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Temporal trends in lower extremity amputation in Middle East and North Africa (MENA) region: analysis of the GBD dataset 1990–2019

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Abstract

Background Lower extremity amputations (LEAs) significantly contribute to mortality and morbidity, often resulting from peripheral artery disease and diabetes mellitus (DM). Traumatic injuries also account for many LEAs. Despite the global burden, the epidemiology of LEAs, particularly in the Middle East and North Africa (MENA) region, remains underexplored. This study utilizes the Global Burden of Disease (GBD) dataset to analyze temporal trends in LEAs in the MENA region from 1990 to 2019.

Methods The study utilized the 2019 GBD dataset, which includes estimates for incidence, prevalence, and disability-adjusted life-years (DALYs) across 369 diseases. Age-standardized incidence rates (ASIRs) for LEAs were extracted for 21 MENA countries. Trends were analyzed using percentage change calculations and Joinpoint regression to identify significant shifts in LEA rates over time.

Results From 1990 to 2019, male LEA rates generally decreased, while female rates increased. Significant increases in LEA rates were observed in Syria, Yemen, and Afghanistan, correlating with periods of conflict and instability. Conversely, countries like Iraq, Palestine, Sudan, Lebanon, Iran, and Kuwait saw marked decreases. The study highlighted a complex interplay of socio-political factors, natural disasters, and chronic diseases like DM in shaping LEA trends across the region.

Conclusion The study reveals variable LEA trends in the MENA region, influenced by conflicts, natural disasters, and chronic diseases. These findings underscore the need for targeted public health interventions, improved healthcare access, and robust data collection systems to reduce the burden of LEAs and improve patient outcomes in the MENA region.

Keywords Lower extremity amputation, MENA region, Global burden of disease, Temporal trends, Healthcare disparities

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Introduction

Lower extremity amputations (LEAs) represent a significant contributor to both mortality and morbidity [1, 2]. These surgical procedures are primarily performed to address critical conditions such as ischemic, infected, necrotic tissue, or locally unresectable tumors, and in certain cases, they play a life-saving role. The predominant cause of LEAs is peripheral artery disease, either as a standalone ailment or in conjunction with diabetes mellitus (DM) [3, 4]. This debilitating vascular condition accounts for more than half of all LEAs [5, 6]. Traumatic injury, the second leading cause, often resulting from unforeseen accidents, forms a substantial subset within this spectrum [3, 4, 7].

Globally, the epidemiology of LEA continues to be understudied. To date, limited research in literature has shown mixed results. Reports on national trends of LEA in the United States of America (USA) suggest that among Medicare enrollees, incidence rates of LEA may have declined in the first decade of the 21st century [8]. While global perspectives on LEAs provide a broad understanding, regional disparities, particularly in the Middle East and North Africa (MENA) region, remain underexplored. This region, characterized by its unique socioeconomic, cultural, and healthcare dynamics, exhibits distinct patterns in the incidence and causes of LEAs. For instance, Salman [9] demonstrated that the age-adjusted rates for Jordanian males and females were the second highest after the United States for both major and minor LEAs. This indicates not only a significant health burden but also suggests underlying disparities in healthcare access and quality across the region. Further emphasizing the gravity of the situation, Bandarian et al. reported that the estimated rate of foot amputation among diabetes patients and those with diabetic foot ulcers (DFUs) in the Middle East is alarmingly high [10]. This prevalence may be indicative of several systemic issues, including low quality of preventive foot care, socioeconomic challenges, and a general lack of patient awareness or education in countries with elevated amputation rates.

Despite these alarming indicators, comprehensive analysis of temporal trends in lower extremity amputation across the MENA region remains sparse. The Global Burden of Disease (GBD) dataset offers a comprehensive overview from 1990 to 2019, shedding light on these trends and helping to identify key factors contributing to changes over time. Surprisingly, while the GBD dataset has been instrumental in understanding various health outcomes globally, its application to study the specific dynamics of LEAs in the MENA region has not been extensively pursued. This oversight is particularly critical given the region's complex socio-political landscape, marked by periods of political turmoil, conflict, and wars [11–13], which significantly influence health outcomes, including amputations. The ongoing conflicts and instability make it even more imperative to understand how these factors correlate with the rates and causes of LEAs, informing healthcare planning and resource allocation in these challenging contexts.

Consequently, this study aims to be the first to harness the extensive data of the GBD from 1990 to 2019 to analyze the temporal trends of lower extremity amputations in the MENA region. By doing so, we seek to fill a significant void in the current understanding of how socio-political dynamics, healthcare access, and disease prevalence have shaped the incidence trends of LEAs over nearly three decades. Our analysis will provide valuable insights into the effectiveness of existing health policies and the need for targeted interventions. The findings are expected to guide policymakers, healthcare providers, and researchers in developing strategies to reduce the incidence of LEAs, improve patient outcomes, and address the underlying disparities in healthcare access and quality across the MENA region.

Methods

Data source

Data Source The present study utilized the 2019 edition of the GBD dataset [23]. The GBD dataset is a comprehensive resource providing estimates across a range of crucial health measures, encompassing variables such as mortality rates, incidence, prevalence, years of life lost (YLLs), years lived with disability (YLDs), and disability-adjusted life-years (DALYs). These estimations cover a spectrum of 369 diseases and injuries while considering 87 distinct risk factors. Furthermore, GBD data is stratified by gender, and it encompasses information from 204 countries and territories, enabling extensive cross-national comparisons [8, 24]. Of significance, the GBD dataset is updated on an annual basis, thus facilitating comprehensive assessments of temporal trends spanning from 1990 to 2019 for all the aforementioned health metrics.

The GBD study aggregates data from various sources including vital registration systems, censuses, sample registration systems, surveys, healthcare facilities, and death certificates. This data undergoes processing, adjustment for relevant covariates, and is modeled using standardized methodologies such as the Cause of Death Ensemble model (CODEm), spatiotemporal Gaussian process regression (ST-GPR), and DisMod-MR. The GBD Compare website facilitates the downloading and interactive exploration of the study's results.

To tackle missing data, the GBD study team employs different strategies based on the nature of the missing information. When data is presumed to be missing at random, multiple imputation techniques are applied. For data not missing at random, methods like inverse probability weighting are used. The team places a high priority on data quality and consistency, and their methods are meticulously documented to ensure transparency in how missing data is managed during the analysis [14, 15].

Comprehensive explanations of the processing and modeling approaches employed are available in the existing literature [16–25].

Data handling

Age standardized incidence rates per 100 000 population (ASIRs) were extracted from the GBD Results Tool for each of the years 1990–2019 inclusive for each of the 21 countries within the MENA region, per sex. The GBD data were analysed for LEAs, which were further stratified into toe amputation and LEA proximal to toes (unilateral and bilateral combined).

We used the GBD dataset categorization of MENA countries, which included 21 countries listed as follows: Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, Yemen.

Statistical analysis

To analyze LEA trends, two methodologies were employed. Initially, the gross percentage change was computed for the period from 1990 to 2019. Additionally, Joinpoint regression analysis, facilitated by the Surveillance Research Program of the United States National Cancer Institute, was utilized. This analysis method uses a logarithmic scale to link different line segments into the simplest model. It begins with no Joinpoints (indicating a straight line) and tests the statistical significance of adding more Joinpoints using the Monte Carlo permutation method. If significant, these Joinpoints are incorporated into the model. The software also calculates estimated annual percent changes (EAPC) for each segment, along with 95% confidence intervals. EAPCs help determine if there's a deviation from the hypothesis of no change. Thus, in the final model, each Joinpoint signifies a statistically significant shift in the trend (either upward or downward), and each segment's trend is characterized by its EAPC and corresponding confidence levels. This approach allows for the assessment of trend changes at a consistent percentage rate per year.

Results

1990–2019 lower extremity amputation incidence

Figure 1 demonstrates LEA ASIR per 100,000 population per country in 2019 (Fig. 1a and b) and 1990 (Fig. 1c and d) for male and female patients. In 1990, Syria had the lowest incidence of LEA proximal to toes in male and female patients (9.6 and 8.2 per 100,000, respectively). In 2019, Sudan had the lowest incidence of LEA proximal to toes in both male and female patients (6.2 per 100,000 for male and 4.9 per 100,000 for female patients). In 1990, the highest incidence of LEA proximal to toes in females was observed in Iran (39.5 per 100 000), and for males, it was observed in Kuwait (60.6 per 100 000). The highest incidences in 2019 were seen in Afghanistan for both sexes (61.4 per 100,000 for male patients and 52.4 per 100,000 for female patients).

In 1990, the lowest incidences of toe amputation among box sexes were observed in Egypt (21.5 per 100 000 for male patients and 14.6 per 100 000 for female patients). In 2019, the lowest incidences of toe amputation among box sexes were observed in Jordan (26.5 per 100 000 for male patients and 16.3 per 100 000 for female patients). In 1990, Kuwait had the largest toe amputations for males and females (388.9 and 188.5 per 100,000, respectively). In 2019, Afghanistan saw the highest toe amputation ASIRs among both sexes (294.8 per 100,000 for male patients and 268.9 per 100,000 for female patients).

The distribution of total incidence for LEA and toe amputation is represented geographically for both sexes for 1990 and 2019 (Fig. 2).

Trends in lower extremity amputation incidence

Supplementary Table 1 shows the calculated percentage change between 1990 and 2019 in ASIR incidence, per country by sex. Overall, the trend shows that there has been a decrease of **6.7%** in male LEA, **16.6%** in male toe amputation, and an increase of **12.7%** in female LEA and **13.0%** in female toe amputation.

Concerning LEA, Syria shows the highest increase in males and females, with a gross percentage change of 330.0% and 377.8%, respectively. Yemen and Afghanistan also show significant increases, with 263.5% and 172.9% in males and 184.9% and 340.3% in females, respectively. Countries like Libya, Saudi Arabia, Egypt, Turkey, and Tunisia show moderate male and female increases. Morocco shows a negligible change in males, with a gross percentage change of 0.3%, but a significant increase in females, with 17.7%. Bahrain, Oman, Emirates, Jordan, Qatar, and Algeria show decreases in males but increases or minor decreases in females. Iraq, Palestine, Sudan, Lebanon, Iran, and Kuwait show significant decreases in males and females.

Regarding toe amputation, Yemen shows the highest increase in males and females, with a gross percentage change of 792.9% and 845.8%, respectively. Syria and Libya also show significant increases, with 518.2% and 234.8% in males and 649.6% and 252.7% in females, respectively.

Countries like Afghanistan, Egypt, and Saudi Arabia show moderate increases in incidence rates among males and females. Bahrain, Jordan, and Morocco show

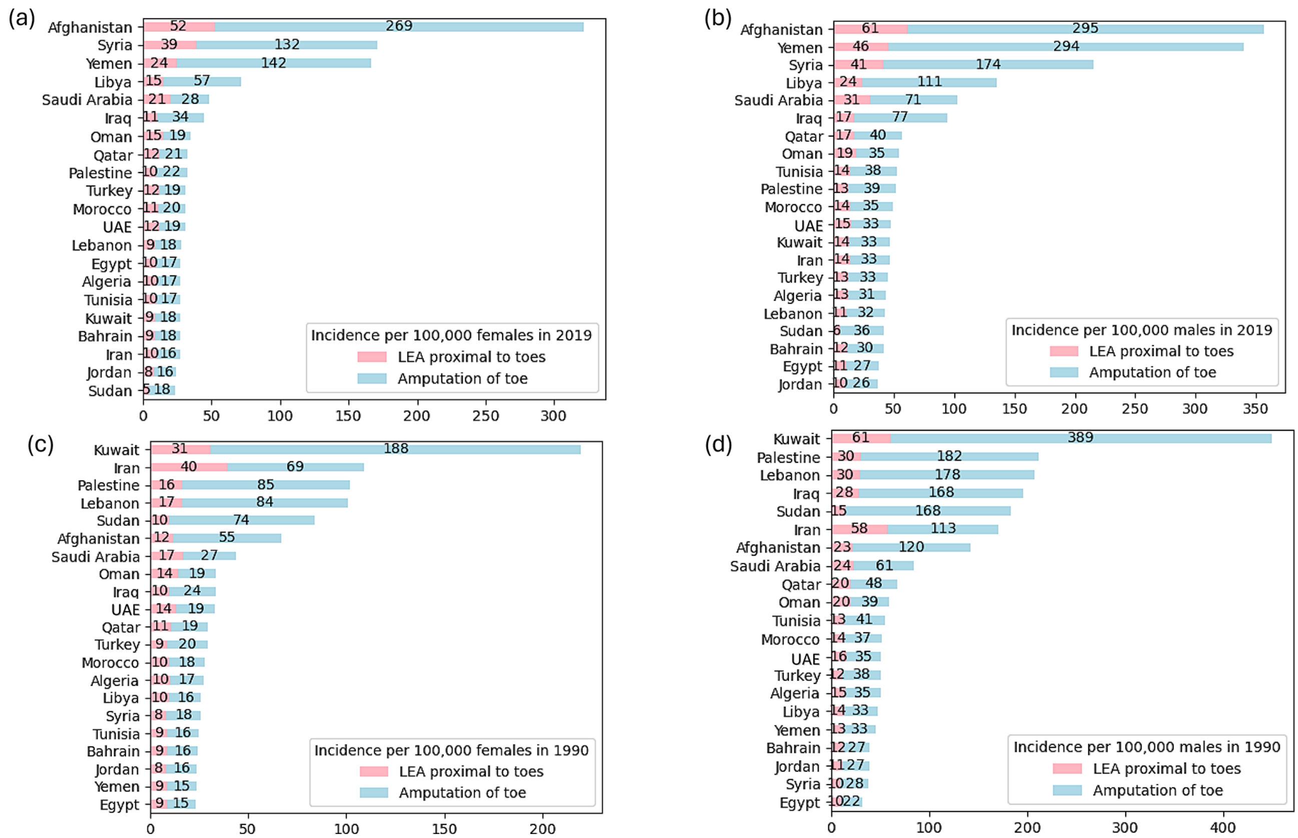

Fig. 1 The distribution of total incidence for LEA and toe amputation is represented geographically for (**a**) females in 2019, (**b**) males in 2019, (**c**) females in 1990, and (**d**) males in 1990

negligible changes among males and females. Emirates, Tunisia, Oman, Algeria, and Turkey show decreases in males but increases or minor decreases in females. Qatar, Iraq, Iran, Palestine, Sudan, Lebanon, and Kuwait show significant decreases in males and females.

Joinpoint analysis for lower extremity amputation incidence

Figures 3 and 4; Tables 1, 2, 3 and 4 present the results of the Joinpoint regression analysis for the four trends in all LEA ASIRs between 1990 and 2019 in female and male patients (countries with six trends shown in supplementary data). EAPC in incidence rates for periods covered by each trend are demonstrated. Significant trend changes in ASIRs are reported. Several countries showed sudden spikes in LEA or toe amputation, such as Afghanistan, Algeria, Egypt, Iraq, Palestine, Syria, Sudan, Yemen, and Turkey, which could be associated with particular events in each trending period.

Discussion

This study is the first to assess the burden of LEAs in the MENA region using the GBD dataset from 1990 to 2019. To the best of our knowledge, this is the first research to epidemiologically investigate the temporal trends in LEA in the MENA region. Additionally, this is the first research to utilize the comprehensive GBD dataset for those purposes. Overall, our analysis reveals variable trends in LEA and toe amputation rates across different countries. Male LEA and toe amputation rates generally decreased, while female rates increased. Syria, Yemen, and Afghanistan showed significant increases in LEA rates, aligning with periods of socio-political instability and conflict. In contrast, countries like Iraq, Palestine, Sudan, Lebanon, Iran, and Kuwait saw marked decreases. These findings highlight the impact of healthcare access, socioeconomic factors, and regional turmoil on LEA incidences.

The differential trends in LEAs observed across the MENA region in this study appear to be influenced by a complex interplay of factors, including wars, natural disasters, and the prevalence of medical conditions like DM and peripheral vascular diseases. While wars and earthquakes are known to contribute significantly to limb amputations globally [26], DM and peripheral vascular diseases are more commonly cited in developed countries [27, 28]. Our findings suggest a similar pattern, with a generally higher incidence of LEAs in males than in females, aligning with previous literature [29, 30].

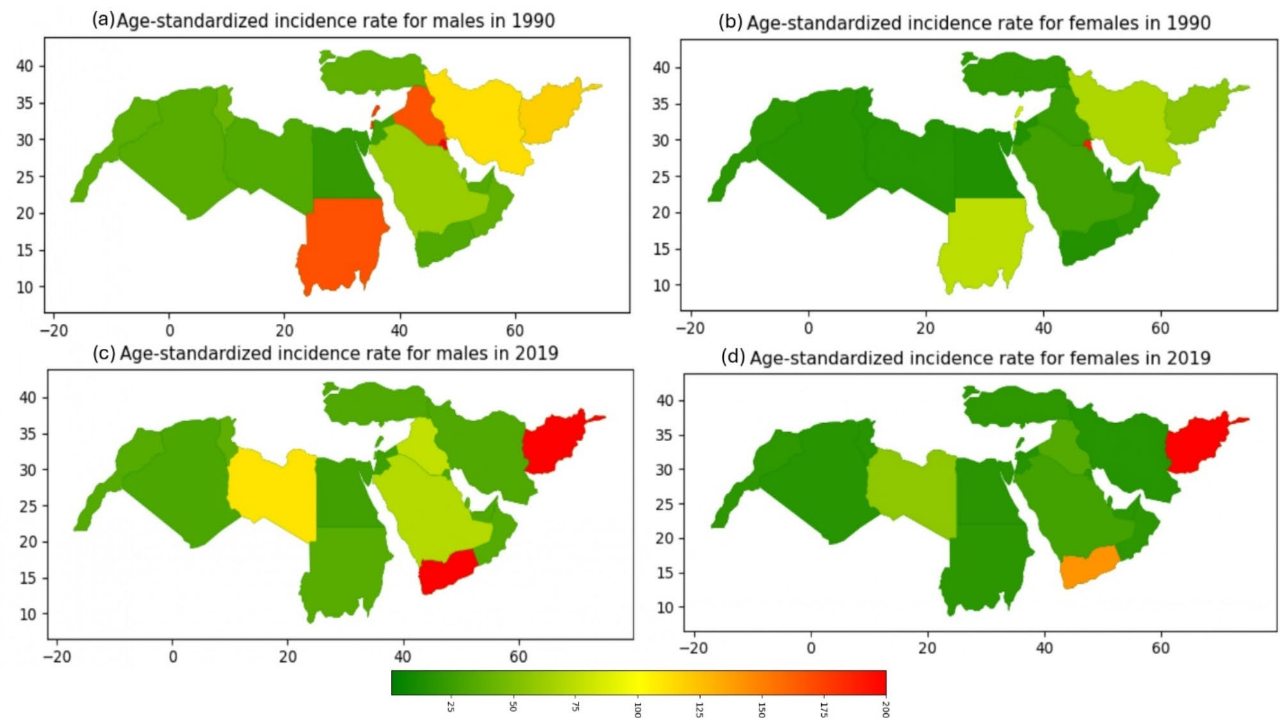

Fig. 2 Overall age-standardized incidence rate for (**a**) males in 1990, (**b**) females in 1990, (**c**) males in 2019, and (**d**) females in 2019. Each map shows the Middle East and North Africa region with country coordinates. The colors green (low), yellow (mid), and red (high) represent the incident rate for each country

In the case of Iran, the notable peak in LEAs among females in 1990 coincides with the Mencil-Rudbar earthquake. This devastating event may be a potential explanation for this surge, although detailed documentation on the specific outcomes related to amputation is lacking [31]. Similarly, the Gulf War's timing in 1990 might offer a plausible context for the observed high incidence of LEAs in Kuwait, affecting both LEAs and toe amputations [32]. The spike in amputations in Afghanistan in 2019 may be tentatively linked to the escalation of civilian attacks, suggesting how political instability can impact health outcomes.

When analyzing trends specific to individual countries, it becomes evident that local events can significantly affect LEA rates. In Morocco, the peak in LEAs in 2004 coincides with a year marked by several earthquakes, including one of 6.3 magnitude. This temporal correlation suggests a possible link between these seismic events and the increase in amputation rates, though direct evidence connecting the two remains sparse [33]. In Turkey, the overall increase in amputations is predominantly driven by rising incidences of DM and peripheral vascular disease [34–36]. The sharp rise in 1999, particularly in the earthquake-affected Marmara region, suggests that major natural disasters might play a role in these spikes [37].

The analysis of Afghanistan, Iraq, Palestine, and Syria reveals that LEAs are likely correlated with ongoing conflicts. The upward trend in LEAs in Afghanistan from 2004 to 2019 coincides with the protracted civil war [38], offering a potential explanation for the increased rates. The peaks in Iraq's LEA rates in 2005 and 2015 seem to align with periods of intensified conflict [39], while the increase in Palestine beginning in 1999 and continuing until 2010 parallels the timeline of the second intifada [40]. The rise in LEA rates in Syria in 2013 is consistent with the escalation of the civil war starting in 2011 [41], suggesting a link between the conflict and health outcomes.

Conversely, in Jordan, Lebanon, and Sudan, the trends seem to be influenced more by non-traumatic factors such as DM and vascular diseases. Jordan's increasing trend from 2015 to 2019 might be attributed to the growing prevalence of vascular diseases and DM [42]. Lebanon's peak in 2006, following a year of conflict, coincides with an observed increase in DM-related lower limb amputations [43], suggesting that both the conflict and the rise in DM might have contributed to this peak [44]. Additionally, limitations in access to medical care during conflicts [45, 46] may have contributed to the increase in DM-related complications, such as amputations. In Sudan, the pattern of peaks, including in 1991, aligns with studies indicating that diabetic septic foot is

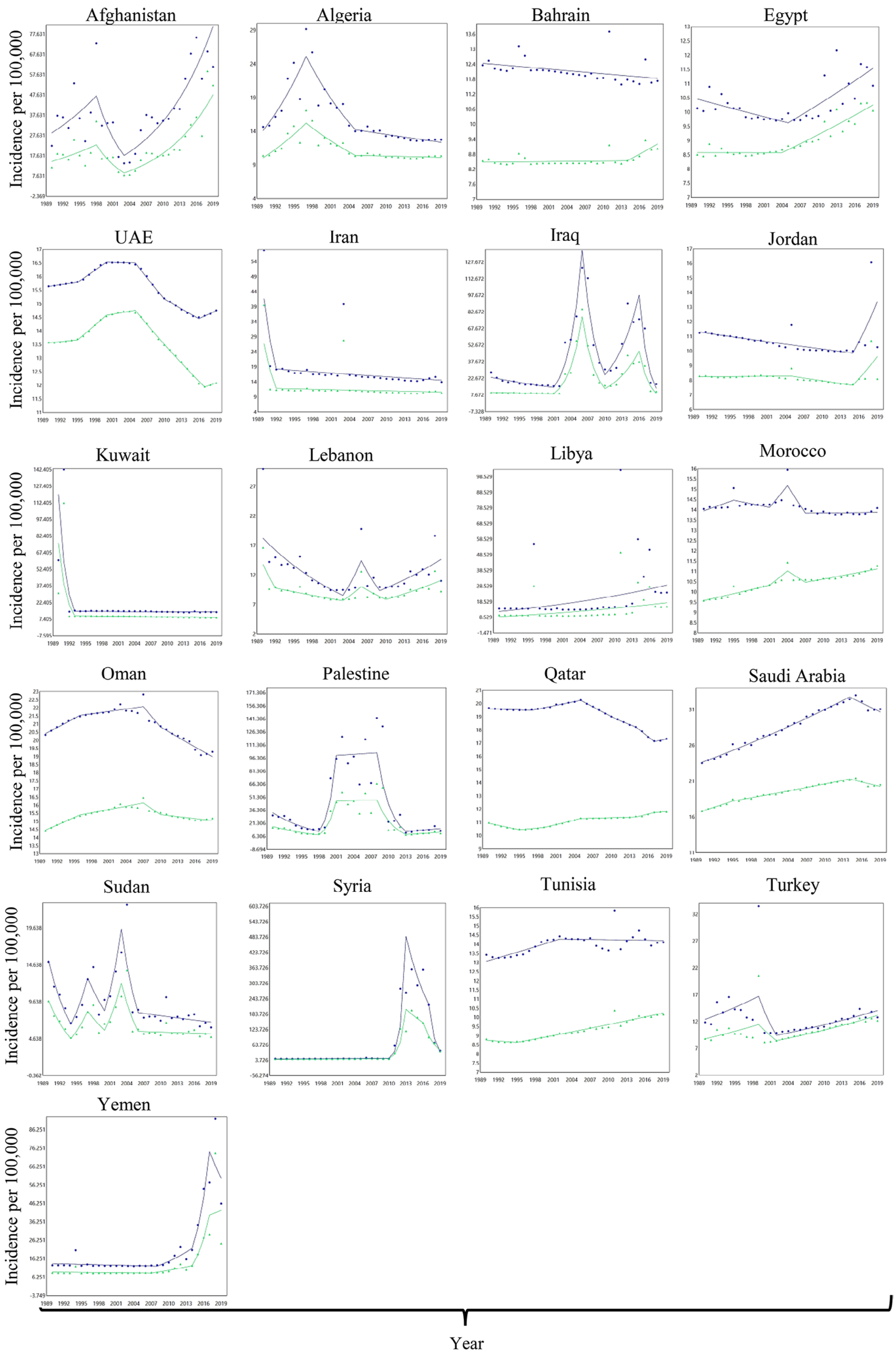

Fig. 3 Trends in age standardized incidence rates (ASIRs) per 100 000 for lower extremity amputation (LEA) proximal to toes in Middle East and North Africa (MENA) countries between 1990 and 2019. Filled circles (blue) indicate male patients; and filled triangles (green) indicate female patients

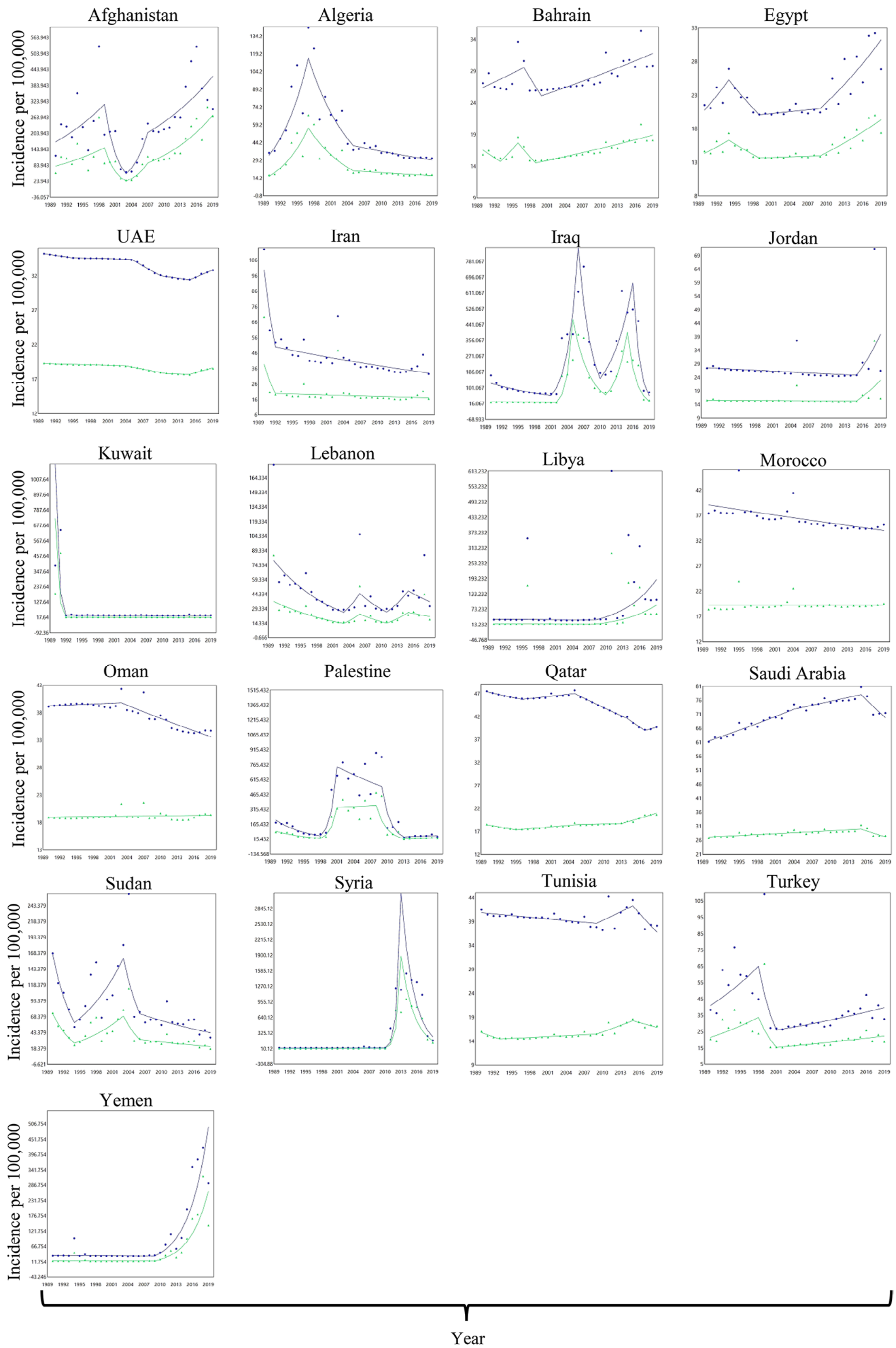

Fig. 4 Trends in age standardized incidence rates (ASIRs) per 100 000 for Teo amputations in Middle East and North Africa (MENA) countries between 1990 and 2019. Filled circles (blue) indicate male patients; and filled triangles (green) indicate female patients

Table 1 Joinpoint analysis for age-standardized incidence rates (ASIRs) for lower extremity amputation (LEA) proximal to toes in the Middle East and North Africa region (MENA) 21 countries for years 1990 to 2019 in female patients

Country	Trend 1			Trend 2			Trend 3			Trend 4		
	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value
Afghanistan	1990–1998	5.66 (0.09 to 18.46)	0.048	1998–2003	-16.93 (-32.28 to -6.55)	0.020	2003–2019	10.91 (8.36 to 14.25)	0.008			
Algeria	1990–1997	6.09 (4.34 to 8.25)	< 0.001	1997–2005	-4.62 (-7.6 to -3.35)	< 0.001	2005–2019	-0.21 (-0.78 to 0.53)	0.538			
Bahrain	1990–2014	0.03 (-0.09 to 0.11)	0.618	2014–2019	1.53 (0.72 to 3.26)	< 0.001						
Egypt	1990–2004	-0.01 (-0.21 to 0.17)	0.960	2004–2019	1.2 (1.05 to 1.39)	< 0.001						
Emirates	1990–1995	0.16 (-0.12 to 0.32)	0.143	1995–2000	1.3 (1.11 to 1.62)	< 0.001	2000–2005	0.25 (0.09 to 0.39)	0.023	2005–2017	-1.75 (-1.8 to -1.71)	< 0.001
Iran	1990–1992	-33.39 (-48.74 to -9.91)	0.001	1992–2019	-0.4 (-1.05 to 0.54)	0.325						
Iraq	1990–2001	-1.26 (-4.03 to 1.23)	0.314	2001–2006	55.28 (43.58 to 74.9)	< 0.001	2006–2010	-35.77 (-45.21 to -27.25)	< 0.001	2010–2016	23.44 (15.97 to 34.83)	< 0.001
Jordan	1990–2005	0.04 (-0.23 to 4.59)	0.782	2005–2015	-0.78 (-4.13 to -0.29)	0.013	2015–2019	5.87 (3.06 to 11.53)	0.003			
Kuwait	1990–1993	-48.53 (-66.64 to -36.56)	< 0.001	1993–2019	-0.56 (-1.4 to 0.34)	0.188						
Lebanon	1990–1992	-15.7 (-19.94 to -6.35)	< 0.001	1992–2003	-2.22 (-3.26 to -0.83)	0.028	2003–2006	9.46 (3 to 12.74)	0.021	2006–2010	-5.95 (-10.72 to -1.9)	0.022
Libya	1990–2019	2.44 (0.91 to 4.05)	0.000									
Morocco	1990–2001	0.69 (0.34 to 0.83)	0.018	2001–2004	2.2 (1.12 to 2.75)	0.021	2004–2007	-1.71 (-2.23 to -0.53)	0.021	2007–2019	0.51 (0.37 to 0.7)	0.008
Oman	1990–1996	1.05 (0.84 to 1.46)	< 0.001	1996–2007	0.43 (0.31 to 0.54)	0.002	2007–2010	-1.51 (-1.77 to -0.84)	< 0.001	2010–2019	-0.27 (-0.39 to -0.07)	0.026
Palestine	1990–1998	-9.54 (-15.84 to -5.21)	0.003	1998–2001	81.2 (43.16 to 101.49)	0.003	2001–2008	0.34 (-7.28 to 7.82)	0.995	2008–2013	-29.25 (-43.1 to -21.36)	0.000
Qatar	1990–1995	-0.94 (-1.07 to -0.82)	< 0.001	1995–1999	0.43 (0.05 to 0.59)	0.042	1999–2005	1.04 (0.89 to 1.17)	< 0.001	2005–2014	0.11 (0.04 to 0.82)	0.021
Saudi Arabia	1990–1995	1.63 (1.27 to 2.38)	< 0.001	1995–2014	0.83 (0.76 to 0.89)	< 0.001	2014–2019	-1.01 (-1.63 to -0.58)	< 0.001			
Sudan	1990–1994	-17.06 (-26.49 to -12.32)	< 0.001	1994–1997	21.68 (10.36 to 30.19)	< 0.001	1997–2000	-11.55 (-17.61 to -3.7)	0.016	2000–2003	28.07 (17.09 to 37.06)	0.015
Syria	1990–2010	1.36 (-0.98 to 5.78)	0.080	2010–2013	174.02 (-2.97 to 194.31)	0.073	2013–2016	-9.5 (-18.5 to 202.07)	0.275	2016–2019	-34.51 (-52.54 to -21.04)	< 0.001
Tunisia	1990–1995	-0.27 (-1.61 to 0.26)	0.252	1995–2019	0.72 (0.66 to 0.79)	< 0.001						
Turkey	1990–1999	2.98 (0.17 to 10.75)	0.044	1999–2002	-9.62 (-13.13 to 0.43)	0.052	2002–2019	2.63 (1.59 to 4.07)	0.035			
Yemen	1990–2007	-0.35 (-2.44 to 1.42)	0.338	2007–2014	5.7 (-2.16 to 11.2)	0.086	2014–2017	47.44 (4.27 to 57.31)	0.011	2017–2019	3.08 (-12.49 to 31.28)	0.619

a frequent cause of below-knee amputations [47], pointing to the significant role of this condition in shaping the observed trends.

Public health implications

This study's findings underscore the urgent need for targeted public health interventions in the MENA region to address the variable trends in LEAs. The increased rates of LEAs in countries like Syria, Yemen, and Afghanistan, which correlate with socio-political instability and conflict, highlight the necessity of integrating healthcare delivery into disaster response and conflict resolution strategies. Ensuring access to preventive and emergency healthcare in these settings could significantly mitigate the burden of LEAs [48, 49]. In addition to immediate medical care, long-term strategies should include training local healthcare providers in trauma care and establishing mobile medical units to reach remote areas.

Conversely, the rising incidence of LEAs linked to DM and vascular diseases in countries like Jordan, Lebanon, and Sudan calls for enhanced public health initiatives focused on chronic disease management. These initiatives should include widespread screening, improved access to healthcare services, and educational programs to raise awareness about the risks and management of DM and vascular conditions. Implementing community-based health promotion programs and leveraging telemedicine could also play significant roles in managing these chronic diseases more effectively [50–52]. By addressing these non-traumatic factors, health systems can reduce the prevalence of preventable amputations and improve overall patient outcomes.

Furthermore, the study reveals the critical impact of healthcare access disparities on LEA trends. Research indicates that disparities in healthcare access, such as variations in income, insurance status, and socioeconomic conditions, significantly affect LEA outcomes. Prior research based outside the MENA region demonstrates that individuals from lower socioeconomic backgrounds are at a greater risk for major LEAs due to inadequate access to preventive care and timely treatment [53, 54]. Addressing these disparities is essential for managing LEA rates effectively.

Efforts to address LEAs have focused on prevention, improved healthcare access, and awareness programs. However, disparities persist, with significant gaps in rehabilitation services across different regions and municipalities [55]. This highlights the need for improved access to high-volume hospitals and comprehensive rehabilitation services to address these disparities [56]. In conflict-affected regions, integrating healthcare into disaster response and rebuilding healthcare infrastructure is crucial for reducing LEA rates.

Moreover, the study reveals the importance of robust data collection and analysis in understanding and responding to the health impacts of various factors, including wars, natural disasters, and chronic diseases. Strengthening health information systems, particularly in remote and rural areas, is essential for capturing accurate data and enabling effective public health interventions. This involves not only improving infrastructure but also training local health workers in data collection and management techniques. Collaboration between governments, international organizations, and local communities will be crucial in implementing these measures and ultimately reducing the burden of LEAs in the MENA region [57, 58]. Promoting regional data-sharing agreements can enhance the ability to track and respond to health trends promptly and efficiently.

Strengths and limitations

This study's primary strength lies in its pioneering approach to assessing the burden of LEAs in the MENA region using the GBD dataset spanning 1990 to 2019. By being the first to systematically explore temporal trends in LEA within this geographically and culturally diverse region, the research offers unprecedented insights into how socio-political events, natural disasters, and health conditions like diabetes mellitus and vascular diseases influence LEA rates. Additionally, the comprehensive time frame and use of consistent data sources enhance the reliability of the observed trends, allowing for a nuanced understanding of the factors impacting LEA rates across different countries and time periods.

However, the study faces several limitations that impact the interpretation of its findings. One significant constraint is the lack of data on inter-regional variations within countries, which could more precisely elucidate the impacts of natural disasters or wars affecting specific regions. This absence of localized data prevents a deeper understanding of how these events influence LEA rates in different parts of the same country. Additionally, most available data about lower limb amputations in the MENA region is categorized as below the knee and above the knee amputations, with less research focusing on amputations proximal to the toe and toe amputations specifically. This limits our ability to draw comprehensive conclusions about these types of amputations. Furthermore, the GBD dataset, despite its advanced modeling and estimation methods based on primary data, has inherent limitations [59]. In some Middle Eastern countries, data collection systems are well-established and integrated with healthcare facilities, providing accurate and comprehensive data. However, in other nations within the region, these systems may not be as robust, leading to significant disparities in data quality and availability, especially in remote and rural areas. These

Table 2 Joinpoint analysis for age-standardized incidence rates (ASIRs) for lower extremity amputation (LEA) proximal to toes in the Middle East and North Africa region (MENA) 20 + countries for years 1990 to 2019 in male patients

Country	Trend 1			Trend 2			Trend 3			Trend 4		
	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value
Afghanistan	1990–1998	6.33 (-1.26 to 25.52)	0.076	1998–2003	-17.74 (-34.74 to -3.87)	0.044	2003–2019	9.99 (6.59 to 14.61)	0.022			
Algeria	1990–1997	8.62 (6.16 to 11.59)	< 0.001	1997–2005	-6.86 (-10.74 to -5.14)	< 0.001	2005–2019	-1.01 (-1.79 to -0.01)	0.050			
Bahrain	1990–2019	-0.18 (-0.28 to -0.06)	0.004									
Egypt	1990–2005	-0.56 (-0.99 to -0.26)	0.001	2005–2019	1.31 (0.94 to 1.82)	< 0.001						
Emirates	1990–1995	0.19 (0.03 to 0.31)	0.029	1995–2000	0.92 (0.8 to 1.09)	< 0.001	2000–2005	-0.04 (-0.14 to 0.07)	0.430	2005–2010	-1.66 (-1.78 to -1.56)	< 0.001
Iran	1990–1992	-33.77 (-48.61 to -12.18)	< 0.001	1992–2019	-0.84 (-1.4 to -0.07)	0.040						
Iraq	1990–2001	-4.33 (-7.67 to -1.39)	0.008	2001–2006	57 (41.57 to 84.48)	< 0.001	2006–2010	-34.27 (-46.26 to -21.87)	< 0.001	2010–2016	24.83 (15.93 to 42.67)	< 0.001
Jordan	1990–2015	-0.55 (-0.79 to -0.34)	< 0.001	2015–2019	7.93 (4.04 to 16.71)	< 0.001						
Kuwait	1990–1993	-50.64 (-67.91 to -40.77)	< 0.001	1993–2019	-0.17 (-0.94 to 0.59)	0.601						
Lebanon	1990–2003	-5.65 (-7.43 to -4.46)	0.008	2003–2006	19.08 (4.92 to 26.46)	0.019	2006–2009	-13.46 (-18.86 to -2.72)	0.019	2009–2019	4.6 (2.66 to 8.69)	0.005
Libya	1990–2019	3.03 (1.01 to 5.16)	0.003									
Morocco	1990–1995	0.73 (0.07 to 2.26)	0.027	1995–2001	-0.41 (-1.7 to 1.86)	0.102	2001–2004	2.45 (-2.78 to 3.26)	0.093	2004–2007	-3.04 (-3.68 to 0.24)	0.067
Oman	1990–1996	0.91 (0.46 to 1.74)	0.024	1996–2007	0.23 (-0.31 to 0.63)	0.124	2007–2010	-1.94 (-2.3 to 0.6)	0.150			
Palestine	1990–1998	-11.97 (-18.55 to -7.42)	< 0.001	1998–2001	102.04 (54.14 to 127.38)	0.000	2001–2008	0.43 (-8.42 to 8.94)	0.988	2010–2019	-1.02 (-1.25 to -0.42)	0.017
Qatar	1990–1997	-0.09 (-0.19 to -0.03)	0.026	1997–2005	0.48 (0.08 to 0.55)	0.032	2005–2011	-1.24 (-1.36 to 0.46)	0.126	2011–2014	-1.01 (-1.19 to -0.92)	< 0.001
Saudi Arabia	1990–2014	1.37 (1.32 to 1.43)	< 0.001	2014–2019	-1.31 (-2.21 to -0.69)	0.000						
Sudan	1990–1994	-18.96 (-29.96 to -13.31)	< 0.001	1994–1997	25.03 (10.88 to 35.73)	< 0.001	1997–2000	-13.13 (-20.26 to -3.37)	0.024	2000–2003	32.24 (17.49 to 43.58)	0.024
Syria	1990–2010	1.2 (-0.76 to 3.22)	0.158	2010–2013	254.49 (1.12 to 297.74)	0.042	2013–2017	-17.8 (-26.42 to 246.84)	0.151	2017–2019	-59.66 (-71.56 to -34.24)	< 0.001
Tunisia	1990–2002	0.75 (0.43 to 1.65)	0.002	2002–2019	-0.04 (-0.52 to 0.15)	0.640						
Turkey	1990–1999	3.37 (0.82 to 8.63)	0.020	1999–2002	-17.33 (-21.43 to -6.03)	0.005	2002–2019	2.38 (1.31 to 3.89)	0.004			
Yemen	1990–2008	-0.59 (-1.5 to 0.07)	0.077	2008–2014	10.14 (4.95 to 14.57)	0.003	2014–2017	50.4 (36.74 to 61.17)	0.000	2017–2019	-10.29 (-22.23 to 5.46)	0.146

Table 3 Joinpoint analysis for age-standardized incidence rates (ASIRs) for toe amputation in the Middle East and North Africa Region (MENA) 20 + countries for years 1990 to 2019 in female patients

Country	Trend 1			Trend 2			Trend 3			Trend 4		
	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value
Afghanistan	1990–1999	7.05 (-1.22 to 17.4)	0.066	1999–2003	-36.52 (-50.89 to 1.84)	0.052	2003–2007	39.66 (-25.67 to 75.21)	0.054	2007–2019	9.43 (-8.33 to 14.95)	0.087
Algeria	1990–1997	20.08 (14.68 to 26.45)	< 0.001	1997–2005	-11.95 (-20.75 to -8.25)	< 0.001	2005–2019	-1.59 (-2.68 to -0.19)	0.034			
Bahrain	1990–1993	-3.76 (-10.01 to 0.66)	0.068	1993–1996	6.24 (-2.49 to 9)	0.057	1996–1999	-6.37 (-8 to 0.9)	0.057	1999–2019	1.33 (1.05 to 1.63)	0.015
Egypt	1990–1994	3.28 (1.52 to 6.07)	< 0.001	1994–1999	-3.49 (-5.99 to -2.26)	< 0.001	1999–2009	0.23 (-0.33 to 0.82)	0.369	2009–2019	3.31 (2.84 to 3.93)	< 0.001
Emirates	1990–2004	-0.12 (-0.18 to -0.06)	0.007	2004–2011	-0.88 (-1.22 to -0.73)	0.009	2011–2015	-0.16 (-0.55 to 0.37)	0.301	2015–2019	1.31 (1.05 to 1.71)	< 0.001
Iran	1990–1992	-28.34 (-45.83 to -1.33)	0.008	1992–2019	-0.54 (-1.13 to 1.01)	0.211						
Iraq	1990–2002	-0.42 (-2.01 to 1.08)	0.580	2002–2005	171.36 (108.05 to 203.64)	< 0.001	2005–2011	-28.54 (-42.06 to -21.49)	< 0.001	2011–2015	58.93 (27.28 to 112.89)	< 0.001
Jordan	1990–2015	-0.07 (-0.48 to 0.24)	0.581	2015–2019	10.62 (4.22 to 22.13)	< 0.001						
Kuwait	1990–1992	-83.17 (-88.12 to -67.23)	< 0.001	1992–2019	-0.38 (-0.84 to 0.11)	0.120						
Lebanon	1990–2003	-7.02 (-9.47 to -4.25)	0.026	2003–2006	18.47 (-9.2 to 26.33)	0.120	2006–2011	-9.29 (-20.51 to 18.44)	0.115	2011–2015	14.79 (-11.73 to 27.12)	0.114
Libya	1990–2008	-0.37 (-3.09 to 1.59)	0.673	2008–2019	17.16 (10.06 to 34.53)	< 0.001						
Morocco	1990–2019	0.01 (-0.17 to 0.19)	0.933									
Oman	1990–2019	0.06 (-0.1 to 0.21)	0.446									
Palestine	1990–1998	-15.91 (-22.18 to -10.36)	0.002	1998–2001	140.83 (70.51 to 176.98)	0.003	2001–2008	0.84 (-11.75 to 12.66)	0.997	2008–2013	-42.88 (-59.55 to -33.71)	0.000
Qatar	1990–1995	-1.26 (-1.84 to -0.85)	0.001	1995–2005	0.63 (0.49 to 1.2)	0.005	2005–2013	0.19 (-0.52 to 0.4)	0.354	2013–2019	1.91 (1.55 to 2.37)	< 0.001
Saudi Arabia	1990–2015	0.4 (0.3 to 0.53)	< 0.001	2015–2019	-2.39 (-5.67 to -0.87)	0.002						
Sudan	1990–1994	-22.21 (-49.01 to -6.1)	0.018	1994–2003	11.17 (5.59 to 39.99)	0.024	2003–2006	-22.34 (-29.87 to -4.51)	0.032	2006–2019	-3.1 (-5.24 to 6.64)	0.203
Syria	1990–2010	1.54 (0.54 to 2.54)	0.003	2010–2013	350.62 (227.98 to 420.66)	< 0.001	2013–2019	-33.19 (-43.8 to -24.63)	< 0.001			
Tunisia	1990–1993	-2.89 (-5.76 to -0.8)	0.004	1993–2009	0.43 (0.21 to 0.73)	0.005	2009–2015	2.81 (2 to 4.98)	< 0.001	2015–2019	-1.98 (-4.52 to -0.64)	0.004
Turkey	1990–1998	5.78 (2.42 to 12.75)	0.005	1998–2001	-22.93 (-27.52 to -10.41)	0.000	2001–2019	2.08 (1.21 to 3.16)	< 0.001			
Yemen	1990–2009	-0.24 (-1.28 to 0.71)	0.591	2009–2019	33.32 (26.56 to 41.78)	< 0.001						

Table 4 Joinpoint analysis for age-standardized incidence rates (ASIRs) for toe amputation in the Middle East and North Africa Region (MENA) 20+countries for years 1990 to 2019 in male patients

Country	Trend 1			Trend 2			Trend 3			Trend 4		
	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value	Year	APC (-95%CI to +95CI%)	*P*-Value
Afghanistan	1990–1999	6.89 (-0.35 to 17.89)	0.056	1999–2003	-36.23 (-52.1 to -20.4)	0.030	2003–2007	41.36 (16.53 to 81.32)	0.030	2007–2019	6.06 (-5.02 to 11.01)	0.144
Algeria	1990–1997	19.28 (14.36 to 25.27)	< 0.001	1997–2005	-11.95 (-19.13 to -8.56)	< 0.001	2005–2019	-2.43 (-3.47 to -1.12)	0.005			
Bahrain	1990–1997	1.63 (-0.51 to 6.89)	0.107	1997–2000	-5.29 (-7.42 to 2.66)	0.101	2000–2019	1.25 (0.14 to 1.98)	0.048			
Egypt	1990–1994	5.02 (2.49 to 9.23)	< 0.001	1994–1999	-4.49 (-8 to -2.67)	< 0.001	1999–2009	0.46 (-0.49 to 1.44)	0.295	2009–2019	4.04 (3.31 to 5.22)	< 0.001
Emirates	1990–1995	-0.35 (-0.49 to -0.26)	< 0.001	1995–2005	-0.06 (-0.09 to -0.02)	0.012	2005–2010	-1.43 (-1.48 to -1.37)	< 0.001	2010–2015	-0.37 (-0.44 to -0.31)	< 0.001
Iran	1990–1992	-29.23 (-40 to -10.53)	< 0.001	1992–2019	-1.52 (-1.98 to -0.88)	0.008						
Iraq	1990–2001	-6.66 (-9.11 to -4.33)	< 0.001	2001–2006	70.64 (49.66 to 103.2)	< 0.001	2006–2010	-35.15 (-51.21 to -18.63)	< 0.001	2010–2016	27.98 (14.16 to 64.06)	< 0.001
Jordan	1990–2015	-0.43 (-0.9 to -0.07)	0.026	2015–2019	12.56 (4.73 to 26.43)	0.001						
Kuwait	1990–1992	-82.44 (-87.22 to -77.97)	< 0.001	1992–2019	-0.26 (-0.65 to 0.16)	0.186						
Lebanon	1990–2003	-8.32 (-10.63 to -6.24)	0.018	2003–2006	20.77 (-8.48 to 29.48)	0.079	2006–2011	-10.55 (-22.62 to 17.28)	0.075	2011–2015	16.6 (-10.79 to 30.87)	0.074
Libya	1990–2008	-0.56 (-3.53 to 1.57)	0.558	2008–2019	17.67 (10.28 to 35.39)	< 0.001						
Morocco	1990–2019	-0.48 (-0.63 to -0.31)	< 0.001									
Oman	1990–2003	0.12 (-0.31 to 1.13)	0.488	2003–2019	-1.06 (-1.75 to -0.78)	< 0.001						
Palestine	1990–1998	-16.38 (-22.27 to -11.29)	< 0.001	1998–2001	146.8 (78.19 to 180.78)	< 0.001	2001–2009	-3.76 (-12.78 to 4.55)	0.321	2009–2013	-48.72 (-60.67 to -37.6)	< 0.001
Qatar	1990–1996	-0.6 (-0.79 to -0.46)	< 0.001	1996–2005	0.32 (0.25 to 0.39)	0.000	2005–2014	-1.36 (-1.41 to -1.26)	0.001	2014–2017	-2.15 (-2.35 to -1.79)	< 0.001
Saudi Arabia	1990–2004	1.22 (1.04 to 2.1)	0.005	2004–2015	0.63 (-0.29 to 0.95)	0.088	2015–2019	-2.76 (-5.31 to -1.56)	0.002			
Sudan	1990–1994	-22.8 (-51.09 to -4.1)	0.032	1994–2003	11.75 (4.51 to 45.41)	0.041	2003–2006	-22.98 (-31.07 to 0.54)	0.053	2006–2019	-4 (-7.05 to 9.09)	0.217
Syria	1990–2010	0.94 (-0.27 to 2.1)	0.122	2010–2013	377.02 (224.15 to 466.26)	< 0.001	2013–2019	-34.54 (-49.32 to -24.16)	< 0.001			
Tunisia	1990–2009	-0.3 (-0.57 to -0.12)	0.002	2009–2015	1.53 (0.61 to 3.88)	0.001	2015–2019	-3.43 (-6.48 to -1.88)	< 0.001			
Turkey	1990–1998	5.93 (2.32 to 12.64)	0.005	1998–2001	-26.42 (-31.09 to -13.16)	< 0.001	2001–2019	2.4 (1.43 to 3.62)	< 0.001			
Yemen	1990–2009	-0.37 (-1.55 to 0.66)	0.448	2009–2019	31.39 (24.66 to 39.97)	< 0.001						

variations introduce potential errors and biases, possibly resulting in the under or overestimation of the true burden of lower extremity amputations.

Future research

Future research in the field of LEAs in the MENA region should prioritize a deeper investigation into the specific causes of these amputations. Given the diverse healthcare systems, socioeconomic conditions, political landscapes, and natural disaster risks across the region, understanding the root causes is essential for developing targeted interventions to reduce LEA prevalence. Additionally, there is a pressing need for studies that incorporate more granular, region-specific data, particularly to understand the localized impacts of wars and natural disasters on amputation rates. This would involve enhancing data collection methodologies to capture inter-regional variations within countries. Future efforts should also focus on longitudinal studies that track changes in amputation rates over time in response to shifts in healthcare policies, socio-economic developments, and the aftermath of conflicts and disasters. Integrating future iterations of the GBD study in the coming years will provide crucial insights into how ongoing conflicts and changing circumstances are influencing these trends. Finally, incorporating patient-centered outcomes and perspectives could provide valuable insights into the quality of life and rehabilitation needs of amputees, guiding more holistic approaches to care and support in the MENA region.

Conclusion

In conclusion, this study provides valuable insights into the temporal trends of LEA in the MENA region from 1990 to 2019. By leveraging the comprehensive GBD dataset, the analysis illuminates the impact of socio-political dynamics, healthcare access, and disease prevalence on LEA rates across 21 MENA countries. The findings highlight the urgent need for targeted public health interventions to mitigate the burden of LEAs, particularly in conflict-affected areas like Syria, Yemen, and Afghanistan.

To effectively address these challenges, policymakers should prioritize the development of comprehensive national strategies that focus on improving access to preventive care, particularly for high-risk populations. Enhancing chronic disease management through integrated care models and promoting public health education about the risks of diabetes and vascular diseases are critical. In conflict-affected regions, international collaboration is essential to support healthcare infrastructure and ensure the availability of essential medical services. For healthcare providers, there is a need to implement standardized protocols for early detection and management of conditions leading to LEAs. Investing in training programs that equip healthcare professionals with the skills to manage complex cases in resource-limited settings will be crucial. Additionally, adopting robust data collection and monitoring systems will enable continuous assessment and refinement of intervention strategies.

These insights can guide policymakers, healthcare providers, and researchers in developing effective strategies to reduce LEA incidence and improve patient outcomes in this geographically and culturally diverse region.

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Author contributions

Y.A.A, O.T, and M.I conceptualized the research question and hypothesis. Y.A.A, M.T and M.A conducted data analysis and graphical representation. Y.A.A, A.A.B, and N.B-B wrote the main manuscript text. All authors contributed to revise work for important intellectual content, gave the final approval of the version to be published, and agreed on all aspects of the work, especially concerning its design, accuracy and integrity. The corresponding author confirms that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval

This study is an observational database study utilizing the data from the Global Burden of Diseases, Injuries, and Risk Factors 2019 study. This study did not require ethical approval. All methods were performed in accordance with Helsinki's declaration.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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