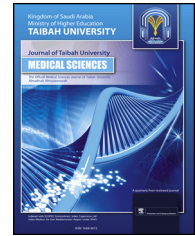




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### Original Article

## Burden of non-communicable diseases in Health Council of Gulf Cooperation (GCC) countries



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### المخلص

**أهداف البحث:** تهدف هذه الدراسة إلى مقارنة الوفيات وسنوات فقدان الحياة المحتملة والخسائر الاقتصادية الناجمة عن تسعة أمراض غير معدية بين مجالس الصحة لدول مجلس التعاون الخليجي.

**طريقة البحث:** تم الحصول على عدد الوفيات ومتوسطالعمر المتوقع حسب العمر والجنس في كل بلد من قاعدة بيانات منظمة الصحة العالمية لعام 2019 لحساب سنوات فقدان الحياة المحتملة حسب المرض والجنس. تم تقدير الخسارة الاقتصادية من خلال الجمع بين الدخل السنوي المعدل للقيمة الحالية مضروباً في مستويات سنوات فقدان الحياة المحتملة لكل مرض حسب الجنس والبلد.

**النتائج:** كشفت النتائج أن الأمراض غير المعدية التسعة كانت مسؤولة عن 152,854 حالة وفاة، و3 ملايين حالة سنة من الحياة المحتملة المفقودة و23.9 مليار دولار أمريكي كخسارة اقتصادية في دول مجلس التعاون الخليجي. كان السبب الأكثر شيوعاً للوفاة هو مرض نقص تروية القلب الذي تسبب في 82,232 حالة وفاة (54% من الإجمالي)، و1.6 مليون حالة وفاة (54% من الإجمالي)، و12.8 مليار دولار أمريكي من الخسائر الاقتصادية (53% من الإجمالي). من ناحية أخرى، كان سرطان الرئة هو السبب الأقل شيوعاً للوفاة، حيث تسبب في وفاة 1960 شخصاً، و37287 شخصاً من سنوات فقدان الحياة المحتملة، و317.6 مليون دولار أمريكي كخسارة اقتصادية. وكانت المملكة العربية السعودية الدولة الأكثر تضرراً بين جميع دول مجلس التعاون الخليجي من حيث الوفيات (68,027)، وسنوات فقدان الحياة المحتملة (1.4 مليون)،

والخسائر الاقتصادية (14.3 مليار دولار أمريكي). وتجدر الإشارة إلى أن المملكة العربية السعودية تمثل 45%، و49%، و60% من الوفيات، والخسائر الاقتصادية، على التوالي للمنطقة بأكملها. وفي المقابل، تعتبر قطر الدولة الأقل تضرراً من حيث الوفيات والإصابات، في حين أن اليمن هي الدولة الأقل تضرراً من حيث الخسارة الاقتصادية.

**الاستنتاجات:** أظهرت نتائج هذه الدراسة أن عبء الأمراض غير المعدية في دول مجلس التعاون الخليجي كان كبيراً من حيث الوفيات، وحالات الوفاة المبكرة، والخسائر الاقتصادية. ويتعين على صناع السياسات أن يولوا المزيد من الاهتمام لاكتشاف هذه الأمراض غير المعدية والوقاية منها والسيطرة عليها وعوامل الخطر المرتبطة بها.

**الكلمات المفتاحية:** الخسارة الاقتصادية؛ مجلس التعاون الخليجي؛ مجلس الصحة الخليجي؛ الأمراض غير المعدية؛ سنوات فقدان؛ الحياة المحتملة

### Abstract

**Objectives:** This study was aimed at comparing deaths, years of potential life loss (YPLL), and economic loss due to nine non-communicable diseases (NCDs) among Health Council of Gulf Cooperation (GCC) countries.

**Methods:** The number of deaths and life expectancy by age and sex in each country, obtained from the 2019 World Health Organization database, were used to calculate YPLL by disease and sex. Economic loss was estimated by combining the annual income adjusted for the present value multiplied by the YPLL for each disease by sex and country.

**Results:** The nine NCDs were responsible for 152,854 deaths, 3 million YPLL, and 23.9 billion US\$ economic

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loss in GCC countries. The most common cause of death was ischemic heart disease, which caused 82,232 deaths (54% of the total), 1.6 million YPLL (54% of the total), and a 12.8 billion US\$ economic loss (53% of the total). The least common cause of death was lung cancer, which caused 1,960 deaths, 37,287 YPLL, and a 317.6 million US\$ economic loss. KSA was the most affected country among all GCC countries in terms of deaths (68,027), YPLL (1.4 million), and economic loss (14.3 billion US\$). Notably, KSA had 45%, 49%, and 60% of the entire region's deaths, YPLL, and economic loss, respectively. In contrast, Qatar was the least affected country in terms of deaths and YPLL, and Yemen was the least affected country in terms of economic loss.

**Conclusion:** The burden of NCDs in GCC countries in terms of deaths, YPLL, and economic loss is substantial. Policymakers should pay greater attention to detecting, preventing, and controlling these NCDs and their risk factors.

**Keywords:** Economic loss; Gulf Cooperation Council; Non-communicable diseases; Years of potential life lost

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## Introduction

The Health Council of Gulf Cooperation Countries (GCC) includes seven countries: the Kingdom of Bahrain, the State of Kuwait, the Sultanate of Oman, the State of Qatar, the Kingdom of Saudi Arabia (KSA), the United Arab Emirates (UAE), and the Republic of Yemen.<sup>1</sup> Non-communicable diseases (NCDs) are chronic diseases that tend to have long durations, and to result from a combination of genetic, physiological, environmental, and behavioral factors. The main causes of NCDs have been described by a 4-by-4 model of risk factors including four risky behaviors and four physiologic risk factors. The four risky lifestyle behaviors are cigarette smoking, alcohol consumption, unhealthy diets, and insufficient physical activity, whereas the four physiological risk factors or biological markers are overweight, rising plasma glucose level, rising blood pressure, and hyperlipidemia.<sup>2</sup> Currently, NCDs are the leading cause of death and disability worldwide, accounting for 41 million deaths and 927 million years of potential life lost (YPLL) each year, and accounting for 71% of all global deaths.<sup>3</sup> Currently, NCDs are responsible for seven of every ten deaths worldwide.<sup>4</sup>

NCDs have severe and long-term economic consequences for individuals, families, and societies. A systematic review from European Union countries has indicated that NCDs account for 25% of healthcare system expenditures and 2% of the gross domestic product (GDP).<sup>5</sup> Cardiovascular diseases (CVDs) make up the majority of this burden (7.6% of healthcare system expenditures) and are followed by cancers (4–6% of healthcare system expenditures), type 2 diabetes mellitus (T2DM) (1.9–5.7% of healthcare

system expenditures), and chronic respiratory diseases (CRDs) (1.7% of healthcare system expenditures).<sup>5</sup> Similarly, in the USA, CVDs are responsible for 216 billion US\$ in healthcare system expenditures per year and 147 billion US\$ in disability-adjusted life years (DALYs). In the Eastern Mediterranean region (EMR), NCDs were responsible for 2.2 million deaths each year, representing 57% of the total deaths in the region. Major types of NCDs accounted for 80% of these deaths. CVDs, cancer, CRDs, and T2DM accounted for 48%, 16%, 8%, and 5% of deaths from all NCDs in the region, respectively. Most of these deaths (60%) occurred prematurely before the age of 70 years.<sup>6</sup>

NCD burden is expected to increase further with population aging; the second largest increase is expected in the EMR, where the GCC countries are located.<sup>7</sup> GCC countries have among the highest rates of NCD risk factors worldwide. The behavioral and physiological risk factors include cigarette smoking; alcohol consumption; physical inactivity; high intake of salt, sugar, and fat; rising blood sugar; high blood pressure; hyperlipidemia; and obesity. An additional contributor is the lack of an effective surveillance system for early-stage disease identification.<sup>8,9</sup> Furthermore, future prevalence forecasts have concerningly predicted that this burden will rise.<sup>8</sup> Currently, KSA, Kuwait, Oman, the UAE, and Bahrain are the Arab countries with the highest prevalence of T2DM.<sup>10</sup> Similarly, cancer incidence is expected to rise significantly in the EMR.<sup>11</sup> The direct medical costs of seven major NCDs (coronary heart disease, stroke, T2DM, breast cancer, colon cancer, chronic obstructive pulmonary disease (COPD), and asthma) in GCC countries were 16.7 billion US\$ in 2019, equal to 0.6% of the GDP, whereas the absenteeism and presenteeism costs due to these NCDs were 0.5 and 2.2% of the GDP, respectively.<sup>12</sup>

YPLL are a valuable measure for public health surveillance, in identifying leading causes of premature death, and evaluating population health improvements.<sup>13</sup> This measure estimates the average number of years that an individual would have lived if death had not occurred prematurely. This measure provides important evidence regarding health outcomes and well-being, and can stimulate the development of public health policies or strengthen existing policies.

Few studies have attempted to quantify the prevalence of NCDs in GCC nations. To date, nearly all previous studies have focused on a single condition/disease by country.<sup>14–20</sup> A recent study in six GCC countries (excluding Yemen) in 2019 estimated the burden of seven major NCDs (coronary heart disease, stroke, T2DM, colon cancer, breast cancer, COPD, and asthma) on direct medical costs, absenteeism (lost productivity due to missed days of work), and presenteeism (lost productivity due to diminished productivity at work).<sup>12</sup> However, that study did not estimate disease burden in terms of the number of deaths, YPLL, and costs of premature death attributable to each disease. Therefore, the present study was aimed at estimating the burden of NCDs among GCC countries by using YPLL and the cost of premature death due to each disease. The findings may provide baseline information for understanding the burden of NCDs in each country and planning effective interventions to combat NCDs in the future.

## Materials and Methods

### Study design

A descriptive study was conducted to estimate the burden and costs of premature mortality due to NCDs in GCC countries, by using secondary data.

### Study site

The study site was the GCC, consisting of seven countries: the Kingdom of Bahrain, the State of Kuwait, the Sultanate of Oman, the State of Qatar, the KSA, UAE, and the Republic of Yemen.<sup>1</sup>

### Source of data

To calculate YPLL for each NCD, we used the most recently updated secondary data for mortality due to each NCD, classified by age and sex, among the GCC countries during 2019 in the WHO database.<sup>21</sup> The total number of deaths due to each disease by age group (30–49, 50–59, 60–69, and 70+ years) by sex in each country was extracted to a pre-designed data collection form in Microsoft Excel. The cost of death was calculated by using World Bank data on gross national income (GNI) per capita according to the updated information for each country in 2019.<sup>22</sup>

### Four main NCD groups

The four main NCDs are considered 1) CVDs, including ischemic heart disease (IHD), hypertensive heart disease (HHD), and stroke; 2) T2DM; 3), CRDs, comprising asthma and COPD; and 4) cancers, including colorectal, lung, and breast cancer.<sup>23,24</sup>

### Mortality due to NCDs

The number of deaths in 2019 due to CVDs, T2DM, CRDs, and cancers, by age and sex in each GCC country was obtained from the WHO database published in 2020, wherein the number of deaths by cause, sex, country, and age (30–49, 50–59, 60–69, and 70+ years) was reported.

### Estimation of YPLL

YPLL refers to the potential years that people would have lived if premature death due to an NCDs had not occurred. YPLL were determined as the remaining years of life expectancy at the time of death. For each country, YPLL were calculated for each age group for all diseases. To determine the remaining life expectancy at the time of death, we used life tables published by the WHO for 2019 that provided age-specific and sex-specific death rates by GCC country.<sup>25</sup> The YPLL for each case of death were estimated with the following formula<sup>26</sup>:

YPLL = life expectancy at the time of death or actual age at death

For example, if a person dies at the age of 45 years in a country in which the life expectancy of people in their 40s is 29, the YPLL for this person is 29 years. We summed the YPLL for people who died from each NCD group (CVDs, T2DM, CRDs, and cancers) in each age group by sex in each country.<sup>26</sup> The total YPLL was the sum of YPLL in each age and sex group in each country as follows:

$$\text{YPLL for each country} = \Sigma \text{YPLL}_{\text{CVDs}} + \text{YPLL}_{\text{Cancers}} + \text{YPLL}_{\text{CRDs}} + \text{YPLL}_{\text{T2DM}}$$

Notably, to overcome the differences in the reported age groups between the death report and life expectancy report, we aggregated the life expectancy groups and determined their average to match the groups used in the death report. The life expectancy report used constant 5-year intervals, whereas the death report used differing intervals (30–49, 50–59, 60–69, and 70+ years).

### Estimation of economic loss due to premature death

The economic loss due to premature death by NCDs was calculated as the total YPLL for each NCD by sex, multiplied by the updated GNI per capita of each country. Economic loss was calculated as present values with the discounting method.<sup>27</sup>

Cost of death = GNI × YPLL (adjusted for present value of future earnings)

Present value = amount received in future / (1 + discount interest rate)<sup>number of years</sup>

We estimated the mortality cost for each age and sex group by combining the annual income of each age and sex group in 2019, the appropriate growth rate, and the corresponding life expectancy for that age group. The total population,<sup>28</sup> GNI, and GNI per capita<sup>22</sup> by country in 2019 is shown in Table 1.

## Results

In the GCC countries, the number of YPLL resulting from the nine NCDs in 2019 was 3 million. KSA had the highest YPLL, at 1.5 million, and was followed by Yemen, at 0.95 million. In contrast, the countries with the lowest YPLL

**Table 1: GNI in GCC countries, 2019.**

Country	Total population	GNI billion US\$	GNI per capita US\$
Bahrain	1,494,179	36.39	22,230
Kuwait	4,441,088	155.37	36,200
Oman	4,602,757	82.16	16,430
Qatar	2,807,224	171.96	61,180
KSA	35,827,350	846.46	23,220
United Arab Emirates	9,211,649	420.06	43,830
Yemen	31,546,681	21.59	820

GNI, gross national income; US\$, United States dollar.

were Qatar, with 0.038 million and Bahrain, with 0.04 million (Table 2).

The most common disease causing death in GCC countries was IHD, which caused 82,232 deaths and resulted in 1.6 million YPLL and a 12.8 billion US\$ economic loss. In contrast, the least common disease causing death in GCC countries was lung cancer, which caused 1,960 deaths, resulting in 0.038 million YPLL and a 318 million US\$ economic loss (Table 2).

A comparison of GCC countries indicated that CVDs were responsible for 82%, 81%, and 78% of the total deaths, YPLL, and economic loss due to all NCDs, respectively. Among the NCD groups, CRDs ranked second in terms of NCD deaths (7% of total deaths), but

ranked last in terms of YPLL (6%) and economic loss (6%). However, T2DM ranked third in terms of deaths (6%) and economic loss (6%). Similarly, cancer ranked last in terms of deaths (5%), and ranked second in terms of YPLL (7%) and economic loss (8%), as shown in Table 3.

A country comparison indicated that KSA was the most affected GCC country in terms of deaths (68,027 deaths), YPLL (1.4 million years), and economic loss (14.3 billion US\$), and had 45%, 49%, and 60% of the deaths, YPLL, and economic loss in the entire region. Yemen ranked second in terms of deaths (57,107 deaths) and YPLL (0.94 million years), but the UAE ranked second in terms of economic loss (5 billion US\$). In contrast, Qatar was the least affected

**Table 2: Total deaths, YPLL, and economic loss by sex and disease among GCC countries.**

Disease	Deaths (thousand)				YPLL (million years)				Economic loss (billion US\$)			
	Male	Female	Total	%**	Male	Female	Total	%**	Male	Female	Total	%**
Colon cancers*	2.1	1.3	3.4	2	0.05	0.03	0.08	3	0.46	0.31	0.77	3
Lung cancer	1.3	0.6	2.0	1	0.03	0.01	0.04	1	0.24	0.08	0.32	1
Breast cancer	NA	2.7	2.7	2	NA	0.08	0.08	3	NA	0.79	0.79	3
DM	5.5	3.8	9.2	6	0.11	0.07	0.18	6	1.17	0.56	1.73	7
HHD	3.7	4.0	7.7	5	0.07	0.07	0.13	4	0.51	0.29	0.81	3
IHD	52.7	29.5	82.2	54	1.09	0.52	1.61	55	9.57	3.20	12.77	53
Stroke	19.2	15.7	34.9	23	0.37	0.28	0.65	22	3.16	1.95	5.11	21
COPD	4.6	2.7	7.3	5	0.08	0.04	0.13	4	0.79	0.27	1.06	4
Asthma	1.8	1.6	3.4	2	0.04	0.03	0.07	2	0.34	0.21	0.55	2
<b>Total</b>	<b>90.9</b>	<b>61.9</b>	<b>152.9</b>	<b>100</b>	<b>1.82</b>	<b>1.14</b>	<b>2.95</b>	<b>100</b>	<b>16.23</b>	<b>7.67</b>	<b>23.90</b>	<b>100</b>

\*Includes colon and rectum cancers; \*\* Percentage of GCC total.

COPD: chronic obstructive pulmonary disease; DM: diabetes mellitus; HHD: hypertensive heart disease; IHD: ischemic heart disease; YPLL: years of potential life lost; NA: not applicable.

**Table 3: Total deaths, YPLL, and economic loss by NCD group among GCC countries.**

NCD group	Deaths (thousand)		YPLL (million years)		Economic loss (billion US\$)	
	Total	%	Total	%	Total	%
CVDs	124.9	82	2.39	81	18.68	78
CRDs	10.7	7	0.20	6	1.61	6
T2DM	9.2	6	0.18	6	1.73	7
Cancers	8.0	5	0.19	7	1.88	8

CRD: chronic respiratory disease; CVD: cardiovascular disease; DM: diabetes mellitus

**Table 4: Total deaths, YPLL, and economic loss due to NCDs by sex among GCC countries.**

Country	Deaths (thousand)				YPLL (million years)				Economic loss (billion US\$)			
	Male	Female	Total	%*	Male	Female	Total	%*	Male	Female	Total	%*
Bahrain	1.4	1.0	2.4	2	0.03	0.01	0.04	1	0.26	0.13	0.39	2
Kuwait	3.2	0.9	4.1	3	0.09	0.02	0.11	4	1.48	0.45	1.93	8
Oman	5.1	3.8	8.9	6	0.08	0.05	0.13	5	0.58	0.33	0.91	4
Qatar	1.3	0.9	2.1	1	0.03	0.01	0.04	1	0.79	0.26	1.06	4
KSA	43.1	24.9	68.0	45	0.94	0.50	1.44	49	9.15	5.11	14.26	60
UAE	8.0	2.2	10.2	7	0.19	0.06	0.25	8	3.82	1.24	5.06	21
Yemen	28.8	28.3	57.1	37	0.46	0.48	0.94	32	0.14	0.15	0.30	1
<b>TOTAL</b>	<b>90.9</b>	<b>61.9</b>	<b>152.9</b>	<b>100</b>	<b>1.82</b>	<b>1.14</b>	<b>2.95</b>	<b>100</b>	<b>16.23</b>	<b>7.67</b>	<b>23.90</b>	<b>100</b>

\* Percentage for country with respect to the GCC total.

UAE: United Arab Emirates; YPLL: years of potential life lost.



**Table 5: Summary of total deaths, YPLL, and economic loss among GCC countries.**

No	Country	Deaths (thousands)		YPLL (million years)		Economic loss (billion US\$)	
		Total	%	Total	%	Total	%
1	KSA	68.0	45	1.44	49	14.26	60
2	Yemen	57.1	37	0.94	32	0.30	1
3	UAE	10.2	7	0.25	8	5.06	21
4	Oman	8.9	5	0.13	5	0.91	4
5	Kuwait	4.1	3	0.11	4	1.93	8
6	Bahrain	2.4	2	0.04	1	0.39	2
7	Qatar	2.1	1	0.04	1	1.06	4
<b>Total</b>		<b>152.9</b>	<b>100</b>	<b>2.95</b>	<b>100</b>	<b>23.90</b>	<b>100</b>

YPLL: years of potential life lost; UAE: United Arab Emirates.

country in terms of deaths (2,112 deaths) and YPLL (37,417 million years). Yemen was the least affected country in terms of economic loss (0.3 billion US\$), as shown in [Table 4](#).

In summary, KSA and Yemen were the most affected countries in terms of premature deaths (82%) and YPLL (81%) among GCC countries. Qatar and Bahrain were the least affected countries in terms of premature deaths (3%) and YPLL (2%). Furthermore, KSA and the UAE experienced 81% of the total economic loss in GCC countries. Although the UAE had only 7% of the total deaths and 8% of the total YPLL, it experienced 21% of the total economic loss. Similarly, Yemen had 37% of the total deaths and 32% of the total YPLL, but experienced only 1% of the total economic loss in the region ([Table 5](#)).

## Discussion

This study indicated that nine NCDs caused 152,854 deaths in GCC countries in 2019. These deaths resulted in 2,950,861 YPLL and a 23.9 billion US\$ economic loss. IHDs had the highest rate (54%) of the included diseases among all GCC countries, causing 82,232 deaths— 52,697 among males (64%) and 29,535 among females (36%); 1,607,923 YPLL; and a 12.8 billion US\$ economic loss. The second highest rate was for stroke (21%) in all GCC countries except Bahrain and Qatar, where T2DM ranked second and caused 34,906 deaths, 648,254 YPLL, and a 5.1 billion US\$ economic loss. Lung cancer had the lowest rate (1.28%) among the included diseases, causing 1,960 deaths—1,322 among males (67%) and 638 among females (33%); 37,287 YPLL; and a 0.32 billion US\$ economic loss. Breast cancer had the second lowest rate (1.78%) among the included diseases, causing 2,725 deaths, 78,153 YPLL, and a 0.79 billion US\$ economic loss. NCD deaths were higher among males than females in all GCC countries, because of the higher number of males in their populations. These countries experienced high demand for foreign workers, most of whom were men.<sup>29–31</sup> In addition, behavioral risk factors for NCDs, such as cigarette smoking and alcohol consumption, are more common among males than females. Similarly, YPLL and economic loss were higher among males than females in all GCC countries except Yemen, the only low-income country in the region. Therefore, the demand for

expatriate workers in Yemen was low and unlikely to have influenced the sex ratio.

The most affected countries in terms of premature deaths were KSA and Yemen. Those two countries had 82% of the total premature deaths among GCC countries. These findings were expected, because KSA and Yemen are the most populous among the GCC countries. Notably, the populations in KSA and Yemen were 35.8 million and 31.5 million, respectively, in 2019.<sup>28</sup> In contrast, Qatar and Bahrain were the least affected countries, and had 3% of the total premature deaths among GCC countries because of their small populations.

Following the same pattern, YPLL were highest in KSA and Yemen (81% of the total among GCC countries), and lowest in Qatar and Bahrain (2% of the total among GCC countries). These results were justified by the population sizes and numbers of deaths in each country.

KSA and the UAE experienced 81% of the total economic loss in GCC countries. These results were explained by these countries' high income levels and populations. Interestingly, although Yemen is the second most populated country in the region, and had 37% of the total deaths and 32% of the total YPLL in the entire region, it experienced only 1% of the total economic loss, because it is the lowest-income country among the GCC countries.<sup>22</sup> Notably, Yemen is the only low-income country in this region, whereas all other countries are high-income countries.<sup>22</sup> The GNI in Yemen was 820 billion US\$, in contrast to the with 23,220 billion US\$ in KSA and 43,830 billion US\$ in the UAE.<sup>22</sup> Furthermore, the life expectancy in Yemen was lowest in the region. In contrast, although the UAE had only 7% of the total deaths and 8% of the total YPLL, it experienced 21% of the total economic loss because of its high-income status.

A disease comparison among all GCC countries indicated that CVDs were responsible for 82%, 80%, and 77% of the total deaths, YPLL, and economic loss, respectively. This finding might have been due to the high prevalence of CVD risk factors, including physiological risk factors (hypertension, hyperlipidemia, hyperglycemia, and obesity) and behavioral risk factors (physical inactivity, cigarette smoking, alcohol drinking, and unhealthy diet).<sup>32</sup> Moreover, these results were consistent with findings from other regional studies indicating CVDs as the leading cause of death.<sup>8,33,34</sup> GCC countries have

undergone a major economic transition and experienced substantial urbanization in recent years, and the proportion of individuals living in urban centers has doubled in the past decade. This rapid urbanization has been associated with a rise in the burden of CVDs.<sup>35</sup>

At present, CVDs are a major health challenge for the contemporary GCC population, including relatively young adults. For example, the World Health Report has indicated that 35% of deaths per 100,000 in KSA were due to CVDs, as revealed by the current study all data was in 2019.<sup>32</sup> Another study has indicated that CVDs account for more than 45% of all deaths in KSA. IHD is the third most common cause of hospital-based mortality, after road traffic accidents and senility. The high and increasing prevalence of modifiable behavioral risk factors has also been attributed to IHD.<sup>32</sup> Women are more likely than men to have CVD risk factors, including physiological risk factors (hypertension, dyslipidemia, hyperglycemia, and obesity) and behavioral risk factors (physical inactivity and unhealthy diet).<sup>32</sup> Moreover, in the UAE, CVD contributes to 40% of all deaths, and its incidence is increasing in young adults, primarily because of increased burden of its known risk factors such as physical inactivity, abdominal obesity, dyslipidemia, hypertension, and T2DM. Initial prevention, early detection, and robust health-promotion strategies have all successfully lowered the global burden of CVDs, and are expected to have the same effects if applied efficiently in GCC countries.

A recently published study by Finkelstein et al.<sup>12</sup> has analyzed the effects of seven NCDs on mortality and direct health care costs in all GCC countries except Yemen. That study included the same diseases as our study, except HHD and lung cancer, and indicated that IHDs have the highest influence on mortality, although T2DM is most prevalent in all countries. Moreover, cancers were reported to be less common in all countries than observed in our study. The results of our study are consistent with those from previous studies in the EMR by Beheraoui et al. and worldwide by Roth et al., which have indicated that IHDs and stroke were the leading causes of death in the past decades.<sup>36,37</sup> Moreover, in Brazil, CVDs have the greatest influence on mortality and YPLL, and are followed by cancers.<sup>38</sup>

Chronic respiratory diseases (CRDs), T2DM, and cancers were the second, third, and fourth most frequent causes of death. As revealed by the current study in GCC countries, CRDs pose a considerable burden in terms of deaths among in GCC countries. This group of diseases accounted for 7% (second to CVDs) of the total deaths in this study. However, CRDs ranked last in terms of YPPLs and economic loss, possibly because of their occurrence in older age groups. The burden of CRDs is escalating in GCC countries at alarming rates, according to recent evidence.<sup>39</sup> Notably, tobacco smoking is the most important risk factor for CRDs, as well as other CVDs and cancers. The prevalence of smoking in GCC countries is among the highest worldwide.<sup>40</sup> Other modifiable risk factors include air pollution and occupational factors.<sup>39</sup>

T2DM poses a growing burden in GCC countries. As shown in this study, T2DM was responsible for 6%, 6%, and 7% of the total deaths, YPLL, and economic loss, respectively. These figures reflect the notable growing prevalence of T2DM during the past 20 years in these countries.<sup>41</sup> The

GCC countries have experienced a particularly marked and sudden increase in T2DM rates: Kuwait, KSA, the UAE, and Bahrain now rank among the ten countries with the highest prevalence of T2DM worldwide.<sup>42</sup> A study from the region has indicated a prevalence of T2DM as high as 22% in some GCC countries.<sup>43</sup> This prevalence is expected to be aggravated as a result of a dramatic increase in rates of children's T2DM as well as the rates of pre-diabetes among adults in this region.<sup>41</sup> Nonetheless, several risk factors, including physical inactivity, obesity, unhealthy food, and genetic susceptibility, are highly prevalent and significantly contribute to these high rates of T2DM in this region.<sup>41</sup> All GCC countries have shown an increase in physical inactivity, whose prevalence is higher among females than males. For instance, the prevalence of insufficient physical activity is very high among GCC countries, ranging from 33% to 67%,<sup>44</sup> possibly because of a shift from manual labor/high physical activity jobs to more sedentary occupations in the services sector.<sup>45</sup> Females are consistently less active than males, possibly because of prevailing local customs in conservative countries, where women may spend less time than men outside the home, or in public places and exercise facilities. Consequently, these countries had among the highest diabetes-associated mortality, with an age-standardized mortality rate of 139.6 per 100,000 in 2016.<sup>46</sup>

This study has several limitations. First, the estimate was limited to only nine NCDs. Although the list of NCDs varies, we were unable to include all NCDs. We believed that the effect of this omission was minimal, as evidenced by the cancer statistics in GCC countries. Despite our inclusion of the three most prevalent cancer types, their aggregate effects on death were less than those of T2DM alone. Therefore, we believe that we included the most important diseases. Second, this study estimated the burden of included diseases in terms of deaths, YPLL, and economic loss at the population level. However, other burden measures, such as DALYs, could not be estimated, because of a lack of individual-level data. Third, we sourced the mortality data from the WHO database. We believed that national mortality data could more precisely reflect the status in each country. Unfortunately, such data are scarce for GCC countries. Finally, the secondary data derived from different sources required adjustment because of the reporting of deaths in age groups different from the 5-year groups used for reporting life expectancy. Therefore, we aggregated the life expectancy groups and took their average to match the groups used for death reporting.

## Conclusion and recommendations

This study indicated a substantial burden of the nine NCDs in GCC countries, in terms of deaths, YPLL, and economic loss. This study adds to the scant literature examining the effects of NCDs in GCC countries from epidemiologic and economic viewpoints. To our knowledge, this study presents the first economic evaluation of these nine NCDs to incorporate and synthesize the highest level, most suitable information available for the GCC context. The results of this study are expected to help decision-makers formulate appropriate policies to detect, prevent, and control these NCDs in the region.

Notably, CVD prevention and control should be a policy priority, with emphasis on routine screening and lifestyle modification. Policymakers should work to provide national data for each disease and country, and should pay greater attention to national NCD surveillance.

Future studies are warranted to estimate NCD burden according to additional measures such as DALYs and to expand the scope to include all other NCDs. Estimation of the burden of specific risk factors such as cigarette smoking, alcohol consumption, unhealthy diets, hypertension, hyperglycemia, hyperlipidemia, physical inactivity, obesity, and air pollution in each GCC country must be explored.

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### Conflict of interest

The authors have no conflict of interest to declare.

### Ethical approval

This study was granted ethical approval exemption from the Ethical Reviewer Board, Faculty of Public Health, Mahidol University (MUPH-IRB No.78.141.6/EC 044) (19 January 2023), because it used secondary data and did not include any human or animal research.

### Authors contributions

ETA and KC conceived and designed the research. ETA conducted research, and analyzed and interpreted the data, with advice from KC. ETA and KC wrote the manuscript. KS and MAN provided advice and suggestions. KC revised and comprehensively verified the writing of this manuscript. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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