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Epidemiological trends and burden of metabolic dysfunction-associated steatotic liver disease in the Middle East and North Africa region: a 32-year analysis of health impact

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Abstract

Background Metabolic dysfunction-associated steatotic liver disease (MASLD) is a condition marked by excess liver fat, ranging from simple steatosis to non-alcoholic steatohepatitis. Updated reports on the epidemiology of MASLD in the Middle East and North Africa (MENA) region are needed. This study aimed to report the trends in the MASLD burden in the MENA region from 1990 to 2021, as well as age and sex patterns and their association with the sociodemographic index (SDI).

Methods Data on the incidence, prevalence, disability-adjusted life years (DALYs), and mortality of MASLD in 21 countries within the MENA region from 1990 to 2021 were extracted from the GBD 2021 study. The relationship with the SDI and the burden attributable to risk factors, such as high fasting plasma glucose and smoking, were examined.

Results Between 1990 and 2021, the MENA region experienced a 13.8% increase in the age-standardized incidence rate, reaching 1,037.6 per 100,000 population. The age-standardized prevalence saw a rise of 26.4%. Women experienced a higher increase in incidence than men. The highest rates of DALYs were observed among older adults. Countries with a high SDI faced a greater disease burden. High fasting plasma glucose accounted for the largest burden of MASLD.

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Conclusions The study found that the incidence and prevalence of MASLD in the MENA region increased significantly from 1990 to 2021, especially in areas with high SDI. High fasting plasma glucose was the most significant attributable risk factor, highlighting the need for metabolic interventions.

Clinical trial number Not applicable.

Keywords Metabolic dysfunction-associated steatotic liver disease, MASLD, Disability-adjusted life years, Prevalence, Incidence, Middle East, Sociodemographic index, Global burden of disease

Introduction

Metabolic dysfunction-associated steatotic liver disease (MASLD), previously known as non-alcoholic fatty liver disease (NAFLD), is characterized by hepatic fat accumulation in over 5% of hepatocytes in the absence of excessive alcohol consumption [1, 2]. MASLD encompasses a spectrum of liver conditions, from simple steatosis to non-alcoholic steatohepatitis (NASH), which may progress to fibrosis, cirrhosis, and hepatocellular carcinoma [3, 4]. Due to its often-asymptomatic nature in early stages, MASLD is frequently underdiagnosed until advanced stages, increasing the risk of complications and limiting effective management [5, 6]. However, patients may experience non-specific symptoms such as fatigue, malaise, and abdominal discomfort, which, although not unique to MASLD, could serve as early indicators of the disease. Recognizing these non-specific symptoms is important for timely diagnosis and intervention [7]. MASLD is considered a multisystem disease with both hepatic and extra-hepatic manifestations. In addition to increasing the risk of liver-related outcomes such as fibrosis and hepatocellular carcinoma, MASLD is an independent predictor of cardiovascular diseases, which remain the leading cause of mortality among affected individuals [8, 9]. Its progression is largely driven by metabolic dysfunction, including obesity, insulin resistance, type 2 diabetes, and high fasting plasma glucose (HFPG) [2, 10–12]. Additionally, MASLD negatively impacts workforce productivity, resulting in illness, absenteeism, and early retirement. The rising treatment costs primarily pertain to the management of complications associated with MASLD, which encompasses NASH. As MASLD progresses, it often leads to advanced liver conditions such as cirrhosis, increasing the need for extensive medical care and interventions. These costs are not solely related to direct treatment of NASH, as there are currently no specific curative therapies approved for the condition. Instead, they reflect the financial burden of managing associated comorbidities, including diabetes and cardiovascular diseases, which are prevalent among MASLD patients. This necessitates ongoing treatment and monitoring, further escalating healthcare expenses. Additionally, the costs encompass necessary lifestyle interventions aimed at weight reduction and metabolic control, which require healthcare resources for dietary counseling and physical activity programs. Imaging studies, such as ultrasounds and MRIs, are often needed to assess liver health and track disease progression, contributing additional financial strain. Furthermore, frequent consultations with specialists, including hepatologists and endocrinologists, add to the overall economic burden borne by patients and healthcare systems alike. Thus, while the lack of specific treatments for NASH highlights a significant gap in therapy, the comprehensive management of its complications and related conditions continues to drive up treatment costs substantially [13]. MASLD is primarily driven by obesity, which contributes to insulin resistance and other metabolic dysfunctions such as type 2 diabetes and high fasting plasma glucose. These interconnected factors collectively drive disease progression [8, 9, 12, 14].

The global prevalence of NAFLD/MASLD across all age groups increased from 10.5% in 1990 to 16.0% in 2019, reflecting a steady upward trend over three decades. In 2019 alone, there were an estimated 1.2 billion prevalent cases and over 168,000 deaths globally, primarily due to complications such as cirrhosis and hepatocellular carcinoma [15–18]. Both prevalent cases and deaths were more common in males. Between 1990 and 2019, the incident cases of MASLD increased by 95.4% [16, 17, 19]. In 2019, Asia accounted for 57.2% of all-age MASLD cases and 46.2% of all-age MASLD-related liver mortality among global regions. The Middle East and North Africa (MENA) region had the highest crude MASLD prevalence rate, at 26.5%, and, like the global prevalence, it was more common in males.

High prevalence in the MENA region is influenced by a combination of genetic predisposition, poor dietary habits, sedentary lifestyles, and rising rates of obesity and type 2 diabetes [20–22]. Rapid urbanization and economic changes in the MENA region have increased the consumption of unhealthy, high-calorie foods while reducing physical activity. Socio-economic challenges, such as limited healthcare access and poor public health education, hinder effective diagnosis and treatment.

Current management strategies for MASLD, including NASH, primarily focus on addressing associated metabolic risk factors such as obesity, diabetes, and dyslipidemia while preventing the progression to advanced liver diseases, including cirrhosis and hepatocellular

carcinoma, due to the absence of specific approved pharmacologic therapies. Weight loss remains the cornerstone of effective management, with substantial evidence indicating that reductions in body weight can significantly improve liver histology. Consequently, lifestyle modifications, particularly dietary changes such as adopting a Mediterranean diet and the implementation of structured exercise programs are pivotal components of treatment. Moreover, the management of comorbid conditions is essential; pharmacological agents, including metformin and glucagon-like peptide-1 receptor agonists, have demonstrated efficacy in improving liver parameters and facilitating weight loss in individuals with MASLD, while statins may offer additional benefits beyond their lipid-lowering effects. Furthermore, emerging therapies targeting specific pathways, such as dual peroxisome proliferator-activated receptor agonists and antifibrotic agents, are currently under investigation in clinical trials for their potential to directly address liver inflammation and fibrosis. Despite these advancements, the comprehensive management of MASLD remains complex and resource-intensive, necessitating a multidisciplinary approach involving dietitians, endocrinologists, and hepatologists to optimize patient outcomes and effectively address this growing public health concern [2, 21, 23].

Despite increasing global attention, understanding of the MASLD burden in the MENA region would benefit from a more integrated approach that considers clinical characteristics, diagnostic challenges, and common comorbidities. The disease often remains underdiagnosed due to its asymptomatic nature and overlap with other metabolic disorders. Furthermore, comorbid conditions such as type 2 diabetes, obesity, and cardiovascular disease significantly influence both disease progression and the regional burden. Greater awareness and earlier detection strategies could improve epidemiological surveillance and public health response [8, 24]. Previous studies have primarily focused on global or continental trends and regional analyses have often lacked the timeliness and specificity that policymakers and health professionals require to make informed decisions. Therefore, this study aims to provide a comprehensive assessment of MASLD trends in the MENA region from 1990 to 2021, using data from the Global Burden of Disease (GBD) study. We focus on differences by age, sex, and sociodemographic index (SDI), and examine risk factor-attributable burdens, with the goal of informing targeted public health responses in the region.

Methods

Overview

The GBD study, performed by the Institute for Health Metrics and Evaluation, is designed to evaluate and quantify the levels and trends of health on an international scale. The GBD 2021 study assesses the impact of 371 diseases and injuries, along with 88 risk factors, across 204 countries and territories, which are categorized into 21 regions and seven super-regions. This study aimed to report the MASLD burden from 1990 to 2021, specifically for 21 nations within the MENA region. The MENA region is classified as one of the seven super-regions in the GBD system, including 21 countries. The countries that are part of this region are Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, the Syrian Arab Republic, Tunisia, Turkey, the United Arab Emirates, and Yemen. Further details are provided in previous papers [25, 26].

Case definition and data sources

MASLD encompasses a spectrum of liver conditions characterized by excessive fat accumulation within hepatic tissues. This condition can occur without cirrhosis, but it may also progress to cirrhosis, which is identified by the presence of liver scarring. The progression is frequently associated with chronic fat accumulation and inflammatory processes. Population-based studies reporting the prevalence of MASLD were analyzed, and systematic reviews were conducted as one of the data sources. Due to the invasive nature of liver biopsy (the gold standard for MASLD diagnosis), non-invasive methods like ultrasound or other imaging modalities were prioritized for population-based studies and screening programs.

Although liver biopsy is the gold standard for diagnosing MASLD, it is invasive, costly, and not feasible for population-based studies. Therefore, ultrasonography is widely employed as a first-line, non-invasive diagnostic tool in clinical and epidemiological settings. Ultrasound is favored due to its accessibility, safety, and cost-effectiveness; however, it has important limitations. These include reduced sensitivity for detecting mild steatosis, inter-operator variability, and limited accuracy in individuals with obesity or intestinal gas interference. Moreover, the diagnostic performance of ultrasound is lower compared to advanced imaging techniques such as MRI-PDFF or transient elastography (FibroScan) [1, 6]. In the MENA region, the availability and quality of ultrasound equipment vary widely, especially between high- and low-SDI countries. This disparity may result in underdiagnosis or misclassification of MASLD cases in regions with limited healthcare infrastructure and trained personnel. Consequently, prevalence estimates based on ultrasound should be interpreted in light of these limitations [8].

Since most MASLD cases are asymptomatic, studies with active case-finding methods were preferred, and the use of administrative hospital data or claims, which

significantly underestimate MASLD prevalence, was avoided. Since sex-specific estimates were required for the analysis, data presenting information for both sexes were separated into individual estimates for males and females. The data have also been analyzed based on the risk factors of sex, age, alcohol consumption, high fasting plasma glucose, and smoking [25]. In our analysis, we defined high alcohol use as consumption exceeding the theoretical minimum risk exposure level (TMREL). The TMREL represents the level of alcohol consumption associated with the lowest risk of all-cause mortality and is calculated specifically for each region, age group, sex, and year. This region-specific approach is essential for accounting for variations in risk associated with alcohol-related diseases across different populations. High alcohol use was quantified in terms of daily intake of pure alcohol (in grams) among current drinkers, following the definitions established by the 2021 criteria. To comprehensively assess alcohol consumption, we utilized three primary indicators to estimate exposure levels. The first indicator is the proportion of current drinkers, which reflects the percentage of individuals who reported consuming alcohol at least once in the past year. This variable was coded as binary (1 for current drinkers, 0 for non-drinkers) to facilitate clear categorization in the statistical analysis. The second indicator was the average daily grams of alcohol used by current drinkers. This measurement was derived from survey data, which recorded individual alcohol intake over the previous year as continuous values. Such a measure provides a reliable estimate of consumption patterns among current drinkers. The third indicator was the alcohol liters per capita stock, which represents the total annual liters of pure alcohol available per person in the population. This data was sourced from governmental and market statistics and serves as an important proxy for understanding overall alcohol availability and likely consumption levels in the population. To integrate these indicators into a single exposure metric, a weighted sum approach was used. Each indicator was standardized into comparable units for consistency, and weights were assigned based on their relative contributions to overall alcohol use patterns in the population. The weightings were determined through statistical analyses of data from previous studies that examined the relationship between these indicators and alcohol-related health outcomes in similar demographics. Furthermore, to address potential biases in our analysis, variables that account for tourism-related alcohol consumption were included. These variables encompassed the number of tourists visiting the region in the previous year, the total duration of their stay, and the estimated proportion of unrecorded alcohol produced outside regulated markets. By adopting this comprehensive approach, the aim was to ensure a nuanced interpretation of how alcohol use contributes to the risk of MASLD, thereby enhancing our understanding of its implications for public health [26].

Broad age-group data were converted into five-year age bins based on the estimated age distribution. Data with an age range exceeding 25 years were categorized as broad age-range data. The age distribution in the study sample was considered representative of the estimated population. The study assumed that the ratio of age-specific prevalence to overall prevalence followed the same pattern as in the GBD 2017 model [25].

Disease modeling and statistical analysis

In GBD 2021, the proportions of cirrhosis due to alcohol, hepatitis B, hepatitis C, NASH/MASLD, and other causes were modeled using DisMod-MR 2.1. Proportions from the five etiology models were then rescaled to sum to one (at the draw level) and used to split the total cirrhosis mortality estimates from CODEm. DisMod-MR 2.1 is a tool used to estimate non-fatal health outcomes for the GBD. It integrates diverse, high-quality data sources to improve estimates. The tool estimates global, regional, country, and subnational data. DisMod-MR 2.1 uses different likelihood functions (Gaussian, log-Gaussian, Laplace, and log-Laplace) to estimate non-fatal outcomes. The default is log-Gaussian, and it involves adjusting measurement data using random effects (super-region, region, and country levels) and covariates (e.g., sex, study-level data). These adjustments help refine the estimates, especially in data-sparse regions. The likelihood function is detailed mathematically and depends on the measurement data, random effects, and covariates. Additional information can be found in other sources [25].

The modeling approach for adjusting cryptogenic cirrhosis to NASH has not changed since GBD 2019. Epidemiological studies suggest that some cryptogenic cases may actually be unrecognized NASH cases. In GBD 2017, cryptogenic cases were categorized as "other causes" unless NASH was explicitly identified, and if NASH was not identified, cryptogenic cases were treated as NASH. In GBD 2019, the proportion of NASH cases (out of NASH and cryptogenic cases) was estimated using a Bayesian meta-regression model (MR-BRT). The approach remained largely the same for GBD 2021, with additional data sources included in the meta-regression, but the overall strategy is consistent with that of GBD 2019 [25].

The covariates used in the proportion of cirrhosis due to NASH in the DisMod-MR meta-regression model were: (1) Mean body mass index, (2) Prevalence of obesity, (3) MASLD/NASH prevalence, and (4) Proportion of liver cancer due to NASH (age-standardized) and reported with their 95% uncertainty intervals (UIs). After selecting a weighting scheme, 500 draws are made

for the final ensemble, with each model contributing proportionally to its weight. The mean of the draws is used as the final estimate for the CODEm process, and a 95% UI is created from the 0.025 and 0.975 quantiles. Years of life lost (YLLs) are calculated by multiplying estimated deaths by predicted life expectancy based on age, sex, location, and year. Years lived with disability (YLDs) measures the number of years individuals live with disability due to a disease or injury. To calculate YLDs, the cause-specific prevalence of sequelae by age, sex, location, and year was multiplied by the corresponding. Disability weights (DWs) were determined for each disease and injury. DW is a metric representing the health loss level associated with a particular outcome. These weights are rated on a scale from zero to one, where zero signifies full health, and one indicates a state that is equivalent to death. The total DALYs were calculated by summing the YLDs and YLLs. All estimates were standardized and included 95% UIs. The SDI is a composite measure of socio-economic development, which includes mean income per capita, average years of education for individuals aged 15 and above, and the total fertility rate for those under 25 years. The SDI is categorized into five quintiles in the following order: High, High-Middle, Middle, Low-Middle, and Low. One of the key elements of our analysis was the stratification of incidence, prevalence, DALYs, and mortality across various classifications of SDI. This stratification allowed us to assess the burden of MASLD in relation to the socio-economic contexts prevalent in different countries within the MENA region. By systematically analyzing data across these strata, we aimed to reveal inherent disparities in the burden of MASLD, thus contributing to a nuanced understanding of how socio-economic factors influence disease prevalence and public health policies. In our stratified analyses, we reported age-standardized incidence and prevalence rates of MASLD for each country and SDI classification. This approach ensured that our comparisons between countries were equitable and accurately reflected the true burden of the disease. The stratification provides critical insights into which demographics are disproportionately affected by MASLD and how these trends have evolved over the 32-year study period. Furthermore, the stratified analysis of DALYs and mortality associated with MASLD provided additional insights into the health burden attributable to this condition. By differentiating these metrics, the analysis illuminated how socio-economic disparities shape health outcomes. The analyses were performed using R software, version 4.2.1, Python (version 3.10.4), and Stata (version 13.1) [25, 26].

Results

Overall burden of MASLD in MENA

From 1990 to 2021, the age-standardized incidence rate of MASLD in the MENA region increased by 13.8% (95% UI: 11.4 to 16.4), rising from 849.0 to 1,037.6 per 100,000 population. The all-ages incidence nearly tripled, with a 178.8% increase (2,621,743.0 to 6,578,945.5 cases). Age-standardized prevalence increased by 26.4% (24.5 to 28.4), reaching 27,686.7 per 100,000 in 2021, while all-ages prevalence increased by 211.7% (52,713,319.9 to 164,312,588.8). DALYs and deaths also rose: age-standardized DALYs rates non-significantly increased by 9.3% (-12.8 to 35.4), and all-ages DALYs grew by 205.8% (90,349.4 to 276,311.2). Deaths increased by 199.3% (3,676.3 to 11,003.5 all-ages deaths), though age-standardized death rates remained almost stable (2.6 to 2.7 per 100,000) (Table 1; Fig. 1, Table S1, and Table S2).

MASLD burden at the national level

Among both sexes, Egypt and Kuwait had the greatest age-standardized incidence rates in both 1990 and 2021, while Yemen and Sudan had the lowest ones. Regarding age-standardized point prevalence, Kuwait and Sudan had the highest and lowest values in 1990 and 2021 in MENA. In addition, Egypt and Qatar had the largest age-standardized DALYs and death rates in 2021 in MENA, while Turkey and Yemen had the lowest values among both sexes (Table 2 and Table S1).

Sex and age disparities

Women experienced higher increases in age-standardized incidence rates (16.0%; 13.1 to 18.6) compared to men (11.7%; 9.3 to 14.3) between 1990 and 2021 in MENA. Conversely, age-standardized DALYs rates declined by 3.4% (-25.5 to 28.6) in women but rose by 27.7% (2.0 to 57.8) in men. By 2021, women had higher age-standardized DALYs (60.9 vs. 56.8 per 100,000) and death rates (2.9 vs. 2.5 per 100,000) than men (Table 1). The analysis showed that older adults, particularly those aged 95 and above, experienced the highest age-standardized DALYs and death rates in both 1990 and 2021. This pattern reflects the cumulative effects of MASLD over the life course and its progression to severe liver outcomes in advanced age. In addition, the 15–19 and 75–79 age groups had the largest incidence and prevalence rates in 2021 (Fig. 2 and Table S3).

Sociodemographic variations

Countries with higher SDI quintiles exhibited elevated age-standardized incidence, prevalence, DALYs, and death rates compared to low-SDI nations (Figs. 3 and 4). Qatar had the highest age-standardized DALYs and death rates among high-SDI countries in 2021. In low-SDI

Table 1 All-ages number and age-standardized rate of incidence, prevalence, disability-adjusted life years (DALYs), and deaths of metabolic dysfunction-associated steatotic liver disease by sex in 1990 and 2021 and overall percent change over 1990–2021 in the Middle East and North Africa region

Measure	Age, Metric	Year						% Change (1990 to 2021)		
		1990			2021					
		Both	Women	Men	Both	Women	Men	Both	Women	Men
Incidence	Age-standardized	849 (778 to 920.8)	795.4 (725.6 to 864.2)	900.3 (829.1 to 974.8)	1037.6 (963 to 1109.6)	983.5 (908.3 to 1056.3)	1087.8 (1012.3 to 1159.8)	13.8 (11.4 to 16.4)	16 (13.1 to 18.6)	11.7 (9.3 to 14.3)
	All ages	2,621,743 (2382526.8 to 2885697.7)	1169864.8 (1062743 to 1289537.5)	1451878.2 (1317315.9 to 1599143)	6578945.5 (6067957.2 to 7080113.3)	2976705.3 (2737048.1 to 3222917.8)	3602240.2 (3330569.5 to 3861512.1)	178.8 (171.4 to 187.3)	180.8 (172.4 to 189.1)	177.2 (168.8 to 186.8)
Prevalence	Age-standardized	21902.5 (20094.3 to 23849.8)	20603.4 (18867.5 to 22428.8)	23150.4 (21264.5 to 25139.7)	27686.7 (25586.9 to 29914.6)	26412.1 (24411.8 to 28642.5)	28864.8 (26746.8 to 31151.7)	26.4 (24.5 to 28.4)	28.2 (26 to 30.5)	24.7 (22.6 to 26.8)
	All ages	52713319.9 (48290123.1 to 57887147.5)	24040531.2 (22013562.9 to 26409903.3)	28672788.7 (26326649.9 to 31510700.4)	164312588.8 (151441884.9 to 179050647.8)	74983327.6 (69060590.9 to 81726199.4)	89329261.2 (82273240.3 to 97339035.8)	211.7 (203.9 to 219.4)	211.9 (203.9 to 219.4)	211.5 (203.2 to 219.7)
DALYs	Age-standardized	54 (37.5 to 78.2)	63.1 (41.7 to 94.1)	44.5 (31.3 to 63.6)	59 (43.6 to 79.8)	60.9 (43.9 to 83.2)	56.8 (41.6 to 76.8)	9.3 (-12.8 to 35.4)	-3.4 (-25.5 to 28.6)	27.7 (2 to 57.8)
	All ages	90349.4 (63408.9 to 124268.3)	50869.2 (34684.2 to 74191.3)	39480.2 (28279.7 to 55230.3)	276311.2 (205334.4 to 374125.7)	137997.4 (101123.5 to 189106.2)	138313.8 (100697 to 189087.8)	205.8 (144 to 277.2)	171.3 (110.3 to 257.4)	250.3 (179.9 to 328.8)
Deaths	Age-standardized	2.6 (1.7 to 4.1)	3.2 (2.1 to 5.1)	2 (1.4 to 3)	2.7 (1.9 to 3.7)	2.9 (2 to 4)	2.5 (1.8 to 3.4)	2 (-19.5 to 28.6)	-11.1 (-32.3 to 20.7)	24.7 (-1 to 54.2)
	All ages	3676.3 (2497 to 5486.9)	2191.5 (1434.1 to 3345)	1484.7 (1043.5 to 2136.2)	11003.5 (8016 to 14951.6)	5722.6 (4107.3 to 7892.3)	5280.9 (3868.4 to 7099.7)	199.3 (137.8 to 274.4)	161.1 (99.7 to 248.2)	255.7 (181.6 to 338.9)

countries, Afghanistan had the highest burden in 2021 (Table S4).

Risk factor contributions

We assessed the burden of MASLD attributable to relevant risk factors. In 2021, the 5.7 (1.7, 10.7) age-standardized DALYs rates and 0.3 (0.1, 0.5) age-standardized death rates were attributable to all risk factors among both sexes combined, which showed 157.3% and 158.1% increase since 1990, respectively. High fasting plasma glucose (HFPG) was the leading risk factor, contributing to 201.8% (106.0 to 336.7) and 194.3% (99.5 to 325.1) increases in age-standardized DALYs and deaths, respectively, from 1990 to 2021. Smoking-related age-standardized DALYs rates rose by 78.6% (21.5 to 139.7), disproportionately affecting men (86.6%; 23.1 to 151.8) (Table 3; Fig. 5). In both men and women, as well as in all MENA countries, HFPG was the risk factor with the greatest age-standardized DALYs and death in 1990 and 2021 (Figures S1, S2, and Table S5).

Discussion

In the current study, we examined the 32-year epidemiology and burden of MASLD and its socioeconomic associates in the MENA region from 1990 to 2021 by analyzing data from the GBD dataset. The findings showed a significant increase in age-standardized incidence and prevalence rates of MASLD during this period, while the increase in age-standardized mortality rates and DALYs was not statistically significant. This upward trend is consistent with the results of previous studies. For example, Younossi et al. reported that the global prevalence of MASLD has been increasing continuously since the 1990s, reaching 25.24% by 2016, and this increase was more pronounced in the MENA region due to metabolic factors [15]. Also, a systematic review showed that the prevalence of MASLD in the MENA region is significantly higher than the global average and has increased over time [8]. In the study by Golabi et al., the global prevalence of MASLD was estimated at around 38% in 2024, identifying the MENA region as one of the regions with the highest rates at 36.5% [27]. In addition, earlier studies predicted that MASLD prevalence in the

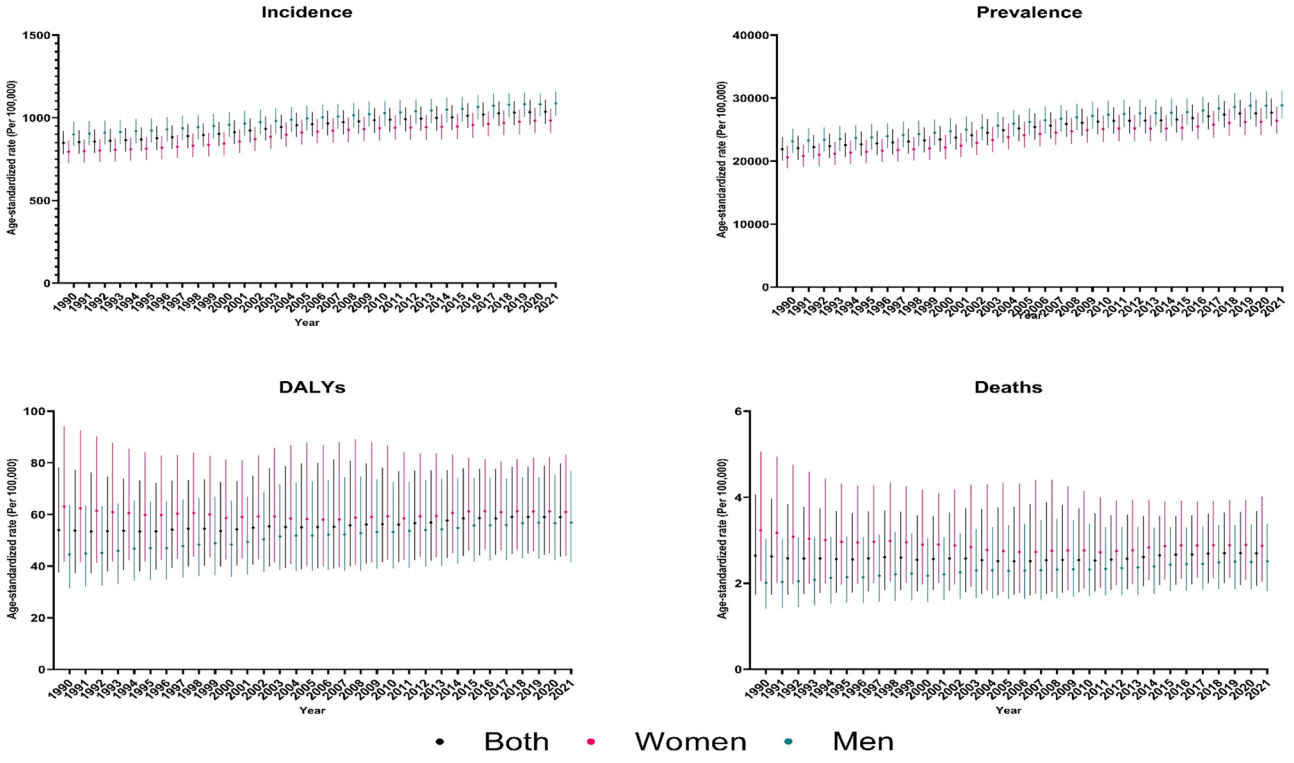

Fig. 1 Time trend of age-standardized rate of incidence, prevalence, disability-adjusted life years (DALYs), and deaths of metabolic dysfunction-associated steatotic liver disease in the Middle East and North Africa region from 1990 to 2021, by sex

MENA region would exceed 35% by 2030 [28]. However, more recent data confirm that this level has already been reached or surpassed in several MENA countries [8, 18].

Teng et al. found that there were 47 new cases of MASLD per 1000 people worldwide, with a higher incidence in men than women. Men were more likely to have MASLD (40%) than women (26%), contributing to an estimated overall prevalence of 32% among adults worldwide [29]. These findings indicate that the burden of MASLD was increasing in the MENA region, and this increase can be associated with changes in lifestyle and diet [30]. Beyond its increasing prevalence, MASLD is associated with significant adverse health outcomes. Recent studies have demonstrated that individuals with MASLD have a higher risk of developing hepatocellular carcinoma, even in the absence of cirrhosis. For instance, a study found that MASLD patients had a four-fold increased risk of hepatocellular carcinoma compared to those without MASLD [31]. Moreover, MASLD is recognized as an independent risk factor for cardiovascular diseases. A large-scale cohort study involving over five million participants revealed that individuals with MASLD had significantly higher risks of myocardial infarction, ischemic stroke, and congestive heart failure compared to those without steatosis [32]. These findings underscore the critical need for early detection and management of MASLD to prevent its progression to severe liver disease and to mitigate the associated cardiovascular risks.

Our results showed that the highest age-standardized DALYs rates in 2021 were observed in Egypt, Qatar, and Saudi Arabia, while Yemen, Turkey, and Kuwait had the lowest rates. This pattern is consistent with the 2019 GBD data, which indicated a high burden of chronic liver diseases (including MASLD) in Egypt and Saudi Arabia due to the high prevalence of obesity and diabetes [33]. Alenezi et al. reported that Saudi Arabia had one of the highest rates of MASLD in MENA because the obesity rate in Saudi Arabia was higher than the global average [34]. These geographic differences likely depend on socioeconomic factors, access to healthcare, and lifestyle patterns.

According to our findings, the highest incidence rates of MASLD were observed in adolescents and young adults (particularly those aged 15–39 years), while the highest age-standardized DALY and mortality rates were seen in older adults (aged 75 years and above), reflecting disease progression and complications in later life. This pattern is consistent with the study by Younossi et al., which showed that the incidence of MASLD is higher in younger age groups due to metabolic factors, but severe complications occur at older ages [8]. Another study reported that the incidence of MASLD is increasing in young adults (20–39 years), but mortality is mainly seen

Table 2 Ranking of the age-standardized rate of incidence, prevalence, disability-adjusted life years (DALYs), and deaths of metabolic dysfunction-associated steatotic liver disease in 1990 and 2021 in the Middle East and North Africa region

Measure	Location	Year					
		1990			2021		
		Both	Women	Men	Both	Women	Men
Incidence	Afghanistan	19	18	18	19	19	19
	Algeria	14	15	15	14	15	13
	Bahrain	5	4	7	7	6	9
	Egypt	1	2	1	1	3	1
	Iran (Islamic Republic of)	6	6	5	3	4	3
	Iraq	8	7	9	13	14	12
	Jordan	9	8	10	8	7	8
	Kuwait	2	1	2	2	1	2
	Lebanon	13	12	13	12	12	14
	Libya	4	5	4	6	8	6
	Morocco	16	14	17	15	13	16
	Oman	15	16	16	10	10	10
	Palestine	12	13	12	16	16	15
	Qatar	3	3	3	4	2	4
	Saudi Arabia	10	10	11	5	5	5
	Sudan	21	21	21	21	21	21
	Syrian Arab Republic	11	11	8	11	11	11
	Tunisia	18	17	19	17	17	18
	Turkey	17	19	14	18	18	17
	United Arab Emirates	7	9	6	9	9	7
	Yemen	20	20	20	20	20	20
Prevalence	Afghanistan	19	19	19	19	19	19
	Algeria	15	15	15	13	13	13
	Bahrain	5	4	7	6	5	8
	Egypt	2	3	2	2	4	1
	Iran (Islamic Republic of)	7	7	6	4	3	3
	Iraq	12	10	11	15	16	16
	Jordan	6	6	5	7	7	7
	Kuwait	1	1	1	1	1	2
	Lebanon	11	8	13	11	11	12
	Libya	4	5	3	9	10	6
	Morocco	18	16	18	16	15	18
	Oman	17	17	17	10	9	11
	Palestine	10	9	10	14	14	14
	Qatar	3	2	4	3	2	4
	Saudi Arabia	13	13	12	5	6	5
	Sudan	21	21	21	21	21	21
	Syrian Arab Republic	9	12	8	12	12	10
	Tunisia	16	14	16	17	17	17
	Turkey	14	18	14	18	18	15
	United Arab Emirates	8	11	9	8	8	9
	Yemen	20	20	20	20	20	20

Table 2 (continued)

Measure	Location	Year					
		1990			2021		
		Both	Women	Men	Both	Women	Men
DALYs	Afghanistan	6	6	10	7	7	16
	Algeria	19	19	20	16	15	18
	Bahrain	4	5	3	5	6	4
	Egypt	1	1	1	1	1	1
	Iran (Islamic Republic of)	9	10	6	10	10	8
	Iraq	11	12	9	11	12	10
	Jordan	12	11	18	18	17	19
	Kuwait	16	16	12	19	20	14
	Lebanon	13	15	13	17	18	15
	Libya	7	7	8	6	5	6
	Morocco	21	20	21	15	16	17
	Oman	14	13	14	8	9	7
	Palestine	8	8	7	14	13	13
	Qatar	2	2	2	2	3	2
	Saudi Arabia	3	3	4	3	4	3
	Sudan	15	14	15	12	11	12
	Syrian Arab Republic	10	9	11	9	8	9
	Tunisia	18	17	17	13	14	11
	Turkey	20	21	19	20	21	20
	United Arab Emirates	5	4	5	4	2	5
	Yemen	17	18	16	21	19	21
Deaths	Afghanistan	6	6	10	10	7	18
	Algeria	19	19	20	15	13	17
	Bahrain	3	4	3	5	5	4
	Egypt	1	1	1	1	1	1
	Iran (Islamic Republic of)	9	10	7	9	9	8
	Iraq	12	13	11	12	14	10
	Jordan	13	11	18	19	16	19
	Kuwait	16	18	13	18	19	14
	Lebanon	11	12	12	17	18	15
	Libya	8	7	8	6	6	6
	Morocco	20	20	21	16	17	16
	Oman	14	15	14	8	10	7
	Palestine	7	8	6	11	12	12
	Qatar	2	2	2	2	3	2
	Saudi Arabia	4	3	4	3	4	3
	Sudan	15	14	16	14	11	13
	Syrian Arab Republic	10	9	9	7	8	9
	Tunisia	17	16	15	13	15	11
	Turkey	21	21	19	20	21	20
	United Arab Emirates	5	5	5	4	2	5
	Yemen	18	17	17	21	20	21

in people over 60 years of age [35]. Huang et al. also confirmed that severe complications of MASLD are more common in older ages [36]. This age difference may be related to the time the disease progresses from early stages to advanced complications.

In terms of sex, our study showed that incidence and prevalence rates of MASLD were higher in men, but age-standardized DALYs and death rates were higher in women. This finding is consistent with the study by Lonardo et al., who showed that men are more susceptible to MASLD due to metabolic factors. Although MASLD prevalence is generally higher in men, postmenopausal women experience more severe complications due to the loss of protective effects of estrogen on hepatic fat metabolism. Estrogen has been shown to play a protective role in reducing insulin resistance and

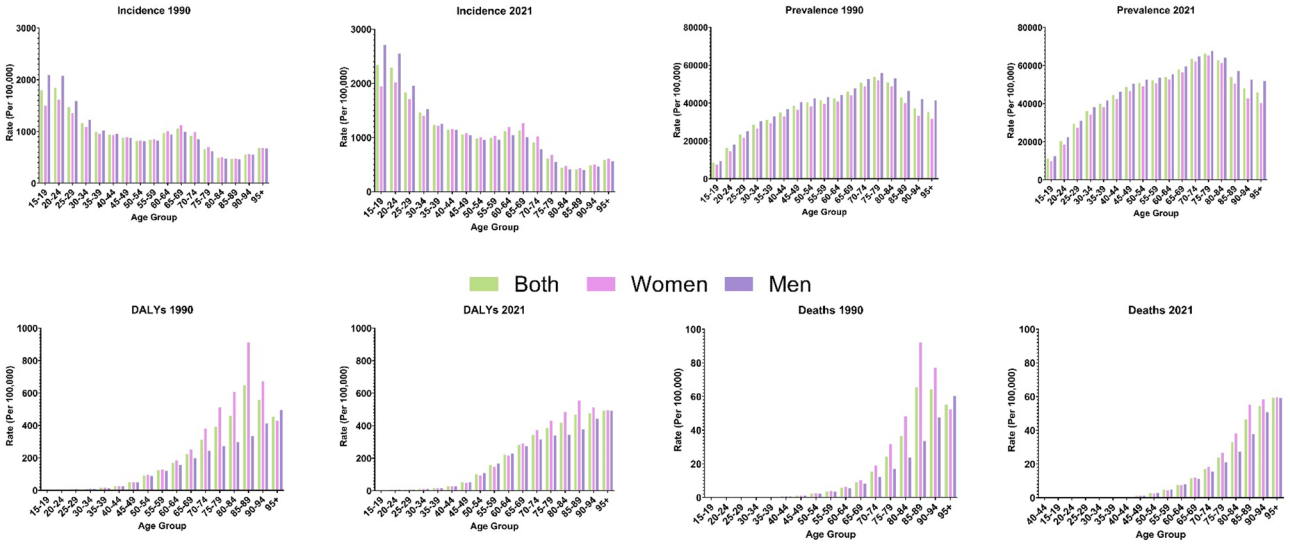

Fig. 2 Rate of incidence, prevalence, disability-adjusted life years (DALYs), and deaths of metabolic dysfunction-associated steatotic liver disease in the Middle East and North Africa region in 1990 and 2021, by sex and age

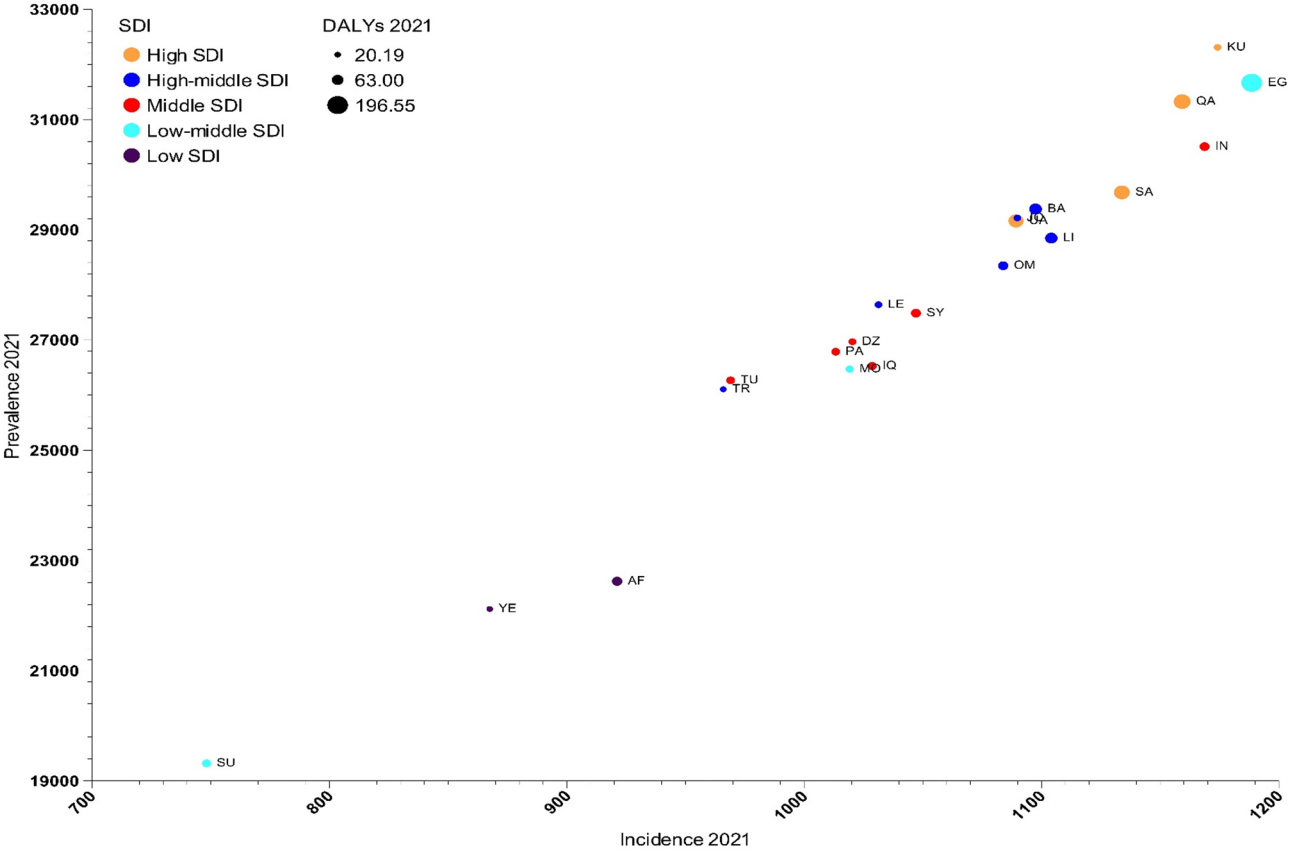

Fig. 3 Age-standardized incidence rate, prevalence, and disability-adjusted life years (DALYs) of metabolic dysfunction-associated steatotic liver disease in the Middle East and North Africa countries in 2021, by sociodemographic index (SDI) quintiles among both sexes

hepatic steatosis. After menopause, reduced estrogen levels contribute to increased visceral adiposity, dyslipidemia, and insulin resistance, all of which exacerbate MASLD progression to more severe outcomes such as NASH, fibrosis, and cirrhosis [37, 38]. It was also shown that liver disease-related mortality is higher in women at older ages, while the prevalence is dominant in men [39]. Moreover, women progress to cirrhosis more rapidly

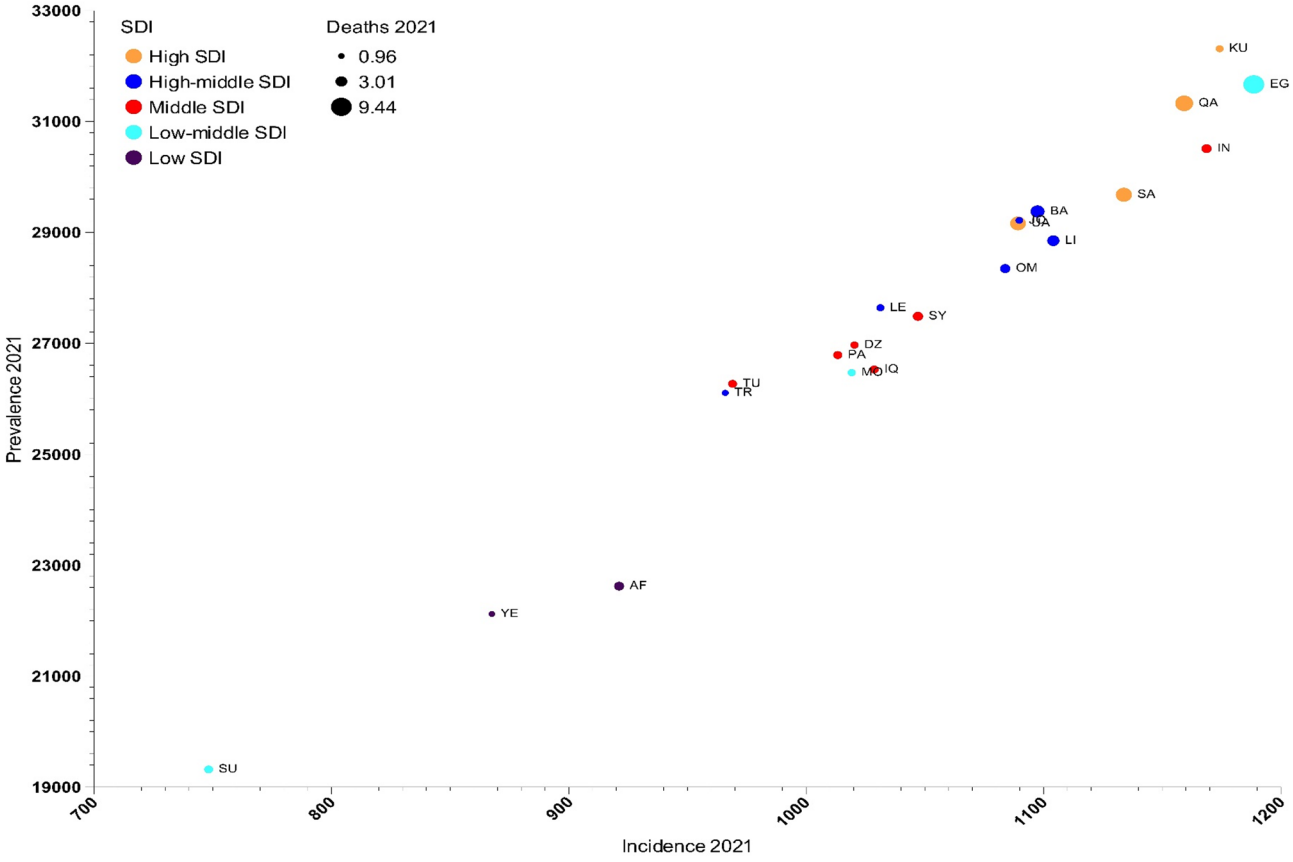

Fig. 4 Age-standardized rate of incidence, prevalence, and deaths of metabolic dysfunction-associated steatotic liver disease in the countries of the Middle East and North Africa in 2021, by sociodemographic index (SDI) quintiles among both sexes

after developing MASLD, which increases the burden of DALYs and mortality [38].

There was a higher burden of MASLD in areas with better SDI. This result is consistent with the study by Chen et al., which showed that increasing monthly income without improving education level and health awareness increased the risk of MASLD [40]. In regions with higher economic development, MASLD's economic and clinical burden was heavier due to the high prevalence of metabolic risk factors [15]. It was also confirmed that in countries with higher SDI, the burden of non-communicable diseases is higher due to increased metabolic risk factors such as obesity and diabetes. In comparison, in regions with lower SDI, communicable diseases predominate [41].

This study showed that HFPG was the risk factor for MASLD with the highest attributable burden. This finding is consistent with the cohort study by Zou et al., which showed that HFPG was independently associated with an increased risk of MASLD [42]. In addition, type 2 diabetes and HFPG are among the strongest risk factors for MASLD and its progression to NASH [43]. It was also shown that HFPG is one of the most important attributable risk factors for the burden of metabolic diseases, including MASLD, globally and has a greater impact in regions with a high prevalence of diabetes [41].

The substantial rise in the age-standardized incidence and prevalence rates of MASLD in the MENA region over the past three decades highlights the need for targeted public health initiatives. Countries in the MENA region can prioritize screening programs for high-risk populations, particularly young adults and older individuals, to mitigate the growing epidemic. Our findings indicate that Egypt and Qatar exhibit the highest incidence and DALY rates. This suggests a need for tailored interventions in these nations, focusing on enhancing healthcare infrastructure, improving access to preventive services, and addressing prevalent risk factors such as HFPG and obesity. The integration of MASLD screening into primary care settings can be assessed in countries with high burden or in specific populations. By training primary care providers to recognize and screen for MASLD, we can facilitate timely intervention and reduce the disease's progression. Moreover, there are notable disparities in the burden of MASLD based on sex and age, necessitating sex-sensitive and age-specific public health strategies. Educational campaigns aimed at postmenopausal women are essential, as this group

Table 3 All-ages number and age-standardized rate of disability-adjusted life years (DALYs) and deaths of metabolic dysfunction-associated steatotic liver disease attributable to risk factors by sex in 1990 and 2021 and overall percent change over 1990–2021 in the Middle East and North Africa region

Risk Factor	Measure	Age, Metric	Year						% Change (1990 to 2021)		
			1990			2021					
			Both	Women	Men	Both	Women	Men	Both	Women	Men
All risk factors	DALYs	Age-standardized	2.2 (0.8 to 4.3)	1.9 (0.3 to 4.4)	2.5 (1 to 4.5)	5.7 (1.7 to 10.7)	4.6 (0.7 to 9.1)	6.7 (2.5 to 12.3)	157.3 (66.2 to 255.7)	146.7 (47.8 to 286.9)	165.4 (63.6 to 266)
		All ages	3735.1 (1303.8 to 7352.2)	1509.4 (259.5 to 3576.7)	2225.7 (892.1 to 3958.7)	26169.7 (8180.9 to 49215.2)	10284.7 (1585.8 to 20366.8)	15885.1 (6076.4 to 28584.3)	600.6 (349.6 to 870.3)	581.4 (319 to 957.8)	613.7 (337.3 to 909.6)
	Deaths	Age-standardized	0.1 (0 to 0.2)	0.1 (0 to 0.2)	0.1 (0 to 0.2)	0.3 (0.1 to 0.5)	0.2 (0 to 0.4)	0.3 (0.1 to 0.5)	158.1 (65.8 to 255.7)	143.4 (47.7 to 283.1)	170.4 (66.1 to 266.3)
		All ages	150.8 (52.2 to 290)	64.4 (9.8 to 155.3)	86.4 (34.1 to 154.2)	1073.5 (304.4 to 2036.3)	439.4 (65.4 to 865.8)	634.1 (240.3 to 1162.9)	611.9 (359.5 to 879.9)	582.3 (306.2 to 970)	634 (349.7 to 911.9)
Alcohol use	DALYs	Age-standardized	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	NA	NA	NA
		All ages	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	NA	NA	NA
	Deaths	Age-standardized	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	NA	NA	NA
		All ages	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	NA	NA	NA
High fasting plasma glucose	DALYs	Age-standardized	1.6 (0.1 to 3.6)	1.7 (0.2 to 4.3)	1.4 (0.1 to 3.2)	4.7 (0.6 to 9.8)	4.5 (0.5 to 9)	5 (0.6 to 10.6)	201.8 (106 to 336.7)	159.2 (62 to 316.7)	253.7 (139.6 to 378.2)
		All ages	2549 (250.1 to 5994.8)	1379.9 (126.4 to 3402.6)	1169.1 (123.5 to 2626)	21317.4 (2588.6 to 44296.5)	9946.9 (1196.1 to 20103.5)	11370.4 (1337.6 to 24014.6)	736.3 (473.7 to 1098.8)	620.8 (357 to 1035)	872.6 (568.9 to 1226.8)
	Deaths	Age-standardized	0.1 (0 to 0.2)	0.1 (0 to 0.2)	0.1 (0 to 0.1)	0.2 (0 to 0.5)	0.2 (0 to 0.4)	0.2 (0 to 0.5)	194.3 (99.5 to 325.1)	153.2 (57.9 to 312.7)	246.2 (134.1 to 362.8)
		All ages	109.2 (10.2 to 248.5)	59.9 (5.1 to 149.8)	49.4 (5.1 to 112.7)	903.4 (107.2 to 1842.4)	427.4 (50.8 to 853.8)	476.1 (54.6 to 1021.1)	727 (461.6 to 1091.7)	613.8 (344.6 to 1053)	864.4 (556.9 to 1203.7)
Smoking	DALYs	Age-standardized	0.8 (0.2 to 1.5)	0.2 (0 to 0.4)	1.3 (0.4 to 2.6)	1.4 (0.4 to 2.5)	0.2 (0.1 to 0.4)	2.5 (0.7 to 4.6)	78.6 (21.5 to 139.7)	14.3 (-21.1 to 63.5)	86.6 (23.1 to 151.8)
		All ages	1374 (398.6 to 2709.3)	152.2 (37.5 to 316.8)	1221.8 (357.7 to 2398.3)	6664.9 (1979.7 to 12540.2)	469 (124.4 to 909.9)	6195.9 (1840.7 to 11689.4)	385.1 (229.3 to 555.3)	208 (114.1 to 337.6)	407.1 (236.5 to 592.1)
	Deaths	Age-standardized	0 (0 to 0.1)	0 (0 to 0)	0.1 (0 to 0.1)	0.1 (0 to 0.1)	0 (0 to 0)	0.1 (0 to 0.2)	80.9 (21 to 140.9)	18.1 (-20.6 to 70.6)	88.8 (24.1 to 152.2)
		All ages	49.2 (14.6 to 98.6)	5.5 (1.4 to 11.8)	43.7 (13 to 86.5)	242.7 (73.5 to 454.8)	17.5 (4.7 to 33.8)	225.2 (68.3 to 420.9)	393.3 (233 to 559.3)	220.3 (120.6 to 356.9)	415 (241.5 to 593.7)

experiences more severe health outcomes. Additionally, public awareness campaigns should be developed and adapted to local sociocultural contexts to effectively convey the risks associated with MASLD and promote lifestyle changes. Tailoring these campaigns to resonate with community values and practices will enhance their effectiveness and foster greater engagement. The rising burden of MASLD in higher socioeconomic development countries reveals a perplexing narrative where economic growth may inadvertently increase non-communicable diseases due to lifestyle changes. Policymakers must ensure that improvements in education and preventive health services accompany economic progress to address health equity and reduce the impact of MASLD effectively. Given the significant contribution of HFPG, public health policies should integrate diabetes prevention and management strategies. This holistic approach can effectively tackle the rising incidence of MASLD. Finally, improvements in health reporting systems and the collection of granular data on MASLD and its risk factors are critical for assessing the effectiveness of public health initiatives and refining intervention strategies.

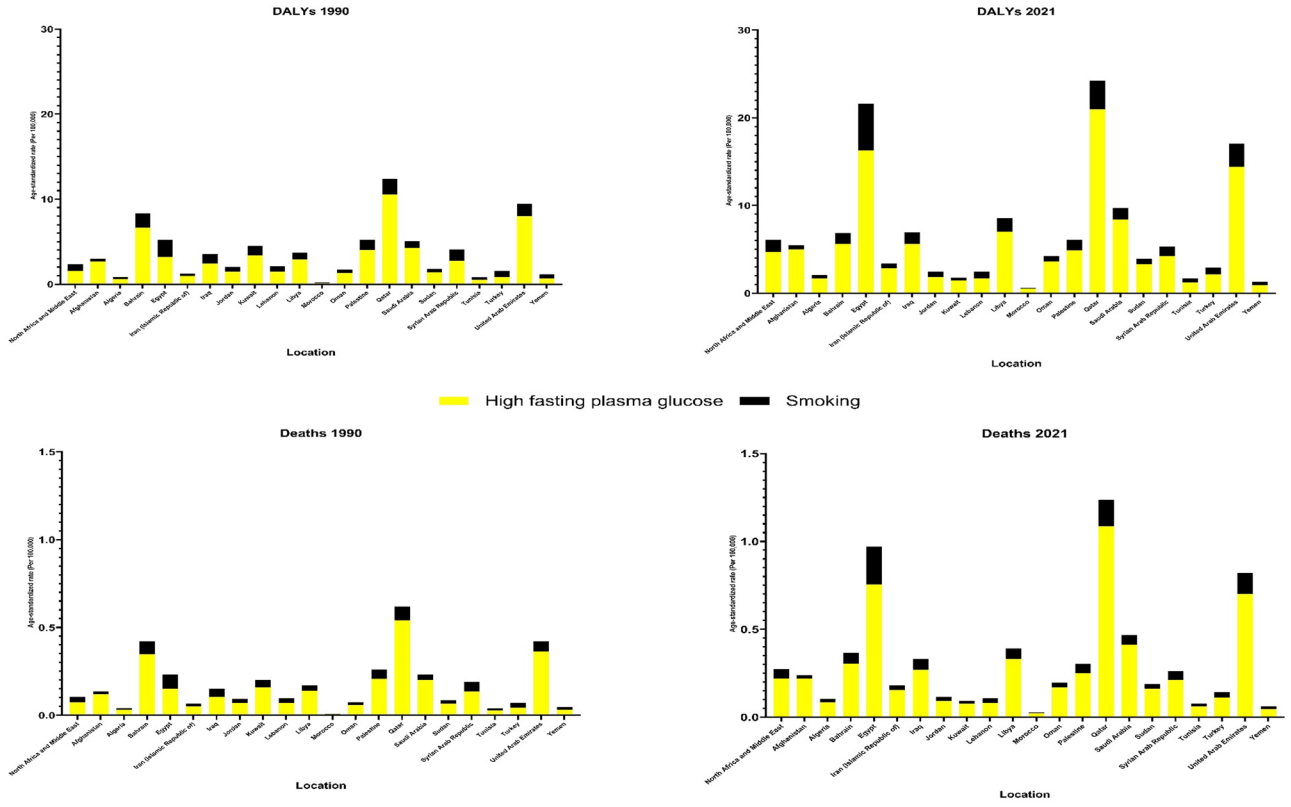

Fig. 5 Age-standardized rate of disability-adjusted life years (DALYs) and deaths of metabolic dysfunction-associated steatotic liver disease attributable to risk factors among both sexes in 1990 and 2021 in the Middle East and North Africa region

A main limitation of the GBD dataset is the dispersion of data across some countries. This issue, particularly in low-resource settings or areas with incomplete health reporting systems, may compromise the accuracy of incidence, prevalence, DALYs, and death estimates. Another limitation is the lack of detailed temporal analysis of specific risk factors at the regional level, as GBD data primarily provide aggregate estimates rather than precise local insights. Moreover, due to the observational nature of this study, it cannot establish causality between socioeconomic factors (e.g., SDI) or HFPG and MASLD burden. These limitations should be considered when interpreting the results and planning future research. Finally, while obesity is widely recognized as the principal risk factor for MASLD, our study focuses on elucidating the burden of MASLD through the analysis of other significant metabolic risk factors. It is essential to note that the GBD dataset does not include data on obesity as a risk factor for MASLD, thereby limiting our ability to address its relationship with MASLD in this analysis directly. Instead, we highlighted other critical contributors to the MASLD burden, notably HFPG and smoking, both of which have been implicated as significant risk factors in contemporary research. By shedding light on these factors, we aim to provide a broader understanding of MASLD etiology, particularly in regions where obesity data may not fully capture the complexity of the disease landscape. Subsequent research should consider integrating obesity metrics to explore the intricate interplay between these risk factors and their cumulative impact on the progression of MASLD.

Conclusion

From 1990 to 2021, the age-standardized incidence and prevalence rates have increased significantly, while the increase in age-standardized death and DALYs rates was not statistically significant. This upward trend was mainly attributed to HFPG, which is the main attributable factor. The highest DALY rates in 2021 were observed in Egypt and Qatar and the lowest in Yemen and Turkey, indicating the influence of SDI on MASLD burden. These findings emphasize the need for interventions focused on preventing and controlling metabolic factors, especially in areas with high SDI, and increased public awareness to reduce the growing burden of MASLD in the MENA region.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s41043-025-00973-5.

Supplementary Material 1

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Author contributions
OE, HP, HS, and SAN designed the study. MMB analyzed the data and performed statistical analyses. ZS, MMB, MAKG, MI, FA, FB, AA, RK, HP, AK, HS, OE, and SAN drafted the initial manuscript. ZS, MMB, MAKG, MI, FA, FB, AA, RK, HP, AK, HS, OE, and SAN critically edited and revised the initial draft. OE, HP, HS, and SAN supervised the project. All authors reviewed the drafted manuscript for critical content and approved the final version.

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Data availability
The data used for these analyses are all publicly available at https://vizhub.healthdata.org/gbd-results/.

Declarations

Ethics approval
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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