9.5)	8.71 (5.79–12.01)	43.4	12.18 (7.61–22.83)	23.64 (15.91–33.9)	48.48	5.9 (3.8–10.95)	6.58 (4.33–9)	10.33	225.25 (142.55–428.09)	223.65 (149.69–312.56)	−0.72
	Both	5.86 (4.19–9.96)	8.53 (6.29–10.86)	31.3	10.51 (7.37–18.94)	23.51 (16.99–31.2)	55.3	5.06 (3.57–8.6)	6.38 (4.69–8.17)	20.69	195.88 (139.32–342.11)	225.65 (162.92–289.01)	13.19

Neuroepidemiology 2021;55:447–459
DOI: 10.1159/000519281

Neuroepidemiology 2021;55:447–459
DOI: 10.1159/000519281

Table 1 (continued)

Country	Sex	Incidence rate of brain cancer according to ASR			Prevalence rate of brain cancer according to ASR			Death rate of brain cancer according to ASR			DALY rate of brain cancer according to ASR		
		1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change
Jordan	F	3.19 (2.25–4.62)	4.07 (2.71–5.52)	21.62	6.98 (4.89–10.83)	14.34 (9.2–20.41)	51.32	2.75 (1.95–4.04)	2.69 (1.79–3.62)	−2.23	100.87 (70.12–143.72)	93.19 (62.1–125.29)	−8.24
	M	3.75 (2.66–5.76)	4.65 (2.94–6.23)	19.35	5.85 (3.97–8.48)	17.15 (10.73–23.2)	65.89	3.26 (2.3–5.02)	2.97 (1.84–4)	−9.76	116.5 (80.87–177.78)	102 (64.09–135.3)	−14.22
	Both	3.48 (2.76–4.9)	4.38 (3.15–5.39)	20.55	6.43 (5.12–8.92)	15.84 (11.38–20.04)	59.41	3.01 (2.39–4.24)	2.84 (2.04–3.53)	−5.99	108.92 (85.37–150.66)	97.82 (69.49–120.61)	−11.35
Kuwait	F	2.58 (2.12–3.81)	2.94 (1.61–4.17)	12.24	8.11 (6.21–11.9)	14.46 (7.89–21.25)	43.91	1.79 (1.47–2.65)	1.47 (0.78–2.06)	−21.77	67.16 (55.39–96.5)	50.73 (27.02–72.1)	−32.39
	M	2.94 (2.38–4.07)	4.84 (3.53–6.27)	39.26	10.52 (7.98–14.57)	25.99 (18.71–34.2)	59.52	1.92 (1.57–2.64)	2.2 (1.59–2.85)	12.73	77.04 (62.41–103.37)	78.42 (56.81–101.6)	1.76
	Both	2.78 (2.41–3.65)	4.01 (2.84–4.99)	30.67	9.42 (7.72–12.29)	20.8 (14.74–26.17)	54.71	1.86 (1.62–2.51)	1.89 (1.34–2.38)	1.59	72.44 (62.78–94.78)	66.18 (47.03–82.8)	−9.46
Lebanon	F	3.66 (2.53–5.38)	5.79 (3.89–8.17)	36.79	7.26 (4.71–11.37)	28.38 (18.08–42.05)	74.42	3.06 (2.16–4.4)	2.88 (1.95–3.97)	−6.25	110.3 (73.94–166.6)	104.29 (70.95–146.35)	−5.76
	M	4.92 (3.4–7.07)	7.75 (5.07–10.33)	36.52	10.41 (6.84–15.76)	40.27 (25.21–54.54)	74.15	4.05 (2.82–5.91)	3.64 (2.46–4.93)	−11.26	147.58 (100.15–215.78)	131.9 (85.22–175.28)	−11.89
	Both	4.29 (3.35–5.82)	6.7 (4.81–8.57)	35.97	8.84 (6.59–12.29)	34 (23.62–44.84)	74	3.55 (2.81–4.77)	3.23 (2.33–4.21)	−9.91	128.89 (98.43–173.78)	117.25 (82.62–151.49)	−9.93
Libya	F	3.21 (2.06–5.1)	3.91 (2.88–5.11)	17.9	6.18 (3.65–11.02)	11.18 (7.68–15.25)	44.72	2.73 (1.8–4.21)	2.87 (2.14–3.8)	4.88	100.33 (63.15–167.19)	103.22 (73.83–135.95)	2.8
	M	5.6 (3.94–8.33)	6.39 (4.41–8.81)	12.36	11.57 (7.53–18.28)	19.25 (13.04–27.48)	39.9	4.66 (3.33–6.9)	4.54 (3.11–6.48)	−2.64	176.16 (118.79–262.94)	163.71 (112.15–225.98)	−7.6
	Both	4.48 (3.45–6.13)	5.18 (3.86–6.82)	13.51	9.03 (6.59–12.97)	15.32 (11–20.22)	41.06	3.76 (2.88–5.17)	3.72 (2.78–4.94)	−1.08	140.8 (104.82–198.18)	134.36 (99.16–175.57)	−4.79
Morocco	F	1.57 (1.07–2.38)	2.08 (1.3–3.07)	24.52	2.61 (1.57–4.62)	5.36 (3.06–8.87)	51.31	4.63 (2.99–6.51)	1.57 (1.03–2.24)	−194.9	51.93 (32.67–76.95)	64.16 (38.48–96.29)	19.06
	M	1.52 (1.04–2.21)	1.62 (1.04–2.22)	6.17	2.56 (1.59–3.86)	3.91 (2.36–5.67)	34.53	1.31 (0.91–1.87)	1.27 (0.83–1.73)	−3.15	55.61 (34.15–92.06)	46.38 (28.39–64.49)	−19.9
	Both	1.54 (1.19–2.06)	1.85 (1.32–2.43)	16.76	2.58 (1.84–3.65)	4.63 (2.99–6.51)	44.28	1.34 (1.03–1.77)	1.42 (1.04–1.87)	5.63	53.78 (38.91–74.19)	64.16 (38.48–96.29)	16.18
Oman	F	1.69 (1.02–2.6)	3.5 (2–4.78)	51.71	3.29 (1.86–5.37)	14.29 (7.59–20.53)	76.98	1.43 (0.87–2.24)	2.07 (1.23–2.8)	30.92	50.82 (30.08–78.67)	71.58 (41.53–98.63)	29
	M	2.58 (1.79–4.18)	3.9 (2.19–5.46)	33.85	5.28 (3.55–8.37)	16.82 (8.55–24.03)	68.61	2.17 (1.49–3.59)	2.21 (1.3–3.09)	1.81	76.72 (53.19–120.18)	73.96 (39.24–104.61)	−3.73
	Both	2.18 (1.6–3.28)	3.7 (2.29–4.66)	41.08	4.41 (3.23–6.41)	15.66 (9.1–20.41)	71.84	1.82 (1.31–2.77)	2.13 (1.4–2.64)	14.55	65.38 (48.6–97.07)	72.57 (43.78–91.34)	9.91

Table 1 (continued)

Country	Sex	Incidence rate of brain cancer according to ASR			Prevalence rate of brain cancer according to ASR			Death rate of brain cancer according to ASR			DALY rate of brain cancer according to ASR		
		1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change
Palestine	F	6.7 (3.78–11.07)	8.32 (5.48–10.2)	19.47	11.77 (6.31–20.6)	21.76 (14.91–28.16)	45.91	5.93 (3.39–9.59)	6.45 (4.11–7.92)	8.06	199.64 (110.26–335.45)	210.04 (142.67–254.56)	4.95
	M	10.71 (7.18–16.44)	10.69 (7.25–13.48)	−0.19	19.78 (13.15–31.03)	28.58 (19.93–38.88)	30.79	9.38 (6.19–14.48)	8.19 (5.3–10.31)	−14.53	316.82 (210.87–486.39)	255.25 (175.51–335.14)	−24.12
	Both	8.58 (6.46–12.38)	9.42 (7.05–11.24)	8.92	15.63 (11.43–22.77)	25.05 (18.94–31.27)	37.6	7.52 (5.57–10.8)	7.24 (5.24–8.68)	−3.87	255.22 (190.39–372.37)	232 (175.63–279.46)	−10.01
Qatar	F	3.79 (2.54–5.31)	5.95 (4.15–8.26)	36.3	6.62 (4.4–10.23)	23.37 (14.94–35.81)	71.67	3.37 (2.2–4.61)	3.61 (2.48–5.04)	6.65	104.11 (70.61–155.77)	101.06 (67.94–141.31)	−3.02
	M	3.98 (2.59–7.42)	5.08 (3.3–8.05)	21.65	8.03 (5.06–15.14)	24.87 (15.65–40.43)	67.71	3.42 (2.24–6.35)	2.56 (1.71–4.13)	−33.59	112.45 (73.36–214.45)	81.17 (50.71–134.27)	−38.54
	Both	3.87 (2.95–6.09)	5.26 (3.82–7.63)	26.43	7.36 (5.4–12.18)	24.31 (16.99–36.41)	69.72	3.38 (2.62–5.22)	2.81 (2.06–3.99)	−20.28	107.22 (79.36–176.24)	85.5 (61.1–128.41)	−25.4
Saudi Arabia	F	1.48 (0.73–3.97)	4.06 (2.66–6.6)	63.55	2.85 (1.38–7.74)	18.62 (11.63–29.51)	84.69	1.54 (0.76–4.16)	2.16 (1.42–3.62)	28.7	54.21 (26.8–144.19)	75.44 (49.07–122.63)	28.14
	M	1.92 (0.96–4.41)	4.12 (2.85–6.47)	53.4	3.64 (1.8–8.39)	17.53 (11.76–27.65)	79.24	1.84 (0.92–4.27)	2.34 (1.62–3.75)	21.37	64.46 (31.85–147.16)	82.01 (56.8–127.29)	21.4
	Both	1.73 (0.94–3.97)	4.09 (3.06–6.18)	57.7	3.29 (1.8–7.39)	17.92 (13.1–26.5)	81.64	1.71 (0.91–3.93)	2.27 (1.68–3.54)	24.67	60.02 (31.97–138.12)	79.41 (59.21–120.87)	24.42
Sudan	F	2.82 (1.06–7.72)	3.53 (1.96–6.08)	20.11	4.61 (1.44–15.3)	7.27 (3.63–12.9)	36.59	2.48 (0.98–6.36)	2.89 (1.7–4.87)	14.19	103.56 (33.86–328.06)	110.39 (59.8–196.78)	6.19
	M	4.58 (2.34–8.93)	5.1 (2.82–7.51)	10.2	7.71 (3.34–16.61)	10.86 (5.78–16.21)	29.01	4.03 (2.16–7.53)	4.14 (2.32–6.06)	2.66	170.07 (77.47–352.69)	159.41 (87.57–236.86)	−6.69
	Both	3.73 (2.24–7.05)	4.35 (2.63–6.25)	14.25	6.21 (3.27–12.89)	9.13 (5.42–13.21)	31.98	3.28 (2–6.07)	3.55 (2.26–5.08)	7.61	137.83 (75.66–281.93)	135.78 (84.22–196.45)	−1.51
Syria	F	4.39 (2.78–6.38)	5.45 (3.74–7.39)	19.45	6.89 (4.4–10.81)	15.27 (10.65–22.01)	54.88	4.02 (2.51–5.73)	4.11 (2.71–5.59)	2.19	132.08 (84.2–200.51)	130.97 (92.69–180.51)	−0.85
	M	5.71 (3.54–8.35)	6.65 (4.11–9.13)	14.14	9.73 (6.15–15.48)	19.52 (13.21–27.15)	50.15	5.1 (3.15–7.26)	4.83 (2.8–6.53)	−5.59	177.05 (109.86–272.92)	157.99 (102.8–217.37)	−12.06
	Both	5.07 (3.66–6.64)	6.06 (4.26–8.07)	16.34	8.35 (6.14–12.26)	17.52 (12.83–23.62)	52.34	4.58 (3.24–5.92)	4.46 (3.02–5.99)	−2.69	155.29 (112.85–221.38)	144.77 (104.67–194.09)	−7.27
Tunisia	F	1.47 (1.07–2.1)	2.05 (1.28–3.02)	28.29	3.25 (2.12–5.36)	8.52 (5.03–13.45)	61.85	1.19 (0.88–1.64)	1.2 (0.79–1.7)	0.83	46.89 (32.48–69.8)	45.52 (28.5–66.36)	−3.01
	M	1.3 (0.92–1.89)	1.8 (1.05–2.63)	27.78	3.06 (2.02–4.62)	7.74 (4.34–11.71)	60.47	1.03 (0.74–1.49)	1.02 (0.61–1.52)	−0.98	41.69 (28.71–61.32)	38.18 (21.78–55.85)	−9.19
	Both	1.38 (1.11–1.8)	1.92 (1.29–2.61)	28.13	3.15 (2.35–4.33)	8.11 (5.22–11.42)	61.16	1.1 (0.89–1.44)	1.11 (0.77–1.49)	0.9	44.23 (34.66–59.2)	45.52 (28.5–66.36)	2.83

Neuroepidemiology 2021;55:447–459
DOI: 10.1159/000519281

Table 1 (continued)

Country	Sex	Incidence rate of brain cancer according to ASR			Prevalence rate of brain cancer according to ASR			Death rate of brain cancer according to ASR			DALY rate of brain cancer according to ASR		
		1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change	1990	2019	percent of change
Turkey	F	4.86 (2.07–9.55)	6.54 (2.88–8.89)	25.69	8.41 (3.37–19.13)	24.3 (10.96–34.16)	65.39	4.31 (1.87–8.08)	4.18 (1.8–5.72)	−3.11	158.3 (65.63–339.59)	138.09 (62.97–188.23)	−14.64
	M	7.22 (2.87–12.25)	8.68 (3.65–12.33)	16.82	12.84 (4.86–23.13)	33.86 (14.91–48.49)	62.08	6.33 (2.57–10.52)	5.3 (2.13–7.69)	−19.43	239.21 (89.59–418.06)	178.72 (75.22–254.21)	−33.85
	Both	6.03 (2.9–8.9)	7.6 (3.66–10.34)	20.66	10.63 (4.76–17)	29.03 (14.46–40)	63.38	5.31 (2.61–7.84)	4.73 (2.15–6.6)	−12.26	198.78 (92.75–303.49)	158.27 (76.68–215.47)	−25.6
United Arab Emirates	F	3.81 (2.5–7.36)	4.76 (2.8–7.61)	19.96	7.15 (4.46–12.39)	13.38 (7.05–22.76)	46.56	3.26 (2.12–6.58)	3.53 (2.1–5.58)	7.65	123.4 (79.28–226.16)	128.16 (74.51–206.5)	3.71
	M	6.14 (3.74–9.92)	6.07 (3.46–8.26)	−1.15	11.82 (7.26–18.11)	17.17 (9.22–24.8)	31.16	5.24 (3.17–8.72)	4.44 (2.52–6.09)	−18.02	196.82 (120.08–306.87)	159.37 (89.36–219.04)	−23.5
	Both	5.27 (3.64–8.13)	5.73 (3.54–7.78)	8.03	10.04 (7.03–14.39)	16.16 (9.47–22.58)	37.87	4.5 (3.01–7.11)	4.2 (2.62–5.75)	−7.14	169.61 (119.31–250.26)	151.49 (91.5–206.73)	−11.96
Yemen	F	2.39 (0.85–6.06)	3.29 (1.77–6.18)	27.36	3.54 (1.12–10.2)	5.77 (2.88–11.02)	38.65	2.19 (0.82–5.31)	2.91 (1.6–5.32)	24.74	83.09 (27.08–230.71)	106.17 (53.92–203.18)	21.74
	M	3.79 (1.8–7.46)	4.48 (2.45–6.94)	15.4	5.69 (2.37–11.98)	7.89 (4.16–12.42)	27.88	3.47 (1.72–6.67)	3.94 (2.21–6.13)	11.93	130.8 (56.05–271.07)	140.56 (73.59–218.88)	6.94
	Both	3.08 (1.84–5.72)	3.88 (2.44–5.68)	20.62	4.62 (2.5–9.02)	6.82 (4.09–9.91)	32.26	2.81 (1.73–5.1)	3.42 (2.19–5.06)	17.84	107.04 (58.9–206.86)	123.29 (74.87–181.54)	13.18
North Africa and Middle East	F	3.41 (2.12–5.67)	4.78 (3.02–5.77)	28.66	6.18 (3.48–11.29)	14.64 (9.31–18.29)	57.79	2.98 (1.92–4.77)	3.39 (2.15–4.07)	12.09	112.79 (66.2–199.77)	118.46 (77.03–142.38)	4.79
	M	4.73 (2.89–6.81)	5.65 (3.27–6.84)	16.28	8.78 (4.94–13.13)	18.15 (10.31–22.38)	51.63	4.09 (2.62–5.78)	3.9 (2.28–4.7)	−4.87	156.35 (90.24–234.21)	137.52 (82–168.31)	−13.69
	Both	4.08 (2.95–5.8)	5.23 (3.5–6.15)	21.99	7.51 (4.95–11.01)	16.45 (10.83–19.54)	54.35	3.55 (2.59–4.93)	3.65 (2.45–4.3)	2.74	135.09 (92.57–199.92)	128.34 (87.81–151.3)	−5.26
Global	F	3.31 (2.77–4.39)	3.89 (2.78–4.46)	14.91	7.91 (6.63–10.44)	13.54 (9.79–15.72)	41.58	2.60 (2.18–3.41)	2.56 (1.82–2.88)	−1.56	101.82 (80.47–138.01)	90.85 (67.80–102.01)	−12.07
	M	4.35 (3.44–5.96)	4.84 (3.49–5.56)	10.12	9.00 (7.12–12.45)	13.47 (9.68–15.48)	33.18	3.61 (2.86–4.85)	3.58 (2.55–4.05)	−0.84	141.75 (104.56–199.07)	127.56 (92.92–146.21)	−11.12
	Both	3.82 (3.34–5.00)	4.34 (3.27–4.86)	11.98	8.44 (7.30–10.94)	13.48 (10.09–15.19)	37.39	3.08 (2.71–4.01)	3.05 (2.29–3.36)	−0.98	121.67 (100.03–164.94)	109.04 (84.57–120.92)	−11.58

DALY, disability-adjusted life year.

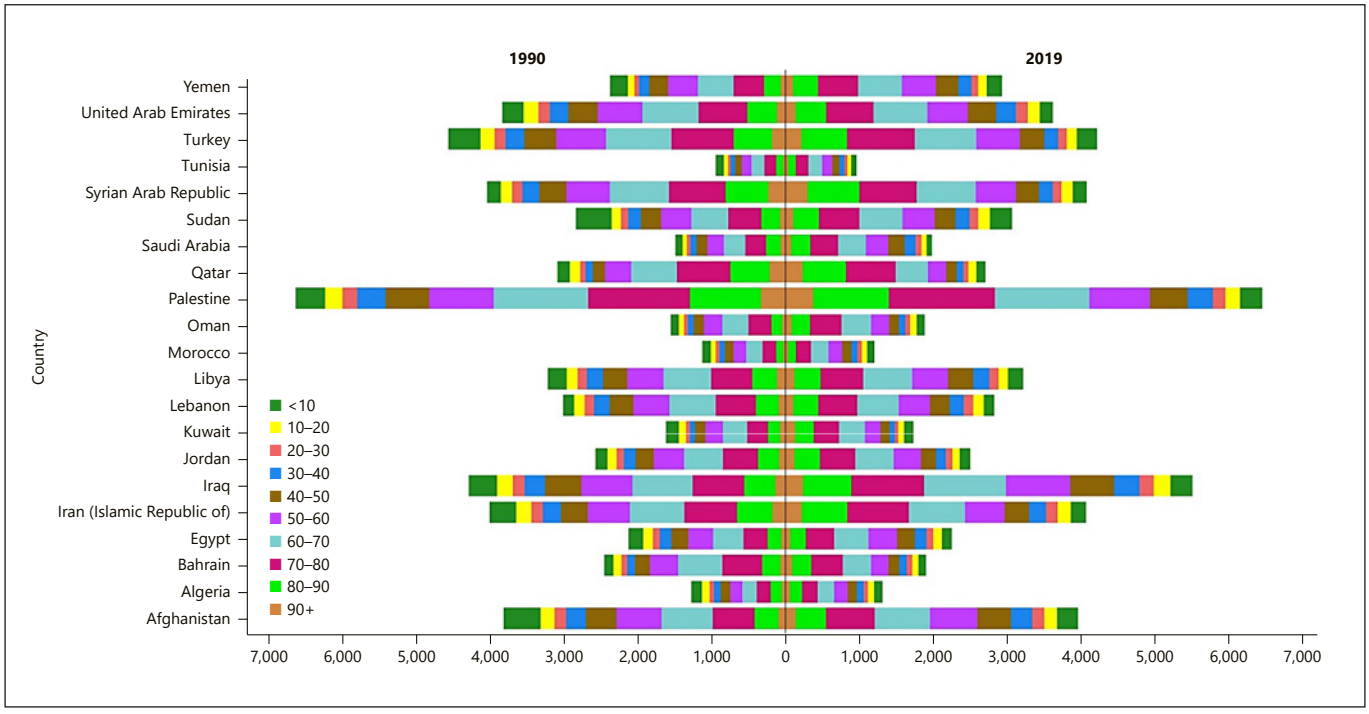

Fig. 1. A Comparison between age patterns of the DALY in 1990 and 2019 in MENA countries.

than men (28.14 vs. 21.4). However, the trends were decreasing in other countries. In 1990, the mortality rate in MENA countries was 3.55, and in 2019, it was 3.65, which has been increased by 2.74%. In the world, the mortality rate was 3.08 and 3.05 in 1990 and 2019, respectively (declined by −0.98%). Therefore, the mortality rate in the countries of the MENA region is higher than the global average. In terms of DALY per 100,000 people, among all 21 included countries, the highest values were observed in Palestine, Turkey, and Iraq and in the age group of above 60 years (Fig. 1). The highest and the lowest values for the mortality rate per 100,000 individuals were related to the age group older than 50 years and people aged <40 years (Fig. 2). Among 21 countries in the Middle East and North Africa in 1990, Palestine (8.58; 6.46–12.38) and Turkey (6.03; 2.9–8.9) had the highest standard incidence rate, and Tunisia (1.38; 1.11–1.8) and Morocco (1.54; 1.19–2.06) had the lowest standard incidence rate in both sexes (Fig. 3). In 1990, Palestine and Turkey had the highest incidence rate among people aged ≥60 years. The prevalence of CNS tumors was significantly increased from 1990 to 2019 (Fig. 4). In terms of countries, the following countries had similar trends: Turkey, Qatar, Lebanon, Kuwait, and Iran. The largest change in the prevalence of brain tumors in 2019 compared to 1990 was related to people under 30 years of age. The rate of DALY decreased in most countries except Iraq, Morocco, Oman, Saudi Arabia, Tunisia, and Yemen (Fig. 5).

Figure 6 shows the trend of standardized age mortality rate during 1990, 2000, 2010, and 2019, and the rate of mortality changes in the MENA region during the years 1990–2019 in male, female, and both was −0.05 (−0.38 to 0.31), 0.14 (−0.35 to 0.81), and 0.03 (−0.33 to 0.30), respectively. The rate of change in the incidence and prevalence of brain cancer during 1990–2019 in the MENA region for men, women, and both was (0.20, −0.25 to 0.68; 0.40, −0.23 to 1.28; and 0.28, −0.20 to 0.63) and (1.07, 0.24–2.06; 1.37, 0.18–3.15; and 1.19, 0.30–1.89), respectively. Figures 7 and 8 show the changes in the countries of the MENA region in 1990, 2000, 2010, and 2019.

Discussion

The incidence rate and prevalence of CNS cancer in 21 countries of the MENA regions increased from 1990 to 2019, similar to the global trend. However, the incidence rate of CNS tumors in this region was more than the glob-

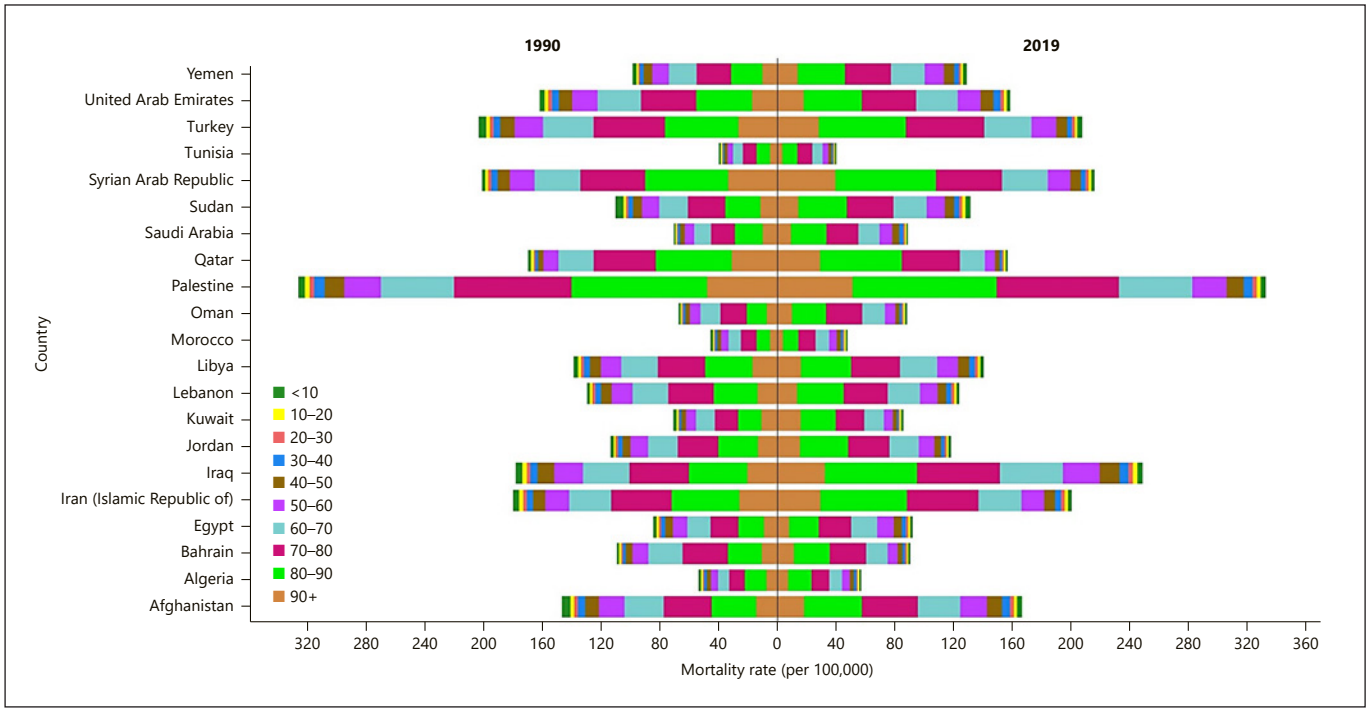

Fig. 2. A Comparison between age patterns of the mortality rate in 1990 and 2019 in MENA countries.

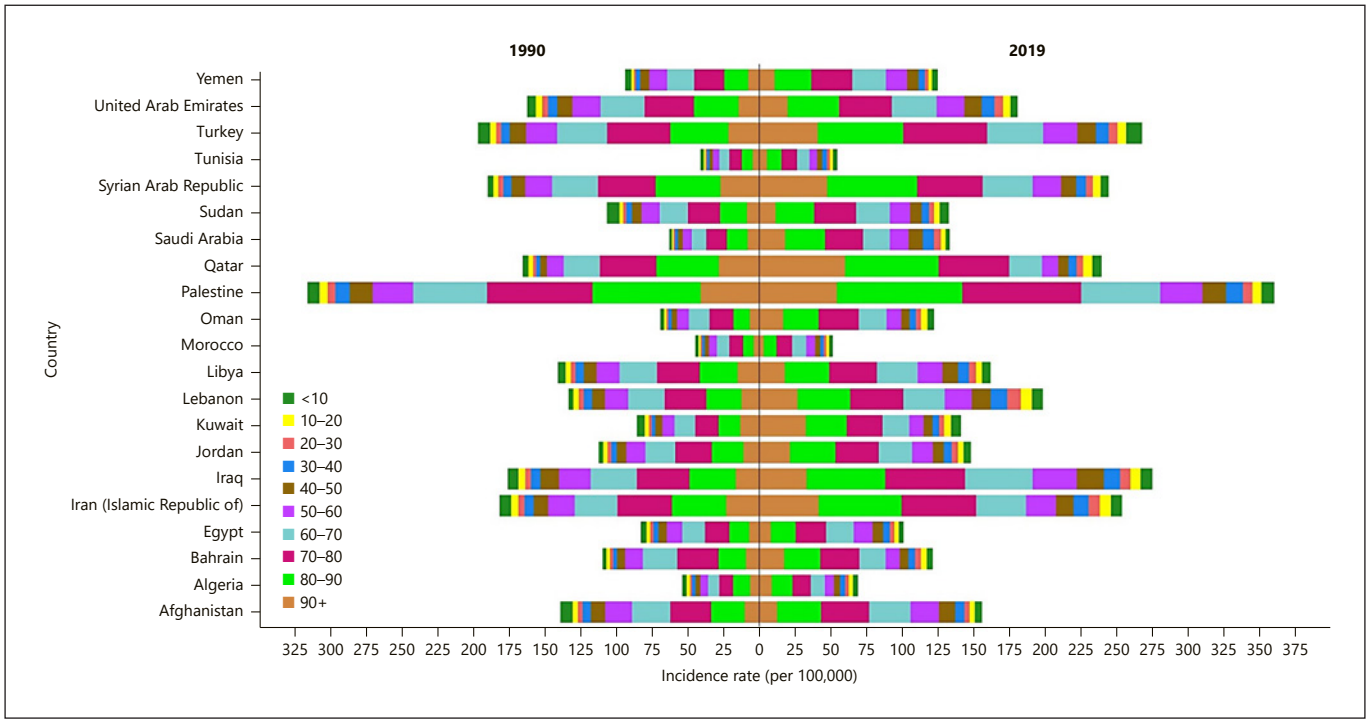

Fig. 3. A Comparison between age patterns of the incidence rate in 1990 and 2019 in MENA countries.

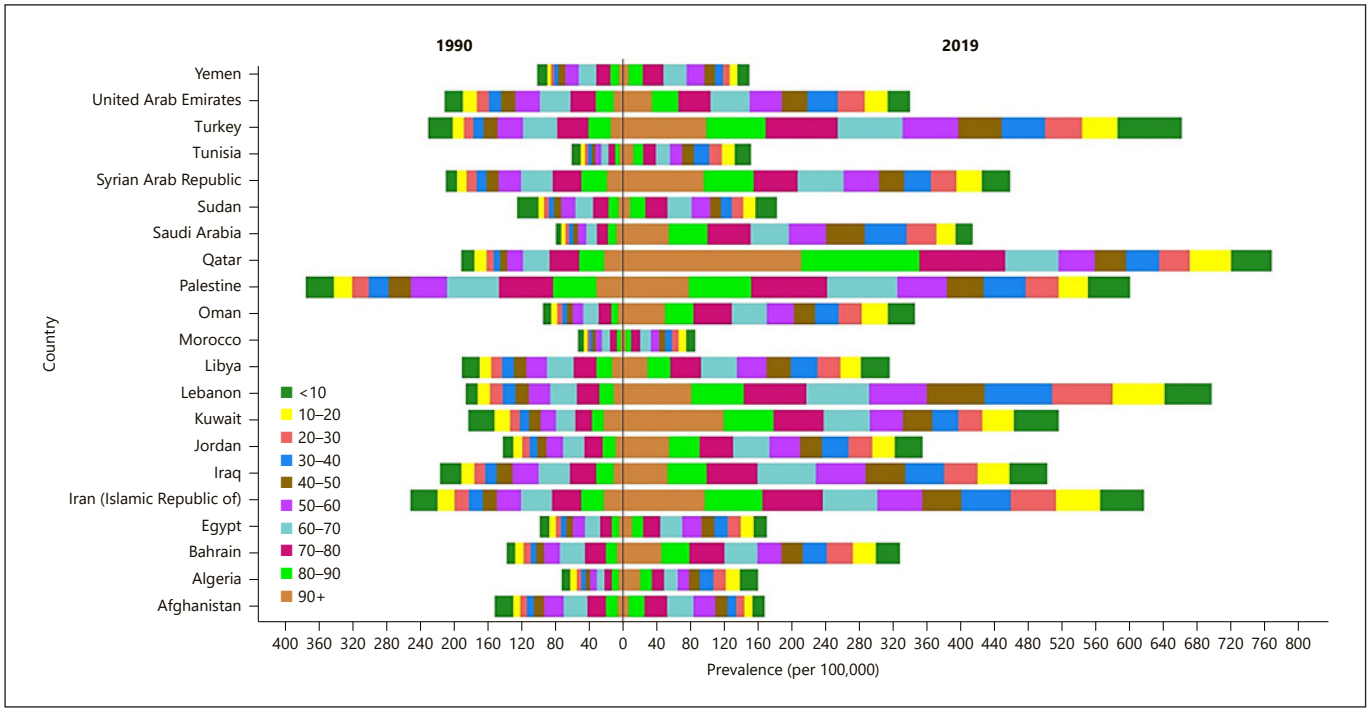

Fig. 4. A Comparison between age patterns of the prevalence in 1990 and 2019 in MENA countries.

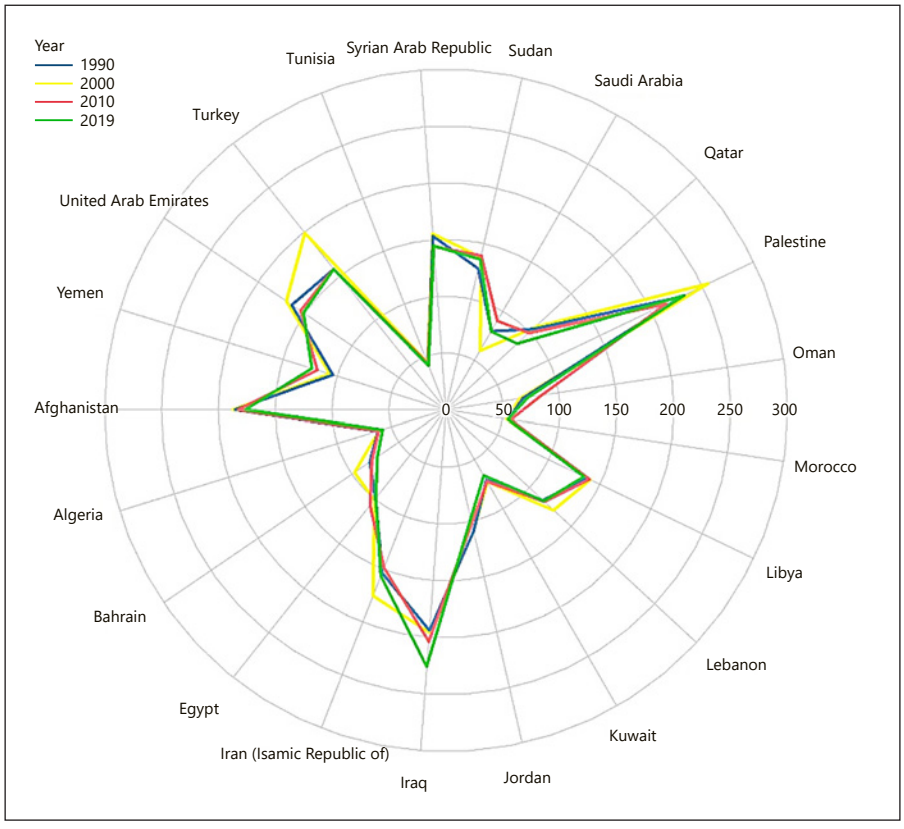

Fig. 5. Trends of age standardized DALY rates in North Africa and the Middle East countries.

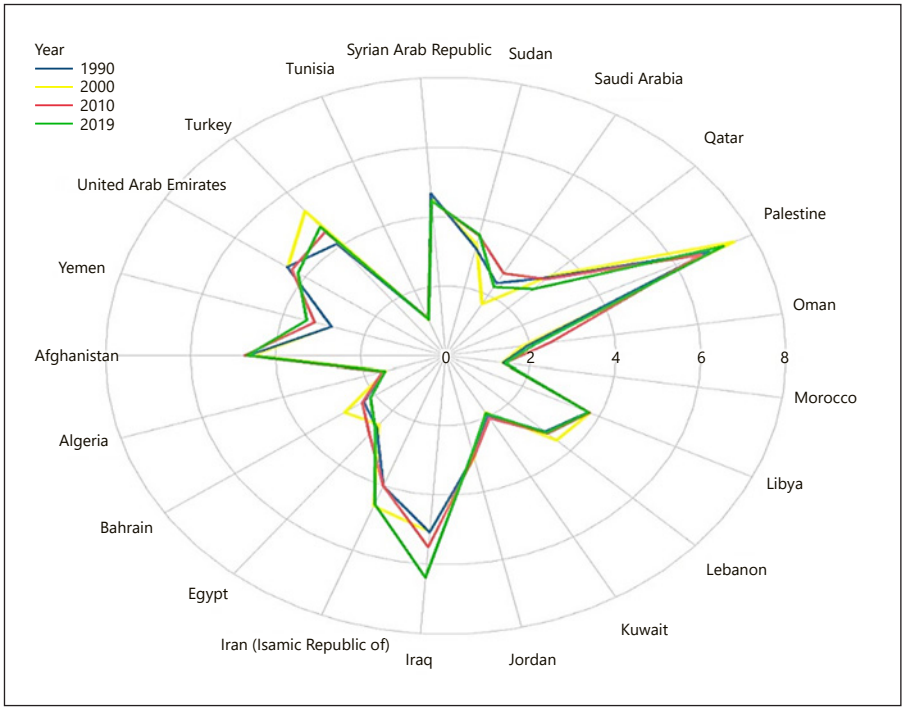

Fig. 6. Trends of age standardized mortality rates in North Africa and the Middle East countries.

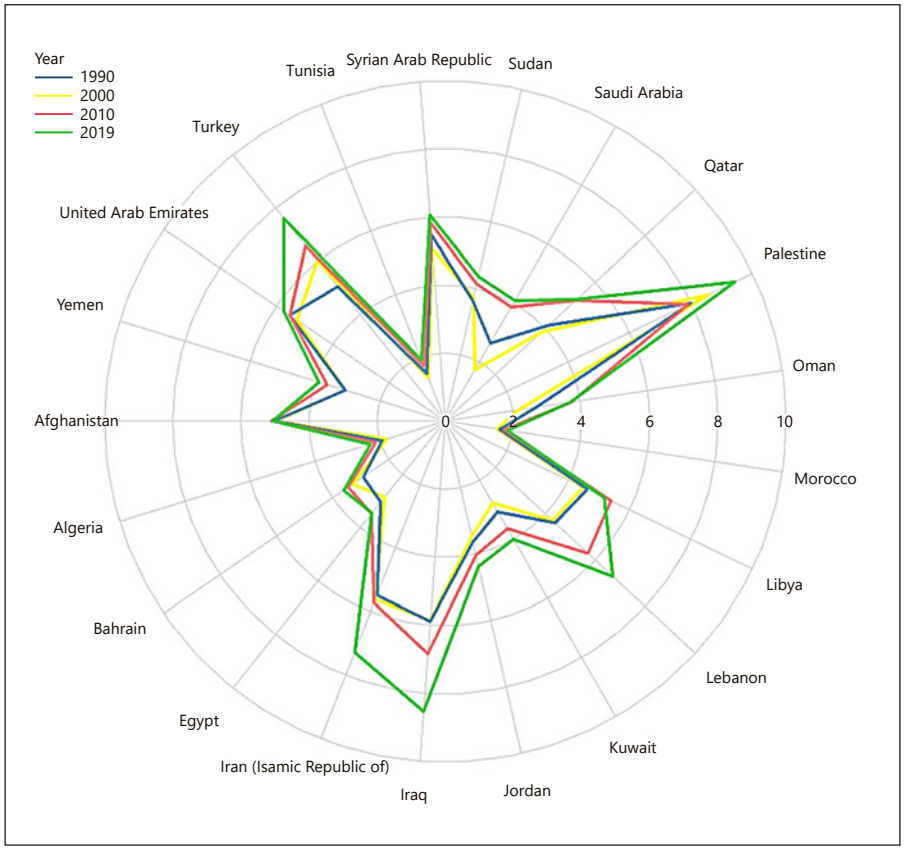

Fig. 7. Trends of age standardized incidence rates in North Africa and the Middle East countries.

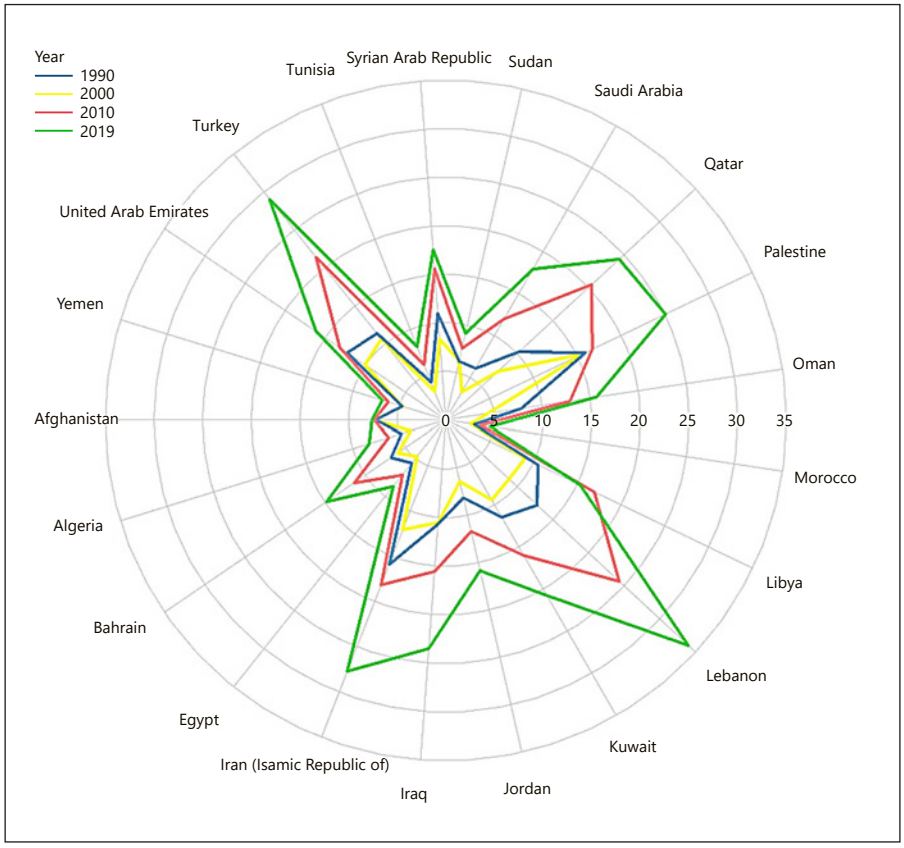

Fig. 8. Trends of age standardized prevalence rates in North Africa and the Middle East countries.

al average. The rate was highest in countries such as Palestine and Iraq in 2019. Besides, the prevalence rate in the MENA region increased during 1990–2019, but it was lower than the global average, which may be due to the lack of screening, timely diagnosis, and appropriate treatment in this region. In fact, the high mortality rate of CNS tumors in the MENA region is contributing to the high incidence but low prevalence of such tumors in the MENA region compared to the global values. The changes in the prevalence of CNS tumors from 1990 to 2019 in the MENA region were more than the world's corresponding value. This can be attributed to the effect of factors such as diet, the effect of magnetic fields, and advances in diagnostic techniques in this region compared to previous years [4, 18, 19]. Given the effect of the war in Palestine and several other countries in MENA, for recent years, the increase in the incidence rate of CNS cancers may also be due to the increased access to diagnostic tests such as CT scan during this period [20]. However, the nature of war and political instability are the main causes of the destruction of health infrastructure within these countries [21, 22], decreasing access to cancer prevention and control programs. The stressful lifestyle within the war plus the destruction of health infrastructures can add to the burden of CNS cancers [23, 24].

The results showed that the prevalence and incidence rate was higher in men than in women, consistent with the results of reports from elsewhere. Such differences might be due to the protective effect of female sex hormones against CNS cancer, chromosomal differences of tumors in women compared to men, and women's lifestyle [25, 26]. Besides, further exposure of men to pesticides which are more common among these countries with the dominance of agriculture as the main source of their economy could be another reason for the higher prevalence and incidence of CNS tumors among men [27, 28]. The incidence rate increases with aging, especially for those aged 80 years old and over, which can be due to conditions such as ischemic and hemorrhagic stroke [29]. In addition to genetic and environmental factors that make the difference in the incidence of cancer between regions and countries, we cannot ignore the role of the factors such as the quality of data which reported to show high diversity among the included countries [30, 31]. In

fact, the quality of registration systems in countries is affected by other variables such as availability of imaging technologies (MRI, CT scan, and X-ray) and expertise of physicians, as well as coverage of cancer and death registries [32, 33].

The present study results showed that the incidence rate of CNS cancer in the MENA region is higher than the global average, but the prevalence is lower than the average in the world. However, shorter survival of patients with CNS tumors decreases the average of prevalence in MENA compared to the corresponding value in the world. In fact, the shorter survival is due to the lack of appropriate treatment and diagnosis facilities which ultimately leads to premature death, which in turn decreases the prevalence [34, 35]. The low incidence of brain cancer in some countries of the MENA region, especially the less-developed countries, is due to the low quality of the registration system plus low access to diagnostic facilities. In contrast, better-developed countries with a high-quality cancer registration system such as Lebanon have recorded a major part of the expected number of cancers that are large in terms of number because of factors such as exposure to ionizing radiation and pesticides [35–38].

Conclusion

This study showed that the estimates of epidemiologic indices (incidence rate, prevalence, DALY, and mortality) of CNS cancers vary among the countries in the MENA region. The incidence rate of CNS cancer per 100,000 people had significantly increased from 1990 to 2019. Future studies need to investigate in depth the reasons for both the diversity among the countries and higher incidence compared to the world.

Acknowledgments

We appreciate the Clinical Research Development Center, Taleghani, and Imam Ali Hospital, Kermanshah University of Medical Sciences, in performing this research.

Statement of Ethics

This GBD study used deidentified data, and the waiver of informed consent was reviewed and approved by the University of Washington Institutional Review Board (Study 9060).

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

The authors did not receive any funding.

Author Contributions

H.R. Saeidi Borojeni, F. Najafi, and M. Naderi contributed to conceptualization. M. Naderi, F. Khosravi Shadmani, Z. Darabi, and M. Darbandi contributed to methodology, data curation, and analysis. M. Naderi, Kh. Farhadi, Sh. Maleki, S. Saeidi Borojeni, F. Khosravi Shadmani, Z. Darabi, M. Darbandi, H.R. Saeidi Borojeni, and F. Najafi contributed to writing – original draft preparation and writing – reviewing and editing.

Data Availability Statement

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request and in accordance with the guidelines in the journal.

References

1 GBD 2016 Brain and Other CNS Cancer Collaborators. Global, regional, and national burden of brain and other CNS cancer, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol. 2019;18(4):376–93.

2 Wrensch M, Minn Y, Chew T, Bondy M, Berger MS. Epidemiology of primary brain tumors: current concepts and review of the literature. Neuro Oncol. 2002;4(4):278–99.

3 Zakrzewski J, Geraghty LN, Rose AE, Christos PJ, Mazumdar M, Polsky D, et al. Clinical variables and primary tumor characteristics predictive of the development of melanoma brain metastases and post-brain metastases survival. Cancer. 2011;117(8):1711–20.

4 Pouchieu C, Gruber A, Berteaud E, Ménégon P, Monteil P, Huchet A, et al. Increasing incidence of central nervous system (CNS) tumors (2000–2012): findings from a population based registry in Gironde (France). BMC Cancer. 2018;18(1):653.

5 McKinney PA. Brain tumours: incidence, survival, and aetiology. J Neurol Neurosurg Psychiatry. 2004;75(Suppl 2):ii12–7.

6 de Robles P, Fiest KM, Frolkis AD, Pringsheim T, Atta C, St Germaine-Smith C, et al. The worldwide incidence and prevalence of primary brain tumors: a systematic review and meta-analysis. Neuro Oncol. 2015;17(6):776–83.

7 Lai R, Crevier L, Thabane L. Genetic polymorphisms of glutathione S-transferases and the risk of adult brain tumors: a meta-analysis. Cancer Epidemiol Biomarkers Prev. 2005; 14(7):1784–90.
8 Wrensch M, Minn Y, Chew T, Bondy M, Berger MS. Epidemiology of primary brain tumors: current concepts and review of the literature. Neuro Oncol. 2002;4(4):278–99.
9 Tian M, Zhu D, Chen D, Huo X, Ge J, Lu J, et al. Prognostic value of age in neurological cancer: an analysis of 22,393 cases from the SEER database. Tumour Biol. 2015;36(11): 8341–8.
10 Khazaei Z, Goodarzi E, Borhaninejad V, Iranmanesh F, Mirshekarpour H, Mirzaei B, et al. The association between incidence and mortality of brain cancer and human development index (HDI): an ecological study. BMC Public Health. 2020;20(1):1696.
11 Jørgensen JT, Johansen MS, Ravnskjær L, Andersen KK, Bräuner EV, Loft S, et al. Long-term exposure to ambient air pollution and incidence of brain tumours: the Danish Nurse Cohort. Neurotoxicology. 2016;55:122–30.
12 Meng Y, Tang C, Yu J, Meng S, Zhang W. Exposure to lead increases the risk of meningioma and brain cancer: a meta-analysis. J Trace Elem Med Biol. 2020;60:126474.
13 Bohnen NI, Kurland LT. Brain tumor and exposure to pesticides in humans: a review of the epidemiologic data. J Neurol Sci. 1995; 132(2):110–21.
14 Kheifets LI. Electric and magnetic field exposure and brain cancer: a review. Bioelectromagnetics. 2001;Suppl 5:S120–31.
15 Etemadi A, Safiri S, Sepanlou SG, Ikuta K, Bisignano C, Shakeri R, et al. The global, regional, and national burden of stomach cancer in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease study 2017. Lancet Gastroenterol Hepatol. 2020; 5(1):42–54.
16 Patel AP, Fisher JL, Nichols E, Abd-Allah F, Abdela J, Abdelalim A, et al. Global, regional, and national burden of brain and other CNS cancer, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol. 2019;18(4):376–93.
17 Annual report of national cancer registration: cancer incidence in 2005 and survival for 1993–2005. Available from: http://www.iarc.fr/ Accessed 2008 Sep 10.
18 Wrensch M, Minn Y, Chew T, Bondy M, Berger MS. Epidemiology of primary brain tumors: current concepts and review of the literature. Neuro Oncol. 2002;4(4):278–99.
19 Neugut AI, Sackstein P, Hillyer GC, Jacobson JS, Bruce J, Lassman AB, et al. Magnetic resonance imaging-based screening for asymptomatic brain tumors: a review. Oncologist. 2019;24(3):375–84.
20 Greig NH, Ries LG, Yancik R, Rapoport SI. Increasing annual incidence of primary malignant brain tumors in the elderly. J Natl Cancer Inst. 1990;82(20):1621–4.
21 Casey SE, Mitchell KT, Amisi IM, Haliza MM, Aveledi B, Kalenga P, et al. Use of facility assessment data to improve reproductive health service delivery in the Democratic Republic of the Congo. Confl Health. 2009;3:12.
22 Moramarco S, Basa FB, Alsilefanee HH, Qadir SA, Emberti Gialloreti L. Developing a public health monitoring system in a War-torn Region: a field report from Iraqi Kurdistan. Disaster Med Public Health Prep. 2020;14(5): 620–2.
23 Telarović S, Telarović S, Relja M, Franinović-Marković J. Impact of war on central nervous system tumors incidence – a 15-year retrospective study in Istria County, Croatia. Coll Antropol. 2006;30(1):149–55.
24 Neugut AI, Sackstein P, Hillyer GC, Jacobson JS, Bruce J, Lassman AB, et al. Magnetic resonance imaging-based screening for asymptomatic brain tumors: a review. Oncologist. 2019;24(3):375–84.
25 Johnson DR, Leeper HE, Uhm JH. Glioblastoma survival in the United States improved after Food and Drug Administration approval of bevacizumab: a population-based analysis. Cancer. 2013;119(19):3489–95.
26 Fisher JL, Schwartzbaum JA, Wrensch M, Wiemels JL. Epidemiology of brain tumors. Neurol Clin. 2007;25(4):867–90. vii.
27 Blair A, Freeman LB. Epidemiologic studies in agricultural populations: observations and future directions. J Agromedicine. 2009; 14(2):125–31.
28 Piel C, Pouchieu C, Carles C, Béziat B, Boulanger M, Bureau M, et al.; AGRICAN Group. Agricultural exposures to carbamate herbicides and fungicides and central nervous system tumour incidence in the cohort AGRICAN. Environ Int. 2019;130:104876.
29 Andersen KK, Tybjerg AJ, Babore AD, Olsen TS. Occult primary brain cancers manifesting in the aftermath of ischaemic and haemorrhagic stroke. Eur Stroke J. 2020;5(3):237–44.
30 Lamszus K. Meningioma pathology, genetics, and biology. J Neuropathol Exp Neurol. 2004; 63(4):275–86.
31 Wiemels J, Wrensch M, Claus EB. Epidemiology and etiology of meningioma. J Neurooncol. 2010;99(3):307–14.
32 Curado MP, Voti L, Sortino-Rachou AM. Cancer registration data and quality indicators in low and middle income countries: their interpretation and potential use for the improvement of cancer care. Cancer Causes Control. 2009;20(5):751–6.
33 Smith BL, Ramadan M, Corley B, Hablas A, Seifeldein IA, Soliman AS. Measuring the effect of improvement in methodological techniques on data collection in the Gharbiah population-based cancer registry in Egypt: implications for other low- and middle-income countries. Cancer Epidemiol. 2015; 39(6):1010–4.
34 Szklo M, Nieto FJ. Epidemiology beyond the basics. 3rd ed. Manhattan, New York: Jones and Bartlett Publisher; 2014.
35 Girardi F, Allemani C, Coleman MP. Worldwide trends in survival from common childhood brain tumors: a systematic review. J Glob Oncol. 2019;5:1–25.
36 MOPH. National cancer registry (NCR) of Lebanon. 2019. Available from: https://www.moph.gov.lb/en/Pages/national-cancer-registry.
37 Fares J, Salhab HA, Fares MY, Khachfe HH, Fares Y. Academic medicine and the development of future leaders in healthcare. In: Laher I, editor. Handbook of healthcare in the Arab World. Cham: Springer; 2020.
38 Salhab HA, Khachfe HH, Fares MY, Belkacemi Y, Hosseini H. Central nervous system cancers in the Middle East and North Africa (MENA) region: where does Lebanon stand. Chin Clin Oncol. 2020;9(3):36.