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# Inflammatory bowel disease burden in the Middle East and North Africa Region: a comprehensive analysis of incidence, prevalence, and mortality from 1990-2019

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## Abstract

**Background** The epidemiology of inflammatory bowel disease (IBD) has changed rapidly in recent years. Objective data concerning the IBD burden in the Middle East and North Africa (MENA) region is limited. We aimed to provide a systematic report on the IBD burden in the MENA region. Additionally, we aimed to study the age- and sex-specific trends in IBD incidence, prevalence and mortality rates from 1990-2019.

**Methods** Using the Global Burden of Disease (GBD) 2019 Study Database, we investigated the changes in incidence, prevalence and mortality rate, and disability-adjusted life-years (DALYs), at a regional and country level between 1990 and 2019.

**Results** In 2019, there were 282,534 cases (95% confidence interval [CI] 239,506-334,478) of IBD in the MENA region (50.5% male). There was an overall increase in the incidence and prevalence rates of IBD in the MENA region from 1990 to 2019, while a simultaneous decrease in overall mortality rates was identified. Incidence rates were highest in Jordan, at 6.9 (95%CI 5.8-8.1) per 100,000, and lowest in Morocco, at 1.6 (95%CI 1.4-2) per 100,000. From 1990-2019, the incidence was found increased in males at a higher rate than in females. The age-standardized mortality rate decreased for both sexes by 24% from 1990-2019.

**Conclusion** The trends and geographic variations in IBD within the MENA region provide policymakers with vital information for making informed decisions in policy, research, and investment, thereby enabling the development of more effective strategies and better allocation of resources.

**Keywords** Inflammatory bowel disease, Middle East and North Africa, epidemiology, trend

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## Introduction

Inflammatory bowel disease (IBD) is a group of chronic idiopathic disorders characterized by persistent inflammation of the gastrointestinal tract [1]. While the exact etiology of IBD remains incompletely understood, it is believed to arise from an aberrant immune response in genetically susceptible individuals [2]. The global prevalence of IBD has been steadily rising, transcending ethnic and geographic boundaries, thereby posing significant challenges to healthcare systems and governments worldwide [3].

Despite the remarkable progress in understanding the pathogenesis of IBD and the emergence of many new therapeutic strategies, there is still no definitive cure for this disease. Consequently, the economic burden associated with managing IBD continues to increase exponentially. For instance, in 2016,

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the annual cost for IBD treatment was estimated to surpass $25 billion in the United States (US) alone, making IBD one of the top 5 most expensive gastrointestinal conditions [4]. Similarly, a global analysis of high-income countries suggested a direct annual cost of IBD per patient of $9,000-$12,000 without accounting for indirect costs [5].

The burden of IBD can vary significantly based on geographical location, sex, and age group [2]. However, accurately evaluating the epidemiological changes within these demographics remains an ongoing challenge. While numerous studies have provided valuable insights into IBD at regional, national and multi-country levels, there is a scarcity of comprehensive data concerning the disease burden at a more granular level in the Middle East and North Africa (MENA) region [6].

The MENA region is characterized by its diverse cultures, varied socioeconomic backgrounds, and distinct environmental factors, all of which may influence the epidemiology and manifestations of IBD in this population. There are currently limited data on the epidemiology of IBD in the MENA region, but it is estimated that many countries within the MENA region are in the "acceleration in incidence" epidemiologic phase of IBD [7]. Studying the burden of IBD in the MENA region is crucial to understanding the full extent of its impact on public health and the quality of life of affected individuals. Our study aimed to investigate age- and sex-specific trends in the IBD incidence, prevalence and mortality rates in the MENA region over the past 3 decades, from 1990-2019, utilizing data from the comprehensive Global Burden of Disease (GBD) 2019 database.

## Materials and methods

### Background

We performed a population-based time-trend analysis of IBD incidence, prevalence and mortality rates in the MENA region from 1990-2019 using the GBD 2019 study database. GBD 2019 is a publicly accessible database that includes anonymized de-identified data on various diseases. We used the GBD dataset categorization of MENA countries, which included 21 countries listed as follows in the database: Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Afghanistan, Tunisia, Turkey, United Arab Emirates, and Yemen. The institutional review board's policy deemed this study exempt from review, based on the recommendations of the National Human Research Protections Advisory Committee.

### Data source

We used the GBD 2019 study database to gather data on IBD incidence, prevalence and death rates in the MENA region between 1990 and 2019. The GBD 2019 methodically and comprehensively evaluated 286 causes of death, 369 illnesses and injuries, and 87 risk factors from various relevant data sources, including household surveys, censuses, vital statistics and civil registrations, for 204 nations and territories [8]. The GBD 2019 study was conducted by the Institute for Health Metrics and Evaluation (IHME) at the University of Washington. The GBD study provides a comprehensive and comparable analysis of various health metrics for various diseases and injuries, as well as demographic and geographical variations.

Detailed methodology for the GBD 2019 study estimate have been previously described [8-10]. In short, structured literature reviews were conducted to find published and unpublished data on the incidence, prevalence, case fatality and mortality of IBD. The International Classification of Diseases (ICD)-9 and ICD-10 codes for each cause of IBD were obtained, and used to determine the yearly incidence, prevalence, and mortality rates for IBD, stratified by age, sex, year, and state. Cause of Death Ensemble model (CODEm), spatiotemporal Gaussian process regression (ST-GPR), and the Bayesian meta-regression tool DisMod-MR were the main methods used to estimate the epidemiological parameters stratified by cause, age, sex, year and location for the GBD 2019 study [9]. The GBD 2019 Data Input Sources Tool webpage contains detailed information on data sources utilized in this study [http://ghdx.healthdata.org/gbd-2019/data-input-sources].

### Definitions

The age-standardized rate was determined as a weighted average of age-specific rates, using the proportions of a standard population in the corresponding age groups as weights. The incidence rate referred to the number of patients diagnosed with IBD per 100,000 individuals in a given calendar year. The mortality rate was defined as the number of deaths per 100,000 population due to IBD in a specific calendar year [8]. The annual percentage change (APC) represented the percentage change in IBD incidence, prevalence, or mortality rates from one year to the next, while the average APC (AAPC) denoted the mean percentage change per year over the entire

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study period [11,12]. Trends were classified as increasing or decreasing if the APC or AAPC values were statistically significant positive or negative, respectively, and as stable if the values were not statistically significant. The population was categorized into two age groups based on a 50-year cutoff: younger adults (15-49 years) and older adults (50-79 years).

### Statistical analysis

The Joinpoint Regression Program, version 5.0.2 (NCI), which constructs best-fit models for sequences of logarithmic data, was utilized to quantify temporal trends [13]. This joinpoint regression model, comprising a series of linear statistical models, was used to evaluate the temporal trends in disease burdens related to IBD. It employs the least squares method to estimate changing illness rate patterns, thus reducing the subjectivity inherent in traditional trend analyses based on linear trends. By calculating the sum of squared residuals between estimated and actual values, the joinpoint regression model pinpoints the turning points where trends shift [14].

The analysis began with a minimum of zero joinpoints (indicating a straight line) and included model-fitting tests with up to five joinpoints. The program uses Monte Carlo permutation analysis to determine the minimum number of joinpoints required to create a segmented line that accurately represents time-dependent changes [5]. The APC and AAPC were calculated using parametric estimates, and a 2-sided t-test was employed to determine statistical significance [11]. A pairwise comparison was conducted to assess parallelism and homogeneity. The statistical significance of the absolute difference between the AAPCs was estimated using a Taylor series expansion. A P-value of less than 0.05 was considered statistically significant in all analyses.

## Results

### IBD burden in the MENA region

In 2019, there were 282,534 cases (95% confidence interval [CI] 239,506-334,478) of IBD in the MENA region (50.5% male). The age-standardized prevalence rate (ASPR) of IBD in the MENA region in 2019 was 48.3 (95%CI 41-56.9), with females having a higher ASPR, 49.6 per 100,000 (95%CI 41.9-59) compared to males at 47 per 100,000 (95%CI 40.2-55.8). Between 1990-2019, age-standardized incidence and prevalence rates increased, while mortality rates decreased. The overall age-standardized incidence rates (ASIR) of IBD in the MENA region increased from 2.9 per 100,000 (95%CI 2.6-3.4) population in 1990 to 3.7 per 100,000 (95%CI 3.2-4.5) population in 2019. The increase in ASIR was greater in males (+28.1%) compared to females (+25.9%). ASPR increased from 36.3 per 100,000 (95%CI 31.1-41.1) population in 1990 to 48.3 per 100,000 (95%CI 41-57) population in 2019, with a relative change of (+33%). The age-standardized mortality rate (ASMR) decreased for both sexes by 24% from 1990-2019. Age-standardized disability-adjusted life-years (DALYs) decreased for both sexes, with a larger decrease for males (-9.5% vs. -5.7%) (Supplementary Tables 1 and 2).

### ASIRs of IBD

#### *IBD ASIR by country*

In 2019, ASIRs were highest in Jordan, 6.9 per 100,000 (95%CI 5.8-8.1) and lowest in Morocco 1.6 per 100,000 (95%CI 1.4-2). Overall, the ASIR increased in all countries from 1990-2019, but there was wide regional variation in this increase, with the largest percentage change occurring in Turkey (+64.1%) (Fig. 1, Supplementary Tables 3 and 4).

#### *IBD ASIR by sex*

Over 30 years (1990-2019), there was an overall increase in ASIRs among males (AAPC 0.8%, 95%CI 0.7-0.9%; P<0.001) and females (AAPC 0.6%, 95%CI 0.5-0.7%; P<0.001), with an absolute AAPC difference of 0.2% (95%CI 0.1-0.4%; P=0.003). ASIRs were higher in males than females (4.1 and 3.4 per 100,000, respectively). Sex-specific trends were non-identical (P<0.001) and not parallel (P<0.001), suggesting that ASIRs are different and increasing at a greater rate in males compared to females (Fig. 2A, Supplementary Table 5).

#### *IBD ASIR by age*

Similarly, age-specific trends increased among younger adults (AAPC 1.2%, 95%CI 1.0-1.4%; P<0.001) and older adults (AAPC 1.0%, 95%CI 0.8-1.2%; P<0.001), with an absolute AAPC difference of 0.2% (95%CI 0.1-0.3%; P<0.001) and non-parallel trends (P<0.001), suggesting that ASIRs increased at a higher rate in younger adults than older adults (Fig. 2B, Supplementary Table 5).

### IBD ASPRs

#### *IBD ASPRs with geographic variation*

There were an estimated 282,534 cases of IBD during 2019 in the MENA region, considerably more than the 89,159 cases in 1990. There was a wide geographic variation in the ASPR among the MENA countries in 2019, with the highest rate being in Jordan, 113.5 (95%CI 95.8-133.9) per 100,000, followed by Turkey and Kuwait. Interestingly, all countries saw a significant increase in ASPR from 1990-2019, except Kuwait (-2.5%). The most notable increase was in Turkey, which saw an increase of 95.1% from 50.7 per 100,000 (95%CI 44.4-57) in 1990 to 98.9 per 100,000 (95%CI 85-113) in 2019. Although all age groups saw an increase in ASPR, people aged 50+ years

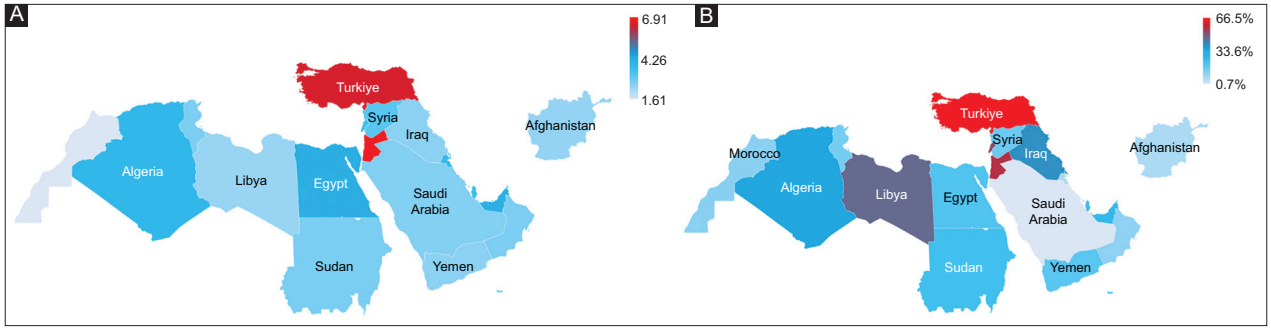


**Figure 1** (A) Age-standardized incidence rates of inflammatory bowel disease (IBD) per 100,000 population in 2019. (B) Percentage change (%) in age-standardized incidence rates of IBD between 1990 and 2019

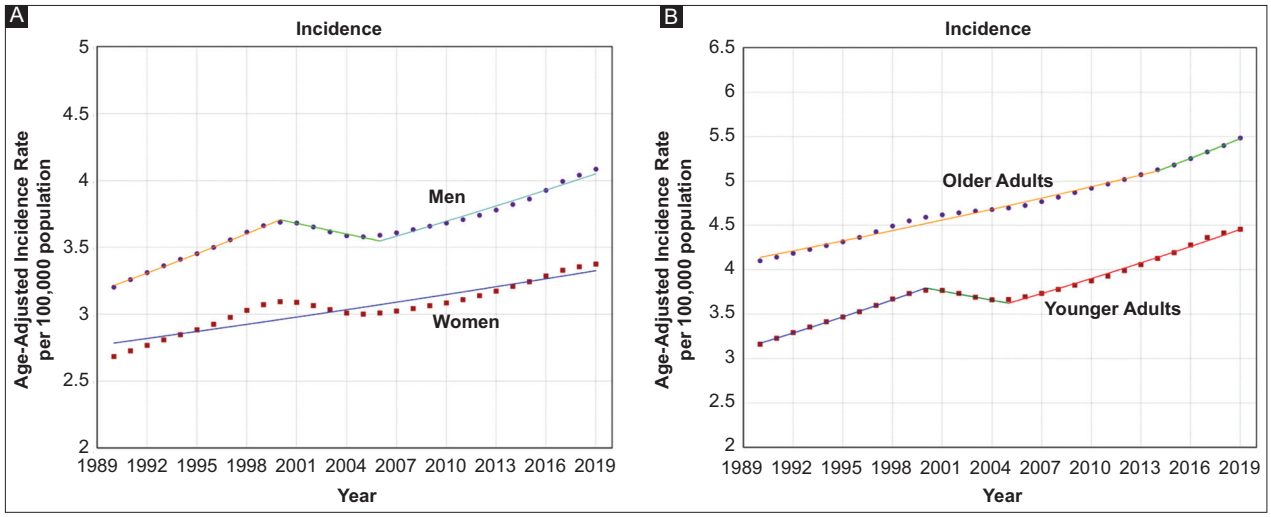


**Figure 2** (A) Sex-specific trends of inflammatory bowel disease (IBD) age-standardized incidence rates. (B) Age-specific trends of IBD age-standardized incidence rates

had the most notable increase, from 32.6 cases per 100,000 in 1990 to 50.8 per 100,000 in 2019, with an increase of 56% (Fig. 3, Supplementary Tables 6 and 7).

### *IBD ASPRs by sex*

Overall, sex-specific ASPRs increased in males (AAPC 1.0%, 95%CI 0.9-1.1%; P<0.001) and females (AAPC 0.9%, 95%CI 0.8-1.0%, P<0.001) with an absolute difference of 0.1% (P=0.46) (Fig. 4A, Supplementary Table 8).

### *IBD ASPRs with age variation*

Compared to the younger adults (AAPC 1.1%, 95%CI 0.9-1.3%; P<0.001), older adults had a greater increase in ASPRs (AAPC 1.5%, 95%CI 1.3-1.7%; P<0.001) with an absolute AAPC difference of 0.4% (95%CI 0.3-0.5%; P<0.001). Age-specific trends were non-identical (P<0.001) and not parallel (P<0.001), suggesting that ASPRs among older adults are different and increasing at a relatively greater rate than in younger adults (Fig. 4B, Supplementary Table 8).

## IBD ASMRs

### *IBD ASMRs with geographic variation*

The absolute number of deaths attributed to IBD in the MENA region increased from 592 (95%CI 407-836) in 1990 to 1033 (95%CI 866-1226) in 2019. There was wide geographic variation in the ASMRs of IBD in 2019 across the MENA countries. The lowest ASMRs were noted in Tunisia and Lebanon (0.14 and 0.15 deaths per 100,000, respectively), while a nearly triple rate was observed in Afghanistan, 0.43 (95%CI 0.32-0.54) per 100,000. The ASMRs decreased in all countries between 1990-2019, with the largest decrease in Jordan (-50%). Interestingly, Sudan was the only country with a relative increase of ASMRs (+50%) (Fig. 5, Supplementary Tables 9 and 10).

### *IBD ASMRs by sex*

Overall, between 1990 and 2019, sex-specific ASMRs decreased in females (AAPC -1.1%, 95%CI -1.3% to -0.9%; P<0.001) at a greater rate than in males (AAPC -0.7%, 95%CI -0.8% to -0.6%;

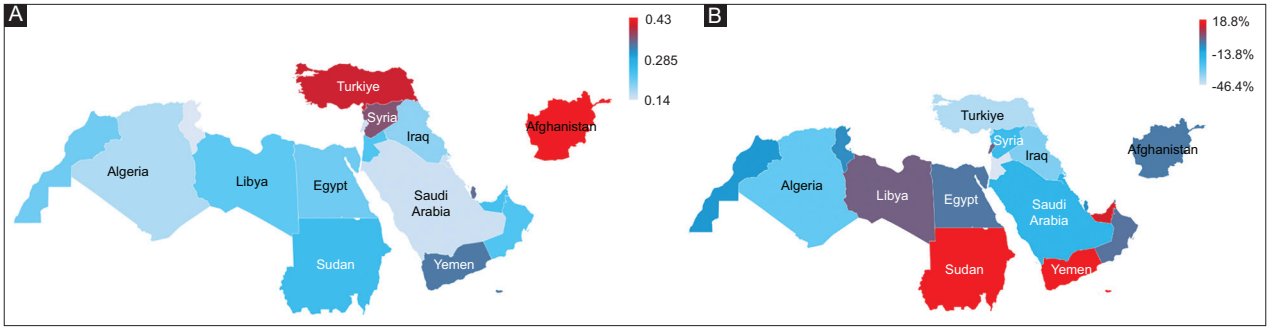


**Figure 3** (A) Age-standardized prevalence rate of inflammatory bowel disease (IBD) per 100,000 population in 2019. (B) Percentage change (%) in age-standardized prevalence rates of IBD between 1990 and 2019

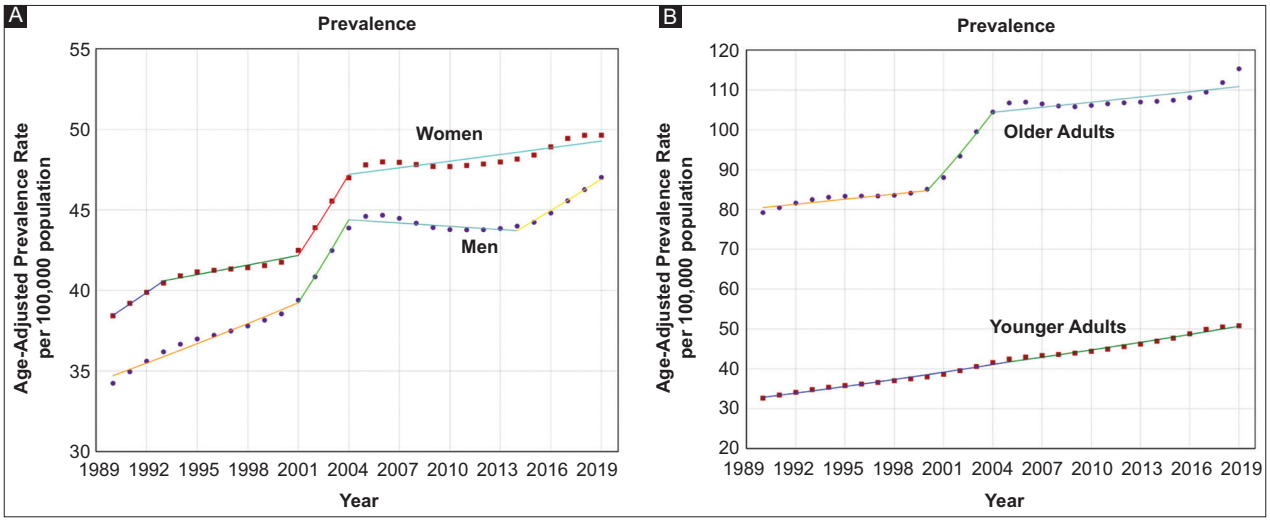


**Figure 4** (A) Sex-specific trends of inflammatory bowel disease (IBD) age-standardized prevalence rates. (B) Age-specific trends of IBD age-standardized prevalence rates

P<0.001) with an absolute AAPC difference of 0.4% (95%CI 0.3-0.5%; P<0.001). Sex-specific trends were neither parallel (P<0.001) nor identical (P<0.001), suggesting that ASMRs among females are different and decreasing at a relatively greater rate than in males (Fig. 6A, Supplementary Table 11).

### *IBD ASMRs with age variation*

Overall, age-specific ASMRs decreased in older adults (AAPC -1.5%, 95%CI -1.6% to -1.4%; P<0.001) at a greater rate than in younger adults (AAPC -0.9%, 95%CI -1.1% to -0.7%; P<0.001), with an absolute AAPC difference of 0.5% (95%CI 0.4-0.6%; P<0.001). Age-specific trends were neither parallel (P<0.001) nor identical (P<0.001), suggesting that ASMRs among older adults are different and decreasing at a greater rate than in younger adults (Fig. 6B, Supplementary Table 11).

## Discussion

Historically, IBD was viewed as a prevalent disease mainly in western countries; however, the incidence and prevalence of IBD have been rapidly evolving throughout the world, and it is now recognized as a global disease. This study showed an increased incidence of IBD in the MENA region, with an overall increase in ASIRs of about 30% from 1990-2019. The reasons for this recent increase in incidence are unclear, but industrialization, changes in dietary habits and changes in the genetic mix in the region may have contributed. In addition, trends in early-life exposure to various microbes could explain changes in IBD epidemiology. As industrialization and modernization progress in MENA countries, children are increasingly exposed to more sterilized environments, which may impede the development of immune tolerance and result in inappropriate immune responses to harmless intestinal microbes later in life. This phenomenon is often referred to as the hygiene hypothesis. Additionally, increased exposure to antibiotics early in life can reduce intestinal microbial diversity and species richness, a factor strongly associated with IBD [15]. Furthermore, the increasing awareness of patients and healthcare providers in the MENA region about IBD, and better access to diagnostic tools such as endoscopy, imaging and stool testing for intestinal inflammation, as well as advances in electronic medical records may play an important role in the diagnosis and proper statistical data collection from these countries [16].

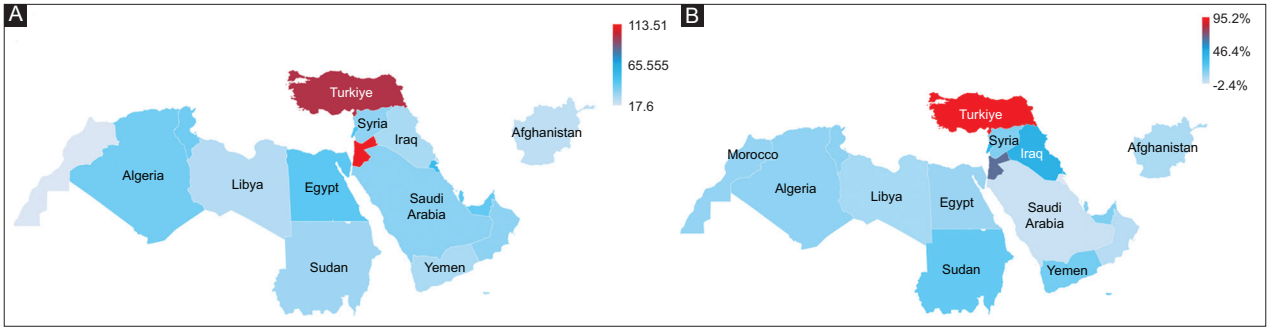


**Figure 5** (A) Age-standardized mortality rate of inflammatory bowel disease (IBD) per 100,000 population in 2019. (B) Percentage change (%) in age-standardized mortality rates of IBD between 1990 and 2019

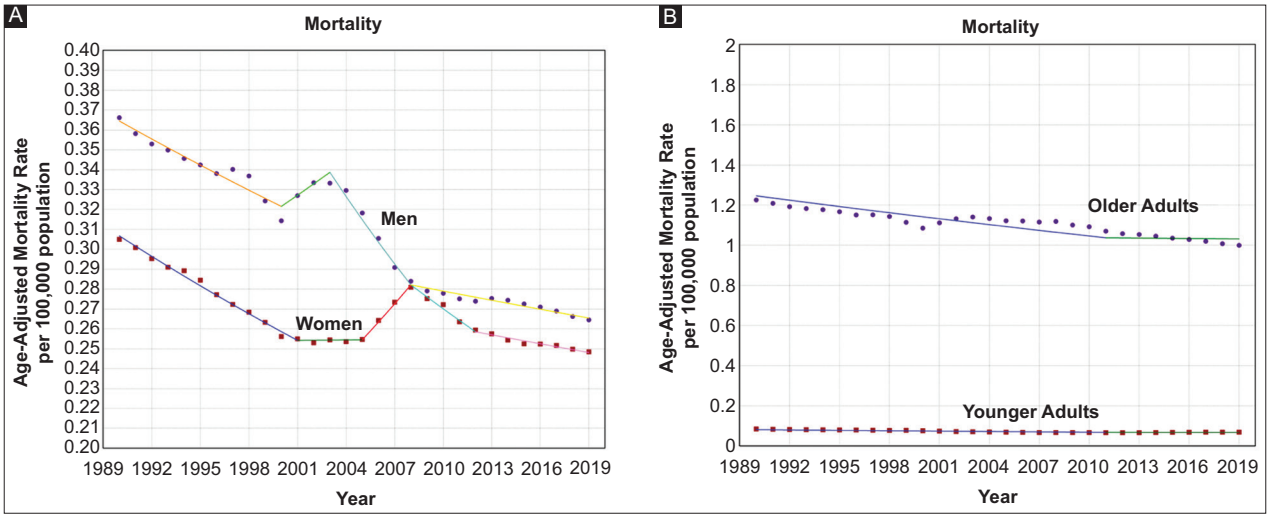


**Figure 6** (A) Sex-specific trends of inflammatory bowel disease (IBD) age-standardized mortality rates. (B) Age-specific trends of IBD age-standardized mortality rates

Previous cohort studies from Asia and Africa showed similar patterns of increasing IBD incidence, and this increase was attributed to the greater urbanization that those countries experienced during the past 3 decades [17-19]. A study examining the epidemiology of ulcerative colitis (UC) showed a rising incidence in most of the countries of the Middle East [20], and was reaffirmed by a study from Egypt showing an increasing number of newly confirmed cases over a 10-year period [21]. Zvidi *et al* [22], found that the incidence and prevalence of IBD in the Jewish and Arab populations were rising, and that the incidence and prevalence of IBD in the Arab population in Israel were relatively higher than those in other Arab countries. An epidemiologic study from Iran, a rapidly developing country with increased urbanization, showed a rapid rise in IBD incidence that collated with other developed countries. One explanation was that people from West Asian descent were similar to the European population in terms of ethnicity, which could explain the increasing incidence in Iran [23,24]. A systematic review and meta-analysis of 16 studies examining the epidemiology of IBD in the Arab world also found a rise in both the incidence and prevalence of IBD over the past 3 decades [25].

In our study, there was an increase in IBD incidence among males and females, but the increase was more pronounced in males. These differences potentially stem from hormonal influences, genetic predispositions, and differences in healthcare-seeking behavior, affecting healthcare access, which may contribute to disparities between the sexes [26-28]. Previous studies from the western world have shown that Crohn's disease [CD] was more predominant in females [29,30]. These findings are in contrast to studies from Asia, where males carried a higher risk of developing both CD and UC [31,32]. A pooled analysis confirmed a greater risk of both CD and UC among Asian males 10-50 years of age [33]. There was also a greater increase in the ASIRs of IBD among younger age groups. This finding is consistent with epidemiological studies that showed that the peak age of onset for CD and UC is 20-30 years and 30-40 years, respectively [34]. An older epidemiological study showed that the mean age of diagnosis of UC in the Middle East ranged between 27.3 and 40 years, with some cohorts showing a mean age ranging between 28.4 and 46.7 years. Those studies failed to show the bimodal variation seen in western populations [24,35,36].

The data regarding IBD mortality worldwide are conflicting, and the mortality rates for CD and UC are likely to be different. A meta-analysis of 22 studies showed no greater risk of mortality in UC compared to the general

population [37]. However, a meta-analysis of mortality rates in CD showed a higher mortality rate in CD compared to the general population [38]. Another nationwide registry study from Finland showed a greater overall mortality among patients with CD and a slightly higher value among patients with UC [39]. One study concluded that the mortality rate is slightly greater in European patients with CD as compared to the general population, while for UC it is similar to the general population [40]. More recently, results from a 30-year follow-up of the Norwegian Inception Cohort (IBSEN Study) showed no difference in overall mortality in IBD patients compared to controls, but higher mortality in male patients with CD [41].

Comparatively, data on mortality rates secondary to IBD in the MENA region are scarce. Our results showed that ASMRs decreased in most of the MENA region countries. The improved mortality rates are potentially due to increased awareness, improved diagnostic modalities and the availability of advanced therapies. Our results also showed a greater decrease in ASMRs among females compared to males. Environmental factors, including biological, social and economic exposure differences, potentially play a major role in the difference in ASMRs between the sexes. Among these factors, the rising and ultimately higher prevalence of smoking in males is likely a significant contributor to this discrepancy in mortality rates, as smoking is one of the most studied environmental factors in patients with IBD [42].

IBD prevalence is rising across MENA countries, with similar rates in both sexes and no significant difference in increase between males and females. Globally, IBD prevalence increased significantly; a study from 195 countries showed that its prevalence increased from 79.5 to 84.3 per 100,000 persons between 1990 and 2017 [2]. A recent modeling study predicted an increasing trend in the prevalence of IBD from 2017 to 2035 in Iran. Notably, the number of patients with IBD increased from 23,000 cases in 2017 to about 30,000 cases in 2021, and is expected to reach about 69,000 cases in 2035. The same study also predicted that the prevalence of IBD cases was going to rise from about 166,000 cases in 2017 to nearly half a million cases in 2035 in the MENA region [42]. Another study from Turkey also showed that the prevalence of IBD is still on the rise, though stabilizing [43].

In comparing the burden of IBD between the MENA regions and western populations, notable distinctions emerge. While both regions have witnessed a rising prevalence of IBD, variations in healthcare infrastructure, access to specialized medical care, and socioeconomic factors contribute to differing morbidity and mortality outcomes [44,45]. In many western countries, advanced healthcare systems and widespread access to advanced treatments have improved IBD management, potentially reducing the disease burden [46]. Conversely, in certain MENA regions, challenges such as limited access to specialized care and socioeconomic disparities may impede optimal disease management and contribute to comparatively higher morbidity and mortality rates [45]. Additionally, cultural factors, dietary habits and genetic predispositions unique to each population may also play a role in shaping these divergent trends [47].

The increasing burden of IBD in the MENA region aligns with the dynamic epidemiological stages proposed by Kaplan *et al* [7]. Our findings, indicative of an increasing disease burden, closely correspond to Kaplan's second stage, highlighting a crucial juncture in the region's IBD epidemiological transition. Kaplan's framework emphasizes the urgency for strategic healthcare planning. Specifically, the need for enhanced diagnostic capabilities, a well-equipped healthcare workforce, and improved accessibility to specialized IBD care becomes pronounced as the MENA region traverses this stage. By employing Kaplan's model, our study provides a comprehensive understanding of the trajectory of IBD in the MENA region, serving as a foundation for the development of targeted interventions to address the emerging challenges in the healthcare system of the region.

This study highlights the potential value of comparing IBD trends among countries with similar socioeconomic characteristics. For instance, countries with a high gross domestic product (GDP) per capita, such as Kuwait and Saudi Arabia, exhibited relatively similar increases in the ASIRs of IBD, with Kuwait experiencing an ASIR increase of 8.8% and Saudi Arabia 3.8%. In contrast, countries with a lower GDP per capita, such as Libya, showed a significantly higher ASIR increase of 50%. These disparities suggest that socioeconomic factors, including healthcare access and quality, dietary habits, urbanization and educational levels, may play a crucial role in influencing IBD trends.

This study has several notable strengths. To the best of our knowledge, it provides the most recent estimates of IBD prevalence, incidence, and mortality rates across the MENA countries, focusing on trends at country level. The primary strength of this study is its extensive coverage over the past 3 decades, surpassing the scope of most previous research. However, several limitations should be acknowledged. Firstly, the study estimated rates of IBD as a whole, without differentiating between UC and CD. Secondly, the observed fluctuations in IBD epidemiological trends in the MENA region may be influenced by migration patterns, particularly in countries experiencing social unrest or conflict. Data collection systems vary significantly across the MENA region; some countries have robust and well-integrated systems with healthcare facilities, while others do not, leading to substantial disparities in data quality and availability. An inherent limitation of the GBD 2019 database is its inclusion of Afghanistan and exclusion of Israel among the MENA countries. Additionally, the GBD database does not use the traditional cutoff age of 18 years for defining adults, so our data analysis categorized 15-49 years as younger adults and 50-79 years as older adults. Lastly, our results are susceptible to ecological fallacy, and the lack of individual-level data limits our ability to draw individual-level inferences. It is important to recognize that this limitation is intrinsic to the GBD study and beyond our control, but it must be considered when interpreting the findings.

In conclusion, there appears to be an epidemiological shift in the geographical distribution of IBD in the MENA region. This is likely to reflect on the healthcare systems in these countries and might call for policy makers to prepare the infrastructure and health resources for this change, so as to be able to mitigate the burden of IBD. The trends suggest that there are ongoing

improvements in diagnosing and treating IBD in the MENA region, hence the decrease in mortality. Further research on IBD prevention may be warranted.

**Summary Box**

**What is already known:**

- Inflammatory bowel disease (IBD) epidemiology has changed rapidly in recent years
- The global prevalence of IBD has been steadily increasing, posing challenges to healthcare systems
- The IBD burden varies by geography, sex, and age group, with rising trends observed in many regions

**What the new findings are:**

- In the Middle East and North Africa (MENA) region, IBD incidence and prevalence rates increased, while mortality rates decreased over the study period from 1990-2019
- Both sexes and age groups showed rising incidence and prevalence rates, with males experiencing a more pronounced increase
- Variations in IBD burden exist among MENA countries, influenced by socioeconomic factors

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## Supplementary material

**Supplementary Table 1** Total all-age, all-inflammatory bowel disease incidence, prevalence, mortality, DALYs, YLLs, and YLDs and their percentage change in 1990 and 2019

| All Measures | Age-standardized rate in North Africa and Middle East region | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Deaths | | | |
| Male | 0.4 (0.3-0.6) | 0.3 (0.2-0.3) | -25.0% |
| Female | 0.3 (0.2-0.5) | 0.2 (0.2-0.3) | -33.3% |
| Both | 0.34 (0.2-0.5) | 0.26 (0.2-0.3) | -24% |
| Prevalence | | | |
| Male | 34.2 (29.4-39.9) | 47 (40.2-55.8) | 37.4% |
| Female | 38.4 (33.1-44.2) | 49.6 (41.9-59) | 29.2% |
| Both | 36.3 (31.1-41.9) | 48.3 (41-56.9) | 33.1% |
| Incidence | | | |
| Male | 3.2 (2.8-3.7) | 4.1 (3.5-4.8) | 28.1% |
| Female | 2.7 (2.4-3.1) | 3.4 (2.9-4) | 25.9% |
| Both | 2.9 (2.6-3.4) | 3.7 (3.2-4.5) | 27.6% |
| DALYs (Disability-Adjusted Life Years) | | | |
| Male | 14.7 (11-20.9) | 13.3 (10.6-16.6) | -9.5% |
| Female | 14 (10.1-18.6) | 13.2 (10.4-16.7) | -5.7% |
| Both | 14.4 (10.8-18.7) | 13.3 (10.6-16.5) | -7.6% |
| YLDs (Years Lived with Disability) | | | |
| Male | 5.1 (3.3-7.2) | 6.9 (4.6-9.6) | 35.3% |
| Female | 6 (3.9-8.4) | 7.6 (5-10.7) | 26.7% |
| Both | 5.5 (3.7-7.7) | 7.2 (4.7-10.1) | 30.9% |
| YLLs (Years of Life Lost) | | | |
| Male | 9.6 (6.5-15.6) | 6.5 (5.2-8) | -32.3% |
| Female | 7.9 (4.6-11.8) | 5.6 (4.6-6.9) | -29.1% |
| Both | 8.8 (6-12.4) | 6.1 (5.1-7.1) | -30.7% |

**Supplementary Table 2** Age-standardized rates of all-age, all-inflammatory bowel disease incidence, prevalence, mortality, DALYs, YLLs, and YLDs and their percentage change in 1990 and 2019

| All Measures | All-ages number in North Africa and Middle East region | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Deaths | | | |
| Male | 325 (222-520) | 556 (448-690) | 71.1% |
| Female | 268 (160-409) | 478 (395-592) | 78.4% |
| Both | 592 (407-836) | 1033 (866-1226) | 74.5% |
| Prevalence | | | |
| Male | 42718 (36678-49524) | 142814 (121316-169151) | 234.3% |
| Female | 46441 (39681-53341) | 139720 (117143-165561) | 200.9% |
| Both | 89159 (76544-102596) | 282534 (239506-334478) | 216.9% |
| Incidence | | | |
| Male | 4492 (3912-5109) | 12934 (10934-15249) | 187.9% |
| Female | 3614 (3137-4088) | 9789 (8240-11699) | 170.9% |
| Both | 8107 (7040-9204) | 22722 (19277-26952) | 180.3% |
| DALYs (Disability-Adjusted Life Years) | | | |
| Male | 18142 (13192-25538) | 37866 (29706-47614) | 108.7% |
| Female | 17296 (11817-23204) | 34888 (26850-44725) | 101.7% |
| Both | 35438 (25569-46318) | 72755 (56928-91112) | 105.3% |
| YLDs (Years Lived with Disability) | | | |
| Male | 6388 (4136-9045) | 20981 (13685-29378) | 228.4% |

*(Contd...)*

**Supplementary Table 2** *(Continued)*

| All Measures | All-ages number in North Africa and Middle East region | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Female | 7417 (4813-10444) | 21632 (14217-30499) | 191.7% |
| Both | 13804 (8984-19350) | 42612 (27805-59873) | 208.7% |
| YLLs (Years of Life Lost) | | | |
| Male | 11754 (7596-18499) | 16886 (13580-21107) | 43.7% |
| Female | 9879 (5127-15492) | 13257 (10793-16585) | 34.2% |
| Both | 21634 (13448-31651) | 30142 (25222-36090) | 39.3% |

**Supplementary Table 3** Total number of all-age, all-inflammatory bowel disease incidence and percentage change of incidence in 1990 and 2019

| Country | Inflammatory bowel disease, incidence in number | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Afghanistan | 192 (159-228) | 684 (557-828) | 256.3% |
| Algeria | 577 (508-648) | 1657 (1373-2043) | 187.2% |
| Bahrain | 13 (11-15) | 58 (48-72) | 346.2% |
| Egypt | 1624 (1415-1814) | 3833 (3168-4689) | 136.0% |
| Iran (Islamic Republic of) | 1347 (1111-1654) | 3167 (2599-3894) | 135.1% |
| Iraq | 240 (202-282) | 984 (810-1191) | 310.0% |
| Jordan | 130 (114-147) | 779 (649-917) | 499.2% |
| Kuwait | 61 (57-66) | 195 (161-239) | 219.7% |
| Lebanon | 65 (54-80) | 194 (161-238) | 198.5% |
| Libya | 51 (42-62) | 178 (146-220) | 249.0% |
| Morocco | 300 (252-354) | 599 (508-712) | 99.7% |
| Oman | 38 (31-46) | 143 (115-173) | 276.3% |
| Palestine | 29 (24-35) | 122 (101-145) | 320.7% |
| Qatar | 13 (10-16) | 125 (102-152) | 861.5% |
| Saudi Arabia | 341 (287-404) | 1122 (929-1353) | 229.0% |
| Sudan | 334 (275-400) | 934 (775-1114) | 179.6% |
| Syrian Arab Republic | 241 (200-289) | 449 (376-544) | 86.3% |
| Tunisia | 168 (139-202) | 349 (288-426) | 107.7% |
| Turkey | 2084 (1859-2316) | 5961 (5119-6893) | 186.0% |
| United Arab Emirates | 58 (47-71) | 520 (410-651) | 796.6% |
| Yemen | 192 (157-230) | 647 (527-793) | 237.0% |

**Supplementary Table 4** Age-standardized rate of all-age, all-inflammatory bowel disease incidence and percentage change of incidence in 1990 and 2019

| Country | Inflammatory bowel disease, age-standardized incidence rate | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Afghanistan | 2.3 (1.9-2.7) | 2.4 (2-3) | 4.3% |
| Algeria | 2.9 (2.6-3.2) | 3.9 (3.2-4.7) | 34.5% |
| Bahrain | 2.6 (2.3-3) | 3.2 (2.7-3.9) | 23.1% |
| Egypt | 3.5 (3-3.9) | 4.2 (3.5-5.2) | 20.0% |
| Iran (Islamic Republic Of) | 3.3 (2.7-4.1) | 3.4 (2.9-4.2) | 3.0% |
| Iraq | 1.8 (1.5-2.1) | 2.5 (2.1-3.1) | 38.9% |
| Jordan | 4.4 (3.9-5) | 6.9 (5.8-8.1) | 56.8% |
| Kuwait | 3.4 (3.2-3.7) | 3.7 (3.1-4.5) | 8.8% |
| Lebanon | 2.3 (1.9-2.9) | 3.6 (3-4.4) | 56.5% |
| Libya | 1.6 (1.4-2) | 2.4 (2-3) | 50.0% |
| Morocco | 1.4 (1.2-1.7) | 1.6 (1.4-1.9) | 14.3% |
| Oman | 2.4 (2-2.9) | 2.7 (2.3-3.3) | 12.5% |
| Palestine | 2 (1.7-2.4) | 2.9 (2.5-3.5) | 45.0% |
| Qatar | 2.8 (2.4-3.4) | 3.6 (3-4.3) | 28.6% |
| Saudi Arabia | 2.6 (2.2-3.1) | 2.7 (2.2-3.2) | 3.8% |
| Sudan | 2.2 (1.9-2.7) | 2.8 (2.3-3.3) | 27.3% |
| Syrian Arab Republic | 2.7 (2.2-3.3) | 3.2 (2.6-3.8) | 18.5% |
| Tunisia | 2.4 (2-2.9) | 2.7 (2.3-3.3) | 12.5% |
| Turkey | 3.9 (3.5-4.3) | 6.4 (5.5-7.4) | 64.1% |
| United Arab Emirates | 3.2 (2.7-3.9) | 4.1 (3.4-5) | 28.1% |
| Yemen | 2.1 (1.7-2.6) | 2.5 (2.1-3.1) | 19.0% |

**Supplementary Table 5** Trend analysis of inflammatory bowel disease (IBD) age-standardized incidence rate with sex and age variations from 1990 to 2019

| Incidence | Trends[a] | | | Sex/Age-specific AAPC difference (95%CI) | Pairwise comparison P-values | | |
|---|---|---|---|---|---|---|---|
| | Time period | APC (95%CI) | AAPC (95%CI) | | Sex/Age-specific AAPC difference | Coincidence[b] | Parallelism[c] |
| Sex | | | | | | | |
| Male | 1990-2000 | 1.4 (1.3 to 1.5) | 0.8 (0.7 to 0.9) | 0.2 | <0.001 | <0.001 | <0.001 |
| | 2000-2006 | -0.7 (-1.0 to -0.4) | | | | | |
| | 2006-2019 | 1.0 (0.9 to 1.1) | | | | | |
| Female | 1990-2019 | 0.6 (0.5 to 0.7) | 0.6 (0.5 to 0.7) | | | | |
| Age | | | | | | | |
| 15-54 years | 1990-2000 | 1.8 (1.7 to 1.9) | 1.2 (1.1 to 1.2) | 0.2 | <0.001 | <0.001 | <0.001 |
| | 2000-2005 | -0.9 (-1.3 to -0.6) | | | | | |
| | 2005-2019 | 1.5 (1.4 to 1.5) | | | | | |
| 55+ years | 1990-2014 | 0.9 (0.8 to 0.9) | 1.0 (0.9 to 1.1) | | | | |
| | 2014-2019 | 1.4 (0.9 to 1.9) | | | | | |

[a]Time-trends were computed using Joinpoint Regression Program (v5.0.2, NCI) with 5 maximum joinpoints allowed (6-line segments)
[b]Tests whether sex- and age-specific trends were identical. A significant P-value indicates that the trends were not identical (i.e., they had different incidence rates and coincidence was rejected)
[c]Tests whether sex- and age-specific trends were parallel. A significant P-value indicates that the trends were not parallel (i.e., parallelism was rejected)
*APC, annual percentage change; AAPC, average annual percentage change; CI, confidence interval*

**Supplementary Table 6** Total all-age, all-inflammatory bowel disease prevalence and percentage change of incidence in 1990 and 2019

| Country | Inflammatory bowel disease, prevalence in number | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Afghanistan | 1738 (1410-2120) | 5699 (4548-7113) | 227.9% |
| Algeria | 5982 (5169-6928) | 16875 (13593-20871) | 182.1% |
| Bahrain | 179 (152-206) | 846 (688-1035) | 372.6% |
| Egypt | 17107 (14592-19726) | 39271 (31782-48388) | 129.6% |
| Iran (Islamic Republic Of) | 14964 (12153-18513) | 40493 (32952-49751) | 170.6% |
| Iraq | 2270 (1890-2694) | 10029 (8221-12199) | 341.8% |
| Jordan | 1611 (1394-1851) | 11508 (9646-13565) | 614.3% |
| Kuwait | 863 (798-937) | 2857 (2338-3483) | 231.1% |
| Lebanon | 881 (721-1091) | 2494 (2037-3050) | 183.1% |
| Libya | 629 (514-759) | 1910 (1557-2333) | 203.7% |
| Morocco | 3007 (2487-3582) | 6614 (5488-7909) | 120.0% |
| Oman | 431 (347-517) | 1575 (1266-1924) | 265.4% |
| Palestine | 374 (305-450) | 1351 (1104-1621) | 261.2% |
| Qatar | 154 (123-187) | 1446 (1178-1746) | 839.0% |
| Saudi Arabia | 3748 (3112-4462) | 13816 (11338-16751) | 268.6% |
| Sudan | 3315 (2684-4060) | 9292 (7568-11371) | 180.3% |
| Syrian Arab Republic | 2248 (1819-2734) | 4862 (3940-5871) | 116.3% |
| Tunisia | 2247 (1845-2720) | 5382 (4413-6568) | 139.5% |
| Turkey | 24930 (21910-28012) | 93902 (80596-107925) | 276.7% |
| United Arab Emirates | 595 (477-725) | 5742 (4546-7126) | 865.0% |
| Yemen | 1826 (1464-2237) | 6284 (5044-7734) | 244.1% |

**Supplementary Table 7** Age-standardized rate of all-age, all-inflammatory bowel disease prevalence and percentage change of incidence in 1990 and 2019

| Country | Inflammatory bowel disease, age-standardized prevalence rate | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Afghanistan | 21.9 (17.8-26.9) | 23.7 (19-29.2) | 8.2% |
| Algeria | 34.7 (30-40.1) | 39.5 (32.2-48.9) | 13.8% |
| Bahrain | 42.2 (36.3-48.4) | 44.1 (36.4-53.1) | 4.5% |
| Egypt | 39.8 (33.9-46) | 44.5 (36.3-55) | 11.8% |
| Iran (Islamic Republic Of) | 41.1 (33.5-50.8) | 44.8 (36.7-55.1) | 9.0% |
| Iraq | 19.7 (16.5-23.4) | 28.1 (23.2-34.2) | 42.6% |
| Jordan | 69.2 (60.1-79.8) | 113.5 (95.8-133.9) | 64.0% |
| Kuwait | 55.7 (51.7-60) | 54.3 (45.1-65.6) | -2.5% |
| Lebanon | 33.2 (27.1-41.1) | 46.2 (37.8-56.7) | 39.2% |
| Libya | 23.6 (19.4-28.7) | 25.8 (21.2-31.4) | 9.3% |
| Morocco | 15.6 (13-18.5) | 17.6 (14.7-21) | 12.8% |
| Oman | 32 (26.3-38.6) | 33.8 (27.8-40.8) | 5.6% |
| Palestine | 31.5 (25.9-38.2) | 35.4 (29.1-42.6) | 12.4% |
| Qatar | 38.5 (31.4-45.8) | 44.5 (36.8-53.7) | 15.6% |

*(Contd...)*

**Supplementary Table 7** *(Continued)*

| Country | Inflammatory bowel disease, age-standardized prevalence rate | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Saudi Arabia | 33.9 (28.5-40.4) | 34.4 (28.7-41.4) | 1.5% |
| Sudan | 25.2 (20.5-31) | 31 (25.2-38) | 23.0% |
| Syrian Arab Republic | 28.7 (23.4-35) | 33.7 (27.3-40.5) | 17.4% |
| Tunisia | 35.3 (29-42.7) | 40.5 (33.2-49.3) | 14.7% |
| Turkey | 50.7 (44.4-57) | 98.9 (85-113.4) | 95.1% |
| United Arab Emirates | 36.5 (30.3-44.1) | 42.7 (35.6-52) | 17.0% |
| Yemen | 23.4 (18.9-29.1) | 28 (22.7-34.9) | 19.7% |

**Supplementary Table 8** Trend analysis of IBD age-standardized prevalence rate with sex and age variations from 1990 to 2019

| Prevalence | Trends[a] | | | Sex/Age-specific AAPC difference (95%CI) | Pairwise comparison P-values | | |
|---|---|---|---|---|---|---|---|
| | Time period | APC (95%CI) | AAPC (95%CI) | | Sex/Age-specific AAPC difference | Coincidence[b] | Parallelism[c] |
| Sex | | | | | | | |
| Male | 1990-2001 | 1.1 (1.0 to 1.2) | 1.0 (0.9 to 1.2) | 0 .1 | <0.001 | <0.001 | <0.001 |
| | 2001-2004 | 4.2 (2.4 to 6.0) | | | | | |
| | 2004-2014 | -0.2 (-0.3 to 0.0) | | | | | |
| | 2014-2019 | 1.4 (1.0 to 1.8) | | | | | |
| Female | 1990-1993 | 1.8 (0.8 to 2.9) | 0.9 (0.6 to 1.1) | | | | |
| | 1993-2001 | 0.5 (0.2 to 0.8) | | | | | |
| | 2001-2004 | 3.8 (1.7 to 6.0) | | | | | |
| | 2004-2019 | 0.3 (0.2 to 0.4) | | | | | |
| Age | | | | | | | |
| 15-54 years | 1990-2005 | 1.6 (1.5 to 1.7) | 1.5 (1.4 to 1.6) | 0.4 | <0.001 | <0.001 | <0.001 |
| | 2005-2019 | 1.4 (1.3 to 1.5) | | | | | |
| 55+ years | 1990-2000 | 0.5 (0.2 to 0.8) | 1.1 (0.8 to 1.4) | | | | |
| | 2000-2004 | 5.4 (3.3 to 7.5) | | | | | |
| | 2004-2019 | 0.4 (0.2 to 0.6) | | | | | |

[a]Time-trends were computed using Joinpoint Regression Program (v5.0.2, NCI) with 5 maximum joinpoints allowed (6-line segments)
[b]Tests whether sex- and age-specific trends were identical. A significant P-value indicates that the trends were not identical (i.e., they had different prevalence rates and coincidence was rejected)
[c]Tests whether sex- and age-specific trends were parallel. A significant P-value indicates that the trends were not parallel (i.e., parallelism was rejected)
*APC, annual percentage change; AAPC, average annual percentage change; CI, confidence interval*

**Supplementary Table 9** Total all-age, all-inflammatory bowel disease mortality and percentage change of incidence in 1990 and 2019

| Country | Inflammatory bowel disease, deaths in number | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Afghanistan | 31 (14-55) | 58 (31-89) | 87.1% |
| Algeria | 28 (18-44) | 53 (38-70) | 89.3% |
| Bahrain | 0 (0-1) | 1 (1-2) | N/A |
| Egypt | 59 (35-119) | 119 (70-186) | 101.7% |
| Iran (Islamic Republic Of) | 51 (33-68) | 132 (55-164) | 158.8% |
| Iraq | 34 (21-51) | 51 (38-67) | 50.0% |
| Jordan | 6 (4-8) | 13 (10-17) | 116.7% |
| Kuwait | 1 (1-2) | 4 (3-5) | 300.0% |

*(Contd...)*

**Supplementary Table 9** *(Continued)*

| Country | Inflammatory bowel disease, deaths in number | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Lebanon | 3 (2-4) | 8 (4-12) | 166.7% |
| Libya | 4 (3-7) | 11 (7-15) | 175.0% |
| Morocco | 31 (19-48) | 59 (41-77) | 90.3% |
| Oman | 2 (1-3) | 4 (3-5) | 100.0% |
| Palestine | 3 (2-4) | 4 (3-6) | 33.3% |
| Qatar | 0 (0-1) | 2 (1-3) | N/A |
| Saudi Arabia | 12 (7-20) | 27 (18-38) | 125.0% |
| Sudan | 21 (10-44) | 48 (28-78) | 128.6% |
| Syrian Arab Republic | 23 (13-35) | 37 (20-52) | 60.9% |
| Tunisia | 7 (5-11) | 16 (11-23) | 128.6% |
| Turkey | 261 (159-401) | 329 (250-471) | 26.1% |
| United Arab Emirates | 1 (1-3) | 13 (7-22) | 1200.0% |
| Yemen | 14 (8-25) | 44 (30-68) | 214.3% |

**Supplementary Table 10** Age-standardized rate of all-age, all-inflammatory bowel disease mortality and percentage change of incidence in 1990 and 2019

| Country | Inflammatory bowel disease, age-standardized mortality rate | | Change |
|---|---|---|---|
| | 1990 | 2019 | 2019/1990 |
| Afghanistan | 0.44 | 0.43 | -4.0% |
| Algeria | 0.25 | 0.17 | -29.4% |
| Bahrain | 0.26 | 0.17 | -34.1% |
| Egypt | 0.22 | 0.21 | -3.3% |
| Iran (Islamic Republic of) | 0.22 | 0.19 | -11.5% |
| Iraq | 0.29 | 0.19 | -33.1% |
| Jordan | 0.43 | 0.23 | -46.4% |
| Kuwait | 0.19 | 0.15 | -17.3% |
| Lebanon | 0.14 | 0.15 | 0.4% |
| Libya | 0.21 | 0.22 | 1.0% |
| Morocco | 0.23 | 0.21 | -9.6% |
| Oman | 0.23 | 0.23 | -2.5% |
| Palestine | 0.33 | 0.20 | -39.6% |
| Qatar | 0.37 | 0.34 | -7.9% |
| Saudi Arabia | 0.19 | 0.15 | -18.2% |
| Sudan | 0.21 | 0.25 | 18.7% |
| Syrian Arab Republic | 0.46 | 0.36 | -21.6% |
| Tunisia | 0.15 | 0.14 | -7.7% |
| Turkey | 0.67 | 0.40 | -40.2% |
| United Arab Emirates | 0.21 | 0.24 | 13.2% |
| Yemen | 0.28 | 0.33 | 18.8% |

**Supplementary Table 11** Trend analysis of IBD age-standardized mortality rate with gender and age variations from 1990-2019

| Mortality | Trends[a] | | | Sex/Age-specific AAPC difference (95%CI) | Pairwise comparison P-values | | |
|---|---|---|---|---|---|---|---|
| | Time period | APC (95%CI) | AAPC (95%CI) | | Sex/Age-specific AAPC difference | Coincidence[b] | Parallelism[c] |
| Sex | | | | | | | |
| Male | 1990-2000 | -1.2 (-1.4 to -1.1) | -1.1 (-1.3 to -0.8) | 0.4 | <0.001 | <0.001 | <0.001 |
| | 2000-2003 | 1.7 (-0.4 to 3.9) | | | | | |
| | 2005-2008 | -3.6 (-4.2 to -2.9) | | | | | |
| | 2008-2019 | -0.6 (-0.7 to -0.4) | | | | | |
| Female | 1990-2001 | -1.7 (-1.8 to -1.6) | -0.7 (-1.0 to -0.5) | | | | |
| | 2001-2005 | 0.0 (-0.8 to 0.9) | | | | | |
| | 2005-2008 | 3.5 (1.8 to 5.2) | | | | | |
| | 2008-2012 | -2.2 (-3.0 to -1.3) | | | | | |
| | 2012-2019 | -0.6 (-0.8 to -0.4) | | | | | |
| Age | | | | | | | |
| 15-54 years | 1990-1999 | -0.9 (-1.2 to -0.7) | -0.9 (-1.1 to -0.7) | 0.6 | <0.001 | <0.001 | <0.001 |
| | 1999-2006 | -2.8 (-3.2 to -2.4) | | | | | |
| | 2006-2019 | 0.1 (-0.1 to 0.3) | | | | | |
| 55+ years | 1990-2000 | -1.5 (-1.6 to -1.4) | -1.5 (-1.6 to -1.4) | | | | |

[a]Time-trends were computed using Joinpoint Regression Program (v5.0.2, NCI) with 5 maximum joinpoints allowed (6-line segments)
[b]Tests whether sex- and age-specific trends were identical. A significant P-value indicates that the trends were not identical (i.e., they had different mortality rates and coincidence was rejected)
[c]Tests whether sex- and age-specific trends were parallel. A significant P-value indicates that the trends were not parallel (i.e., parallelism was rejected)
*APC, annual percentage change; AAPC, average annual percentage change; CI, confidence interval*