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RESEARCH ARTICLE

Regional and National Burden of Traumatic Brain Injury and Spinal Cord Injury in North Africa and Middle East Regions, 1990–2021: A Systematic Analysis for The Global Burden of Disease Study 2021

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Abstract

Background Traumatic brain injury (TBI) and spinal cord injury (SCI) are significant central nervous system injuries with epidemiological importance, particularly in the North Africa and the Middle East (NAME) region, which is diverse in public health aspects across its 21 countries.

Objective This study aims to present an up-to-date assessment of the regional and national TBI and SCI burden and their causes in the NAME region from 1990 to 2021.

Methods We utilized the Global Burden of Disease (GBD) results tool to gather relevant data. The analysis included TBI and SCI incidence, prevalence, and years lived with disability (YLDs) rates, along with absolute numbers and percent change trends by gender, age, and country from 1990 to 2021. We also examined the causes of TBI and SCI and identified the most common causes for each country.

Results In 2021, TBI age-standardized rates of incidence, prevalence, and YLDs were 333 (293, 380), 593 (553, 642), and 87 (63, 114) per 100,000 people, respectively. For SCI, the rates were 10 (7, 13), 256 (200, 344), and 78 (51, 115). Since 1990, incidence rates of TBI and SCI have decreased in most countries. Saudi Arabia, Afghanistan, and Yemen experienced increasing incidence rates for both injuries. Transport injuries and unintentional injuries were the primary causes of TBI and SCI, respectively, in most countries.

Conclusion Despite global trends showing a decreased burden of TBI and SCI, the NAME region's public health systems should remain vigilant. Both injuries are epidemiologically significant and require continued public health interventions to manage and control them in this particular region.

Keywords Global Burden of Disease · North Africa · Middle East · Traumatic Brain Injuries · Spinal Cord Injuries

1 Introduction

Traumatic brain injury (TBI) and spinal cord injury (SCI) are significant public health concerns, contributing substantially to global morbidity and mortality [1]. TBI, a form of acquired brain injury, results from sudden trauma to the brain, such as a violent blow to the head or an object penetrating the skull [2]. The severity of symptoms varies, ranging from mild, including headache, confusion, dizziness, and mood changes to more severe symptoms such as persistent headaches, seizures, speech problems, and loss of coordination [3, 4]. Moderate to severe TBI is characterized by lower Glasgow Coma Scale (GCS) scores, prolonged loss of consciousness, and potential abnormal imaging findings.

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These more serious cognition and functional impairments often lead to higher rates of long-term disability, with 40% of the moderate to severe TBI population suffering long-term disabilities [5].

Similarly, SCI, which can result from trauma (e.g., falling or road accidents) or non-traumatic causes (e.g., tumors, degenerative diseases, infections), leading to varying degrees of sensory and motor function loss below the level of injury [6]. The severity of the deficit, whether complete or incomplete, depends on the level and the extent of the spinal cord injury, resulting in the total or partial loss of both sensory and motor functions below the level of injury [7]. As is apparent by the name, a complete spinal cord injury is characterized by loss of all motor and sensory functions below the level of injury. However, an incomplete loss can be motor or sensory with varying degrees of voluntary anal contractions in the motor incomplete spinal cord injury [8].

In 2019, there were 27.16 million new cases of TBI and 0.91 million new cases of SCI worldwide. TBI accounted for 7.08 million years lived with disability (YLDs), while SCI accounted for 6.20 million YLDs. The age-standardized incidence rates were 346 per 100,000 for TBI and 12 per 100,000 for SCI, with corresponding prevalence rates of 599 per 100,000 and 253 per 100,000 [9]. Despite these global figures, the burden of these injuries is especially notable in specific regions, such as North Africa and the Middle East (NAME), where the age-standardized incidence rates for TBI and SCI were 319 per 100,000 and 9 per 100,000, respectively [9],

The NAME region, comprising 21 countries and 436 million people, presents unique challenges in addressing the burden of TBI and SCI [10–12]. These challenges are multifaceted, involving gaps in healthcare infrastructure, socio-economic inequalities, resource limitations, and a lack of systematic data [13, 14]. Overcoming these challenges requires focused interventions to improve healthcare systems, raise public awareness, and conduct more comprehensive research to guide policy and practice. Additionally, effective injury prevention strategies and rehabilitation programs are essential for improving outcomes for both SCI and TBI patients in the region [15]. A coordinated approach, tailored to the specific socio-cultural and healthcare needs of the NAME region, is crucial for implementing effective prevention and intervention strategies. Furthermore, temporal analysis of TBI and SCI in the NAME region is sparse. Multiple systematic reviews have highlighted the need for large scale epidemiological studies to gain a deep understanding of TBI and SCI burden in the region, which will help facilitate prevention strategies and resource allocations [16, 17]. The global burden of disease (GBD) 2021 study of diseases affecting the nervous system [18] provides an up to date global assessment of TBI and SCI, yet the burden of the region and its individual countries, as well as national and regional trends have yet to be explored.

Although the NAME region is diverse, encompassing linguistic, economic, social, and health dimensions [19–21], it shares key geographical, cultural, and economic factors. These commonalities include a shared cultural heritage, economic interdependence, and mutual challenges such as political instability and resource management [20, 22]. These similarities provide a strong rationale for studying the region as a whole, in addition to the significant burden of these injuries in this region. The region's shared environmental, genetic, and health system-related factors also play a role in shaping the incidence and outcomes of TBI and SCI, making the NAME region a crucial area for studying the epidemiology and natural history of these conditions.

This paper seeks to comprehensively assess the regional and national burden of TBI and SCI within the NAME region from 1990 to 2021, utilizing the up-to-date data from the Global Burden of Disease Study 2021 findings [18, 23]. We explore these injuries to find important trends and patterns that may help guide public health interventions and resource allocation. It will specifically assess the leading causes of TBI and SCI in the NAME region and evaluate the prevalence and incidence, YLD absolute numbers, and rates due to TBI and SCI.

2 Methods

2.1 Overview

This study adheres to the guidelines for accurate and transparent health estimates reporting (GATHER) [24] and the strengthening the reporting of observational studies in epidemiology (STROBE) guideline [25]. We used data from the GBD 2021 study which estimated the burden of 371 diseases or injuries for 204 countries and territories, including TBI/SCI through measures such as prevalence, incidence, years of life lost (YLLs), years lived with disability (YLDs), disability-adjusted life-years (DALYs), and mortality by age groups, gender, cause, location, and year from 1990 to 2021 [18, 23]. The annual reports of TBI/SCI from 1990 to 2021 allow us to assess national and regional trends of burden.

2.2 Data Source

The data for the NAME region and its 21 countries of Afghanistan, Algeria, Bahrain, Egypt, Iraq, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, Turkey, United Arab Emirates (UAE), and Yemen between 1990 and 2021 is available from the GBD results tool (h

ttps://vizhub.healthdata.org/gbd-results/) and GBD compare tool (https://vizhub.healthdata.org/gbd-compare/). The sources of these data include scientific literature, registry data, household surveys, medical record reviews, and insurance claims, among other sources described elsewhere [18].

2.3 Case Definitions

GBD 2021, similar to GBD 2019 [26], classifies TBI/SCI as natures of injury, and not causes of injury, defining SCI as "A spinal cord lesion at or below the cervical level that leads to partial or total paralysis depending on the level and degree of injury." and TBI as "Injury to the head that causes short-term and in some cases long-term damage to the brain, manifesting in loss of concentration, headaches, memory problems, nausea, dizziness, and/or mood changes." [18] and uses the international classification of diseases, 9th edition (ICD-9) or 10th edition (ICD-10) to classify each, with ICD-N-33 and ICD-N-34 classifying SCI and ICD-N-27 and ICD-N-28 classifying TBI. Furthermore, GBD 2021 categorizes TBI into mild TBI (mTBI) or moderate-severe TBI, and SCI into at neck level SCI and below neck level SCI.

2.4 Estimates of Burden

The methods used for the estimation of the burden of TBI/SCI have been previously described [9, 18]. Briefly, the burden of TBI/SCI is reported by prevalence, incidence, and YLDs by age, gender, cause, and year for 21 countries in the NAME region and the region as a whole. Although TBI/SCI may cause death, GBD 2021 does not report mortality for these injuries. Prevalence is the number of individuals in a population with the given injury at the given time while incidence is the number of new injuries in the given time in the same population. Estimates of prevalence and incidence are calculated using Bayesian meta-regression models with a tool called Disease Modelling Meta-Regression (DisMod-MR) 2.1, with details described in GBD 2021 capstone appendix part 16 [18]. This data is subsequently processed and corrected using regression analyses in case of known biases, resulting in standardized estimates of prevalence and incidence.

In addition to prevalence and incidence, GBD reports the burden of TBI/SCI using YLDs, which is estimated by multiplying prevalence counts with pre-determined disability weights [18]. These disability weights range from 0 (perfect health) to 1 (death) and represent the severity of the injury. Disability weights used for the calculation of YLDs for TBI/SCI are available in supplementary material 1, Table S1. Although TBI/SCI may cause mortality, GBD 2021 [18] does not define them as a cause of death, therefore mortality and YLLs are not provided.

2.5 Estimates of Causes

According to the GBD cause hierarchy [26, 27], the leading causes for TBI/SCI age-standardized incidence rates are reported at regional and national levels. GBD 2021 categorizes causes into 4 levels, with level 1 consisting of three categories (communicable, maternal, neonatal, and nutritional diseases; non-communicable diseases; and injuries), level 2 consisting of 22 clusters of causes, and level 3 and 4 specify these causes in more detail (see GBD 2021, appendix 1, Table S2 [27]). Injuries such as TBI/SCI are a level 1 cause, therefore causes of TBI/SCI are reported from injury-specific level 2 causes (unintentional injuries, self-harm and interpersonal violence, and transport injuries), with level 3 and 4 causes reported separately in the supplementary material.

2.6 Presentation of Estimates

All estimates are reported as total number or using the term rates, defined as the number of cases per 100,000 people, in an age-standardized population similar to previous GBD reports [18, 23]. Changes from 1990 to 2021 are reported as percentages. All metrics are reported alongside a 95% uncertainty interval (UI), defined as the 2.5th and 97.5th percentile of 500 draws for each estimate [18]. Estimates are further reported by corresponding gender and 5-year age groups.

3 Results

3.1 Regional Burden

Across the NAME region, TBI had 2.05 (95UI: 1.80, 2.35) million new cases, 3.45 (3.20, 3.74) total cases, and 0.51 (0.37, 0.67) million YLDs, with corresponding age-standardized rates of 333 (293, 380), 593 (553, 642), and 87 (63, 114) per 100,000 people in 2021 (Table S2). SCI had 0.59 (0.44, 0.81) million new cases, 1.58 (1.23, 2.14) million total cases, and 0.48 (0.31, 0.72) million YLDs, with corresponding age-standardized rates of 10 [7, 13], 256 (200, 344), 78 (51, 115) per 100,000 people in 2021 (Table S3). Compared to 1990, the age-standardized incidence rate of TBI has fallen by 13.4% (-18.4%, -7.8%) while the prevalence rate has risen by 9.2% (5.2%, 12.5%) and the YLD rate has fallen by 12.9% (-22.5%, -3.1%) (Table S2). The incidence rate (3.2%, 95UI: -17.3%, 25.7%) and prevalence rate (4.6%, 95UI: -6.2%, 14.5%) of SCI has remained

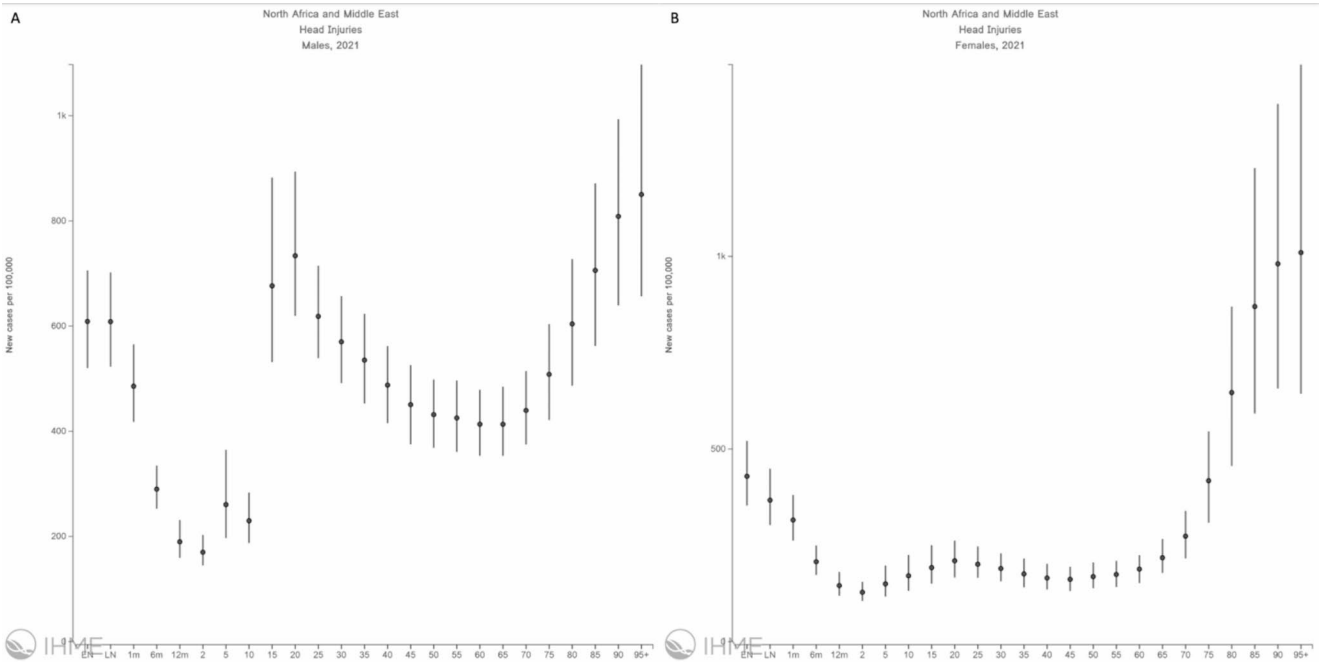

Fig. 1 Age-specific incidence rates of TBI in NAME region, 2021, males (**A**) and females (**B**)

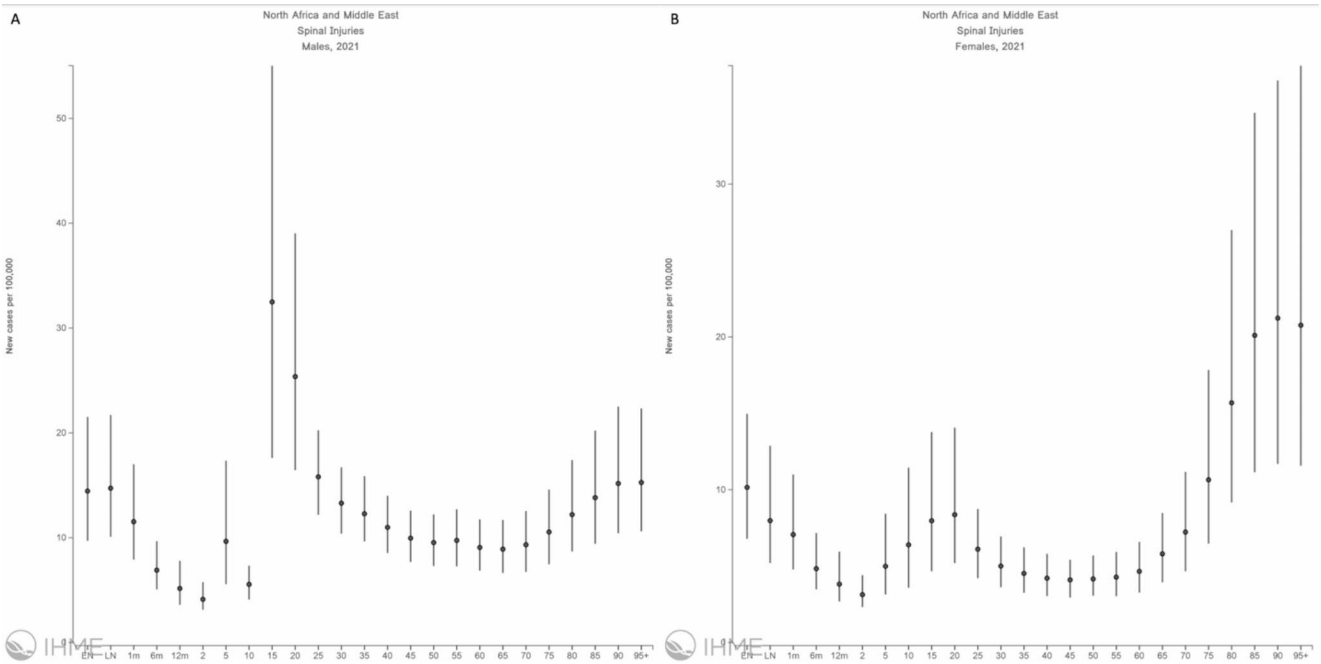

Fig. 2 Age-specific incidence rates of SCI in NAME region, 2021, males (**A**) and females (**B**)

unchanged, yet it's YLD rates have fallen an estimated 13% (-22.5%, -3.1%) (Table S3). Figures 1 and 2 show the regional age- and gender-specific incidence rate for TBI and SCI in 2021. For TBI, males have a higher incidence rate before 6 months and from 15 years to 60 years old, with a similar rate in other age-groups compared to females. Males have higher incidence rates after 85 years and between 15 and 20 years old compared to other age groups. For SCI males have a higher incidence rate from 15 years to 60 years old, with similar rates in other age-groups compared to females. Females have higher incidence rates after 85 years old compared to other age groups.

3.2 National Burden

Within the NAME region, the incidence rate of TBI mostly ranges between 200 and 450 cases per 100,000, with Yemen, Afghanistan, and Saudi Arabia being notable outliers, while SCI rates range between 4.3 and 8.4 cases per 100,000, with Saudi Arabia, Yemen, and Afghanistan as outliers (Figs. 3 and 4). Compared to 1990, the incidence rate of TBI has risen in Saudi Arabia, the Syrian Arab Republic, Yemen, and Afghanistan, remained stable in Libya, and fallen in other countries. SCI rates have risen in Saudi Arabia, the Syrian Arab Republic, Afghanistan, and Yemen, remained stable in Libya and Turkey, and fallen in other countries (Table S2 and S3). When assessing the annual % change of TBI incidence rates, Afghanistan, Yemen, Libya, and Saudi Arabia reported positive annual % change rates, Kuwait, Iran, Sudan, Oman, Algeria, Jordan, Egypt, Palestine, Qatar, and Tunisia reported negative annual % changes, while the rest of the region has reported stable annual % changes. The annual % change of SCI incidence rates have been positive in Afghanistan, Yemen, the Syrian Arab Republic, and Libya, negative in Kuwait, Lebanon, Iran, Sudan, Palestine, Iraq, Algeria, Oman, and Jordan, and stable in other countries (Figs. 3 and 4).

TBI prevalence rates mostly range between 300 and 750 cases per 100,000, with Libya, Iraq, Afghanistan, and Saudi Arabia having the highest TBI cases within the region, while SCI rates range between 100 and 400 cases per 100,000, with Iraq, Palestine, the Syrian Arab Republic, and Afghanistan having the highest rates (Figs. 3 and 4). Compared to 1990, the prevalence rate of TBI has decreased in Algeria, Egypt, Iran, Iraq, Lebanon, Oman, and Qatar, remained stable in Afghanistan, Sudan, and Kuwait, and increased in other countries. SCI prevalence rates, have risen in Libya, Turkey, Saudi Arabia, the Syrian Arab Republic, and Sudan, fallen in Algeria, Egypt, Iran, Iraq, Jordan, Lebanon, Palestine, Qatar, and Saudi Arabia, and remained stable in other countries (Table S2 and S3). The annual % change of TBI prevalence rates have been positive in the Syrian Arab Republic, and Saudi Arabia, negative in Lebanon, Oman, Iran, Algeria, Kuwait, Jordan, Morocco, Egypt, Qatar, Iraq, and Tunisia, and stable in other countries. The annual %

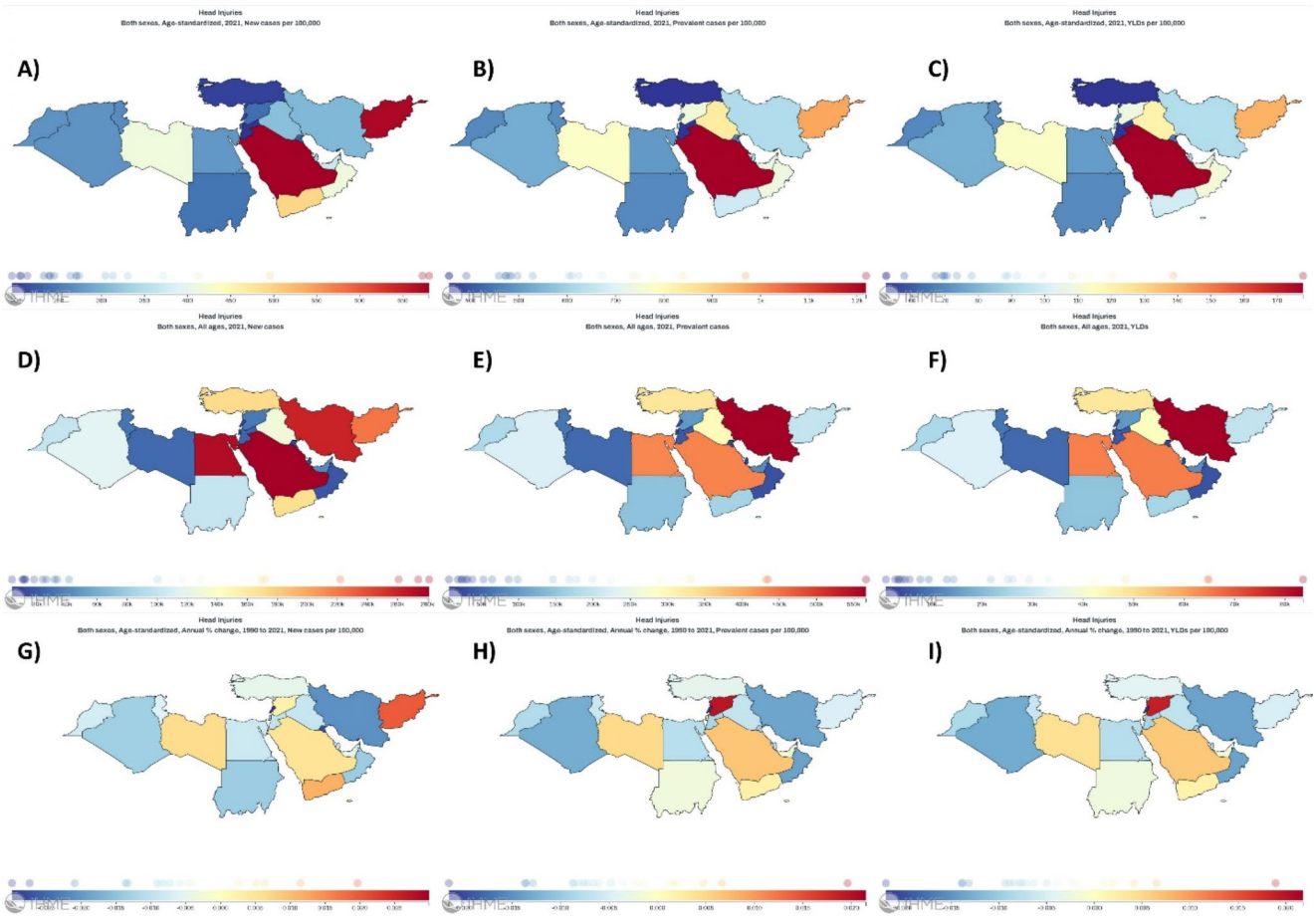

Fig. 3 NAME region map of TBI burden: age-standardized rates of incidence (**A**), age-standardized rates of prevalence (**B**), age-standardized rates of YLD (**C**), absolute number of incidence (**D**), absolute number of prevalence (**E**), absolute number of YLD (**F**), annual % change of incidence (**G**), annual % change of prevalence (**H**), annual % change of YLD (**I**)

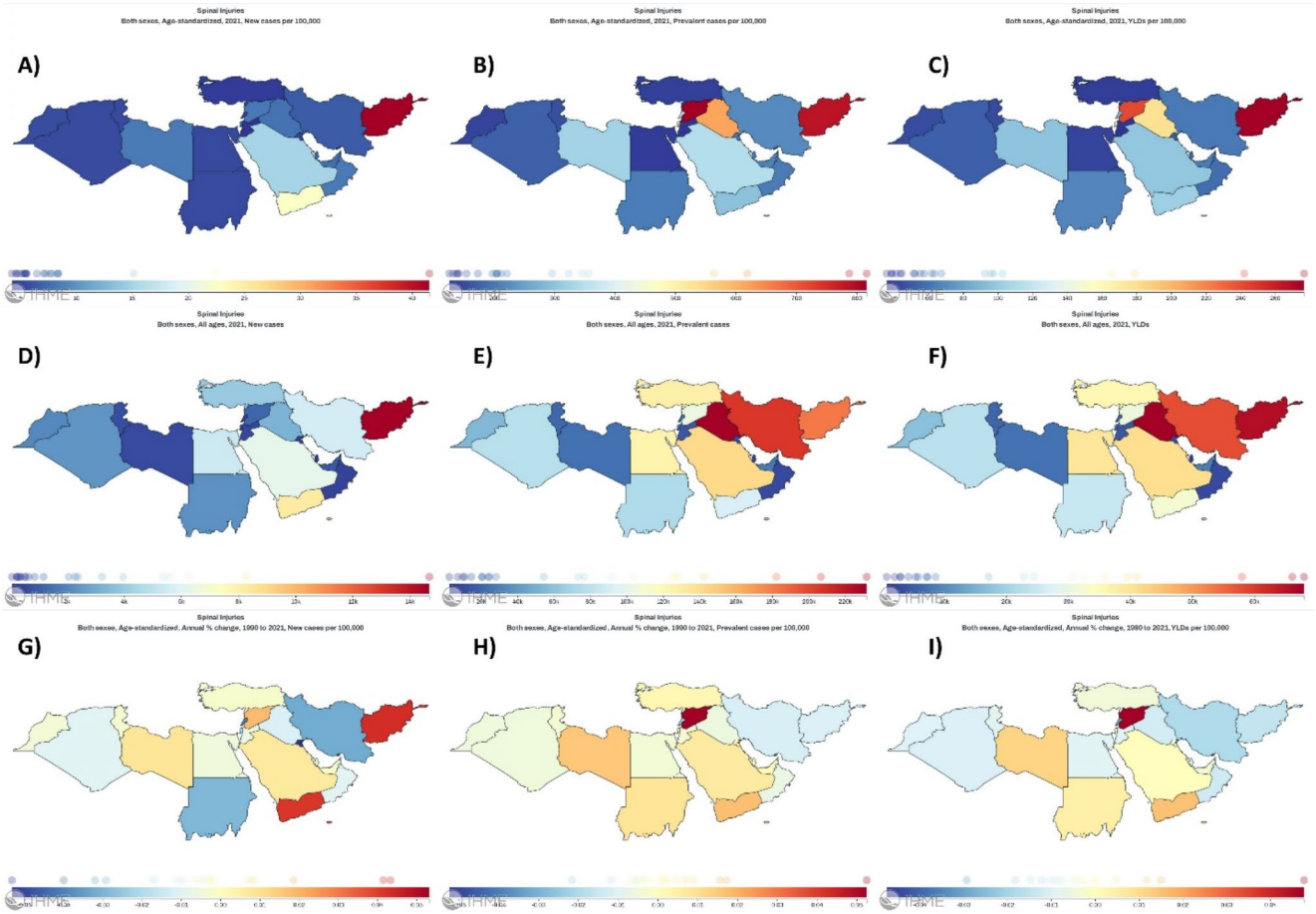

Fig. 4 NAME region map of SCI burden: age-standardized rates of incidence (**A**), age-standardized rates of prevalence (**B**), age-standardized rates of YLD (**C**), absolute number of incidence (**D**), absolute number of prevalence (**E**), absolute number of YLD (**F**), annual % change of incidence (**G**), annual % change of prevalence (**H**), annual % change of YLD (**I**)

change of SCI prevalence rates have been positive in the Syrian Arab Republic, Yemen, Libya, Sudan, and Saudi Arabia, negative in Lebanon, Iran, Afghanistan, Oman, Iraq, and Morocco, and stable in other countries (Figs. 3 and 4).

TBI YLD rates mostly range from 45 to 110 YLDs per 100,000, with Iraq, Libya, Saudi Arabia, and Afghanistan having the highest YLDs, while SCI YLD rates range from 30 to 120 YLDs per 100,000, with Iraq, Palestine, the Syrian Arab Republic, and Afghanistan having the highest YLDs (Figs. 3 and 4). Compared to 1990, the YLD rate of TBI has remained stable in Libya, Palestine, Yemen, and Sudan, increased in Saudi Arabia and the Syrian Arab Republic, and fallen in other countries. Similarly, SCI YLD rates remained stable in Palestine, Saudi Arabia, and Afghanistan, increased in Libya, the Syrian Arab Republic, Yemen, and Sudan, and fallen in other countries (Table S2 and S3). Annual % change of TBI YLD rates has been positive in the Syrian Arab Republic and Saudi Arabia, negative in Lebanon, Iran, Oman, Algeria, Kuwait, Jordan, Morocco, Egypt, Qatar, Iraq, Tunisia, and Bahrain, and stable in other countries. Annual % change of SCI YLD rates has been positive in the Syrian Arab Republic, Yemen, and Libya, negative in Lebanon, Iran, Afghanistan, Oman, Iraq, Algeria, Morocco, Egypt, Tunisia, Qatar, and Bahrain, and stable in other countries (Figs. 3 and 4).

3.3 Leading Causes

The cause-specific incidence rate of TBI and SCI are shown in Fig. 5. Regionally, transport injuries were the main cause of TBI, while unintentional injuries were the main cause for SCI. Across the region, the most common cause for TBI was transport injuries, except in Afghanistan, where self-harm and interpersonal violence were the main cause and Turkey, Palestine, Lebanon, and Kuwait where unintentional injuries where the most common. The most common cause for SCI was unintentional injuries, except for Afghanistan, Yemen, and Iraq where interpersonal violence and self-harm was the main cause and Iran, Libya, Oman, and the United Arab Emirates where transport injuries where the main cause. The leading causes of TBI and SCI at national levels are available in the Tables S4-S9.

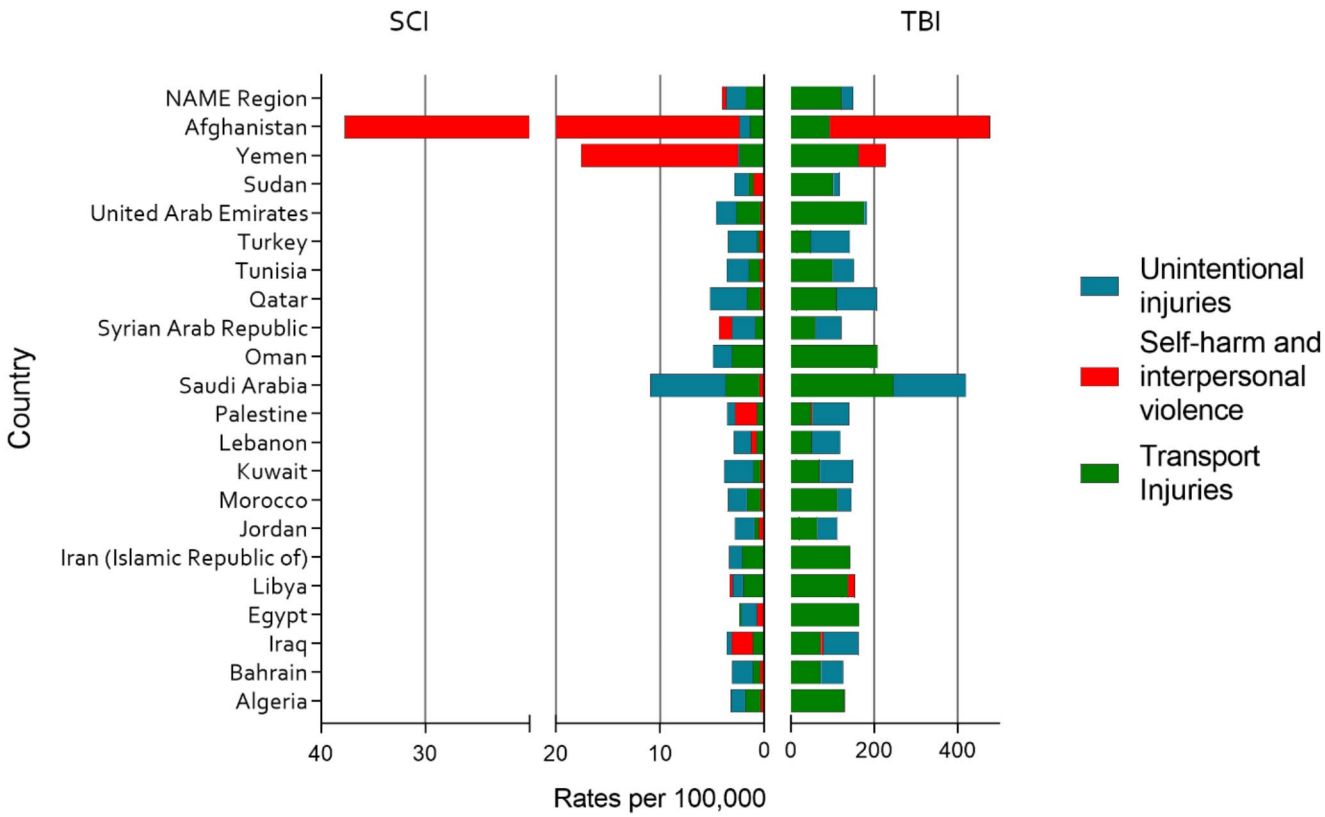

Fig. 5 Incidence rates of most common causes of TBI and SCI in NAME region and its countries

4 Discussion

This report provided the most up-to-date regional and national burden of TBI and SCI in NAME using data from GBD 2021. It was demonstrated that Across the NAME region, TBI had 2.05 million new cases, 3.45 million total cases, and 0.51 million YLDs, while SCI had 0.59 million new cases, 1.58 million total cases, and 0.48 million YLDs. In addition, the variations between leading causes of TBI and SCI in the 21 countries of NAME were presented. The main cause of TBI was transport injuries in most countries, and SCI was most often caused by unintentional injuries.

In accordance to the trends observed globally [9], the age-standardized incidence rates of TBI have decreased significantly relative to 1990. This decrease has been at least attributed to global initiatives and resolutions that have focused on preventing road-related injuries [28], which have been identified as the most common cause of TBI. For instance, in 2004, the world report on prevention of road traffic injuries launched by the World Health Organization (WHO) emphasized the importance of legislation to control speed and alcohol consumption, mandating the use of seatbelts and crash helmets, and the safer design and use of roads and vehicles [29]. Through the advocacy for and implementation of relevant legislations, the European union was able to halve the risk of road traffic injuries in a decade-long period [30], and a great number of countries have also set goals to reduce the risk of road traffic injuries [29]. With this in mind, the increase in TBI rates in Afghanistan and Yemen could also be justified by causes other than transport-related injuries_ such as military conflicts. The decrease of TBI incidence can be explained by the reduction of road traffic injuries across the region and most countries in the past decades [31]. Studies have shown this reduction may not be correlated with the implementation of best practices for road safety recommended by the world health organization [32], and therefore we recommend stricter vehicle safety designs [33]. Another explanation could be the significant improvements in healthcare systems in the region [34], ultimately leading to lower mortality rates among patients and, as a result, increased prevalence. However, given the fact that the decrease in incidence of TBI cases has been larger in magnitude than the increase in prevalence, the YLDs attributed to TBI have ultimately decreased.

The global incidence of SCI has remained steady [9], with the trend remaining consistent in the NAME region since 1990. While efforts have been successful in reducing TBI rates as explained previously, the challenge in reducing SCI rates lies within the difficulty to control its etiology. SCIs are not most commonly caused by transport-related

injuries, unlike TBIs. Instead, they are mostly due to unintentional injuries such as falls, which are speculated to be common among the elderly [35]. With the increase in the proportion of the elderly population as a result of increased life expectancy in the region [36], a greater portion of the population is at risk relative to 1990. Additionally, the swift growth of the construction and manufacturing sectors in several developing NAME countries, along with a clear absence of safety measures and occupational safety regulations [16] could explain the stability of the SCI rates, and even their upward trajectory in a rapidly-developing country such as Saudi Arabia. And lastly, it should be noted that the incidence rates of SCI were markedly higher in countries that were experiencing military conflicts at the time of gathering this data, serving as another lens through which the rates can be interpreted [37]. The decrease in SCI YLDs can also be ascribed to better healthcare, as interventions such as locomotor training have demonstrated potential for improving functional ambulation [38].

Males had higher incidence rates of TBI and SCI in most age groups, with only 1–10 year olds and adults older than 65 having similar rates. This is consistent with previous epidemiological surveys [39, 40], and may be due to males participating in more high risk behaviors and extreme sports [41–43]. This gender gap in risk taking decreases in higher age groups, which would explain why the rates become similar after 65 [43]. Policy makers aiming to reduce the incidence of TBI and SCI can employ policies aimed at reducing risk behaviors in males. These measures include supportive school environments [44] and parental monitoring for adolescents [45], and reductions in childhood adverse events for adults [46].

4.1 Future Research and Limitations

Firstly, the data estimates of GBD studies depend on patients having medical records, which may lead to an underestimation of incidence and prevalence rates, esp. in low-income and those experiencing military conflicts. This limitation is particularly highlighted by the fact that expert estimates of TBI have been much higher than the cases recorded by GBD data in the past [9, 47]. Second, the GBD study reports modelled estimates rather than observed data, and these estimates are often presented with more certainty than it is due given the limitation in data used to construct the estimates, esp. in regions with a large number of developing countries such as NAME. To better understand and compare the limitations of the primary sources in each country, it is advised that these sources be reported using the GBD sources tool. However, this tool does not categorize the sources by the nature of injury. As TBI and SCI are specified as natures of injury in the database, we were unable to report the sources used to model the data reported in this study. Third, it should be noted that our speculations and reasonings regarding the causes of TBI and SCI and how they affect the associated burden should be studied further by large national cohorts in each country. Further, it is crucial that, based on these studies, interventions designed and implemented to lower the burden of TBI and SCI. In addition, special attention in the form of global initiatives should be provided to countries military conflicts in order to alleviate the burden of injuries to the central nervous systems.

5 Conclusion

The regional age-standardized incidence rates of TBI have decreased since 1990, whereas SCI incidence rates have remained stable. National measures of burden are variable, with the burden of TBI most often caused by transport injuries, while unintentional injuries were the main cause of SCI. Males have higher incidence rates in most age groups, and should be given more attention. These findings highlight the need for targeted public health initiatives and allow health professionals of the NAME region to prevent and manage TBI and SCI according to their national burden and leading cause.

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Data Availability All data has been presented in the manuscript.

Declarations

Ethics approval and consent to participate Not applicable, this systematic review and meta-analysis was registered in PROSPERO.

Consent for Publication Not applicable.

Competing Interests The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript.

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