



Need for neurorehabilitation in the Middle East and North Africa from 1990 to 2021: an analysis based on the global burden of disease study

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Background: This study will present the burden of diseases needing neurorehabilitation in Middle East and North Africa (MENA) countries and describe their epidemiology across age and sex groups.

Materials and methods: This study was conducted based on the Global Burden of Disease (GBD) 2021 findings. The authors used years of healthy life lost due to disability (YLD) as a proxy for the need for neurorehabilitation, and extracted the YLD rates and counts for neonatal encephalopathy due to birth asphyxia and trauma, stroke, neural tube defects, Parkinson's disease (PD), motor neuron disease, multiple sclerosis (MS), tension-type headache, other neurological disorders (except migraine, dementia, and epilepsy), head injuries, spinal injuries, nerve injury, and asphyxiation across age groups, sexes, and MENA countries.

Results: YLD rates of disorders needing neurorehabilitation in 1990 and 2021 were 408.08 and 496.19 per 100 000 people, respectively, indicating a 21.59% rise in YLD. Stroke had the highest YLD rates in both 1990 (150.19 per 100 000) and 2021 (192.75 per 100 000). Syria, Saudi Arabia, and the United Arab Emirates had the highest YLD rates for conditions needing neurorehabilitation

Conclusions: Considering the growing demand for neurorehabilitation with the aging of populations and the historical shortage of rehabilitation services in the region, the gap between the demand and supply may further increase in the coming years, leading to consequences for people living with neurological conditions in the region.

Keywords: Middle East And North Africa, neurological disorders, rehabilitation

Introduction

Neurological disorders, a diverse set of clinical conditions, affect 3.4 billion individuals worldwide^[1]. These disorders arise from peripheral or central nervous system damage and include various prevalent disorders, such as stroke, Parkinson's disease, dementia, and traumatic brain injury^[2]. Neurological disorders pose a significant burden on global health as they are the leading cause

HIGHLIGHTS

- The study reports a 21.59% increase in YLD rates for conditions requiring neurorehabilitation in the MENA region from 1990 to 2021.
- Stroke had the highest YLD rates among all conditions needing neurorehabilitation in both 1990 and 2021.
- Syria, Saudi Arabia, and the UAE exhibit the highest YLD rates for conditions requiring neurorehabilitation.

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of disability and the second leading cause of death worldwide^[3]. Being difficult or intractable to cure with mere medicines, these disorders mainly require rehabilitation, that is neurorehabilitation, to improve the quality of life of the affected people^[4].

Neurorehabilitation comprises interdisciplinary care to help patients sustain optimal function in interaction with their environment, independence, and social interactions^[5]. People with neurological disorders can benefit from neurorehabilitation in various ways, including help with everyday activities, speech, bladder and bowel retraining, movement, cognition, and mental health^[6]. There is no data on the need for neurorehabilitation, especially in low-income countries and middle-income countries that show the highest increases in death rates and prevalence of neurological disorders in the past 30 years^[7]. The aging of the global population makes it necessary to assess the need for neurorehabilitation, as age acts as a risk factor for many neurological disorders^[8].

In the Middle East and North Africa (MENA) region, estimates show that the number of older people (> 65) will triple from 4.1% in 2010 to about 12% in 2050^[9]. Epidemiological

assessments help provide the background for future policy-making in these countries. To present this, we aimed to conduct the present study on the need for neurorehabilitation in the MENA region from 1990 to 2021. Analyzing the data on the global burden of disease (GBD), we will present the burden of diseases needing neurorehabilitation in MENA countries and describe their epidemiology across age and sex groups.

Materials and methods

Overview

This work has been reported in line with the strengthening the reporting of cohort, cross-sectional and case-control studies in surgery (STROCSS) (Supplemental Digital Content 1, <http://links.lww.com/MS9/A605>) criteria^[10]. This study was conducted based on the GBD 2021 findings. The methodological aspects of the GBD 2021 study have been reported in detail elsewhere^[11–13]. In brief, the GBD study was conducted to estimate the burden attributable to 371 diseases and injuries and 88 risk factors across 204 countries and territories. We utilized the GBD results tool to extract the data (<https://vizhub.healthdata.org/gbd-results/>).

Need for neurorehabilitation

We utilized Jesus *et al.*^[14] framework to determine the neurological conditions benefiting from neurorehabilitation and determine the need for neurorehabilitation for these conditions. We selected the neurological conditions from their conservative list of conditions that were historically deemed to benefit from physical rehabilitation (Table 1).

We used years of healthy life lost due to disability (YLD) attributable to these conditions as a proxy for the need for neurorehabilitation, as this measure indicates the years a person has lived with a disability that would benefit from physical rehabilitation^[14]. In the GBD study, the number of people living with specific conditions (prevalence) was multiplied by the relevant disability weight to determine the YLD. The distribution of people with varying severities of each condition is also considered when calculating YLD. These disability weights range from 0 to 1, where 1 represents death and 0 represents full health^[11].

Table 1
Conditions included in this study to determine the need for neurorehabilitation

Conditions	
Neonatal encephalopathy due to birth asphyxia and trauma	
Stroke	
Neural tube defects	
Neurological disorders	Parkinson's disease
	Motor neuron disease
	Multiple sclerosis
	Tension-type headache
	Other neurological disorders (except migraine, dementia, and epilepsy)
Injury by nature	Head injuries
	Spinal injuries
	Asphyxiation
	Nerve injury

Indices and analyses

We extracted the prevalence and YLD rates and counts of the neurological conditions benefiting from neurorehabilitation, including neonatal encephalopathy due to birth asphyxia and trauma, stroke, neural tube defects, PD, motor neuron disease, multiple sclerosis (MS), tension-type headache, other neurological disorders (except migraine, dementia, and epilepsy), head injuries, spinal injuries, nerve injury, and asphyxiation across age groups, sexes, and countries. The MENA countries included Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Türkiye, the United Arab Emirates, and Yemen. For both YLD and prevalence values, we extracted the 95% uncertainty intervals (UI).

Furthermore, we extracted the all-causes YLD rates and calculated the percentage of YLD benefiting from neurorehabilitation by dividing the total YLD rate benefiting from neurorehabilitation by the all-causes YLD rate.

We extracted the sociodemographic index (SDI) values across years and countries. SDI values range from 0 to 1, with higher values indicating greater development and better sociodemographic status. SDI is determined by considering the fertility rate of those younger than 25, the mean education level of people aged 15 or older, and the lag-distributed income per capita. We assessed the association between SDI and YLD across MENA countries and years using locally weighted scatterplot smoothing (LOWESS) regression.

We used Python version 3.8, and the Folium, Numpy, Matplotlib, Statsmodels, and Pandas libraries for the analyses.

Results

Prevalence and YLD in MENA

The total prevalence rate of disorders needing neurorehabilitation in the MENA region was 26023.67 per 100 000 people in 1990. Marking a 6.98% total increase from 1990, this prevalence rate reached 27 840.89 per 100 000 people in 2021. Similarly, the total YLD rates increased from 1990 to 2021; YLD rates of disorders needing neurorehabilitation in 1990 and 2021 were 408.08 and 496.19 per 100 000 people, respectively, indicating a 21.59% rise in YLD. Tension-type headaches had the highest prevalence rates in both 1990 (24 118.06 per 100 000 people) and 2021 (25 491.35 per 100 000 people). Moreover, stroke had the highest YLD rates in both 1990 (150.19 per 100 000) and 2021 (192.75 per 100 000).

As shown in Table 2 and Figure 1, most disorders needing neurorehabilitation showed an increasing trend in prevalence and YLD rates when comparing 1990 and 2021. The highest percentage increase in both prevalence and YLD was related to Parkinson's disease, as its prevalence increased from 59.03 to 149.12 per 100 000 people (152.61% change), and its YLD increased from 8.44 to 21.17 (150.74% change). Only four disorders exhibited decreasing rates in prevalence and YLD: neural tube defects, spinal injuries, asphyxiation, and nerve injury. Among them, neural tube defects had the highest percentage decrease in prevalence (from 19.02 to 14.27 per 100 000 people, -24.99% change). Meanwhile, asphyxiation showed the highest percentage decrease in YLD among these disorders; its YLD rate reduced from 0.04 in 1990 to 0.02 per 100 000 in 2021 (-35.34% change).

Table 2
Prevalence and YLD rates of neurological disorders that need neurorehabilitation in the Middle East and North Africa

Disorder	Prevalence rate (per 100 000 people)			YLD rate (per 100 000 people)		
	1990	2021	Percentage change	1990	2021	Percentage change
Neonatal encephalopathy due to birth asphyxia and trauma	132.77 [93.06–188.02]	239.07 [207.47–270.71]	80.06%	29.95 [15.21–57.66]	54.29 [39.29–70.85]	81.24%
Stroke	945.24 [896.08–997.96]	1188.85 [1128.2–1258.79]	25.77%	150.19 [108.33–190.88]	192.75 [139.21–246.15]	28.34%
Parkinson's disease	59.03 [51.55–68.05]	149.12 [132.27–170.06]	152.61%	8.44 [5.94–11.27]	21.17 [14.87–27.97]	150.74%
Multiple sclerosis	18.84 [16.28–21.85]	23.92 [21.4–26.79]	27.00%	4.87 [3.41–6.41]	6.13 [4.35–7.98]	25.91%
Motor neuron disease	3.04 [2.57–3.55]	3.46 [2.99–3.97]	13.84%	0.65 [0.45–0.89]	0.73 [0.52–0.99]	13.65%
Tension-type headache	24 118.06 [21 045.79–27 507.76]	25 491.35 [22 512.54–28 776.57]	5.69%	53.41 [15.39–179.31]	58.25 [17.07–190.25]	9.06%
Other neurological disorders	0.69 [0.46–0.94]	0.8 [0.55–1.06]	15.57%	0.0	15.15 [9.79–21.91]	69.80%
Neural tube defects	19.02 [15.75–22.55]	14.27 [12.23–16.54]	-24.99%	5.59 [3.85–7.7]	4.22 [2.91–5.78]	-24.53%
Head Injuries	463.95 [447.38–484.61]	480.63 [460.43–503.99]	3.59%	67.32 [47.49–90.56]	69.45 [49.04–92.9]	3.17%
Spinal Injuries	202.87 [186.32–222.02]	195.16 [177.52–216.38]	-3.80%	66.23 [46.76–86.26]	57.86 [40.5–76.12]	-12.63%
Asphyxiation	0.15 [0.08–0.23]	0.1 [0.05–0.16]	-35.35%	0.04 [0.02–0.06]	0.02 [0.01–0.04]	-35.34%
Nerve Injury	60.01 [54.72–66.41]	54.16 [49.42–60.16]	-9.75%	6.24 [4.21–8.59]	5.58 [3.85–7.62]	-10.65%
Total	26 023.67	27 840.89	6.98%	408.08	496.19	21.59%

^aAll P-values < 0.001 except P=0.327.
^bP=0.538.

Age and sex patterns

The prevalence and YLD rates of disorders needing neurorehabilitation across age groups were also assessed for 1990 and 2021. The < 5 age group showed the lowest prevalence and YLD rates in 1990 and 2021 across the two sexes. In 1990, the highest prevalence rates of disorders needing neurorehabilitation in females belonged to the 70–74 age group (41 548.56 per 100 000 people), while the highest rates in males were related to the > 95 age group (41 501.21 per 100 000 people). Regarding the YLD values, the 75–79 age group showed the highest YLD in females (1190.87 per 100 000), and the 80–84 age group exhibited the highest YLD in males (1494.51 per 100 000). In 2021, the > 95 age group had the highest prevalence rates in both females (41 909.07 per 100 000) and males (44 761.11 per 100 000). Moreover, both females and males showed the highest YLD rates in the age group 80–84 in 2021, with values of 1411.70 and 1760.46 per 100 000, respectively.

As shown in Figure 2, males exhibited higher YLD counts across all ages in both 1990 and 2021 when compared to females. The only exception was the +95 age group in 1990, when females had greater YLD counts than males. The prevalence counts of disorders needing neurorehabilitation showed a more heterogeneous pattern. In 1990, males had higher prevalence counts than females in all age groups except for 20–24 and >75 years of age. Meanwhile, in 2021, males predominantly had higher prevalence counts than females except for 20–24, 60–84, and +95 years of age.

Figures 3 and 4 present the prevalence and YLD rates of each disorder needing neurorehabilitation in 1990 and 2021 across age groups. In 2021, tension-type headache made up the most prevalent disorder among all age groups, except for those < 5 years old that neonatal encephalopathy due to birth asphyxia and trauma had the highest prevalence (210.84 per 100 000). Moreover, in 2021, stroke had the highest YLD rates in age groups from 45 to +95. The other age groups showed a heterogeneous pattern. The disorders with the highest YLD rates included neonatal encephalopathy due to birth asphyxia and trauma for the ages < 5 to 14, tension-type headache for 15–19, spinal injuries for 20–34, and head injuries for 35–44 age groups.

Differences in countries

We estimated the prevalence and YLD rates of each disorder in all MENA countries in 1990 and 2021. As presented in Figure 5, in 1990, Qatar, Iran, and the United Arab Emirates had the highest pooled prevalence of disorders needing neurorehabilitation, respectively. In 2021, the same three countries had the highest pooled prevalence; Iran was the country with the highest pooled prevalence of disorders needing neurorehabilitation, followed by the United Arab Emirates and Qatar. Comparing 1990 and 2021, all the countries faced an increase in the pooled prevalence of these disorders except Afghanistan, which experienced a -5.58% reduction. The countries with the highest increases in the pooled prevalence included Syria (+27.69%), Saudi Arabia (+24.96%), and Libya (+23.75%). S1 and S2 Figures (Supplemental Digital Content 2, <http://links.lww.com/MS9/A606>) show the choropleth map of MENA countries and their prevalence and YLD rates in 1990 and 2021.

In 2021, the top three disorders needing rehabilitation regarding prevalence rates were tension-type headaches, strokes, and head injuries, respectively, in the MENA countries. The exceptions included Afghanistan (tension-type headaches > head injuries > spinal injuries), Saudi Arabia (tension-type headaches

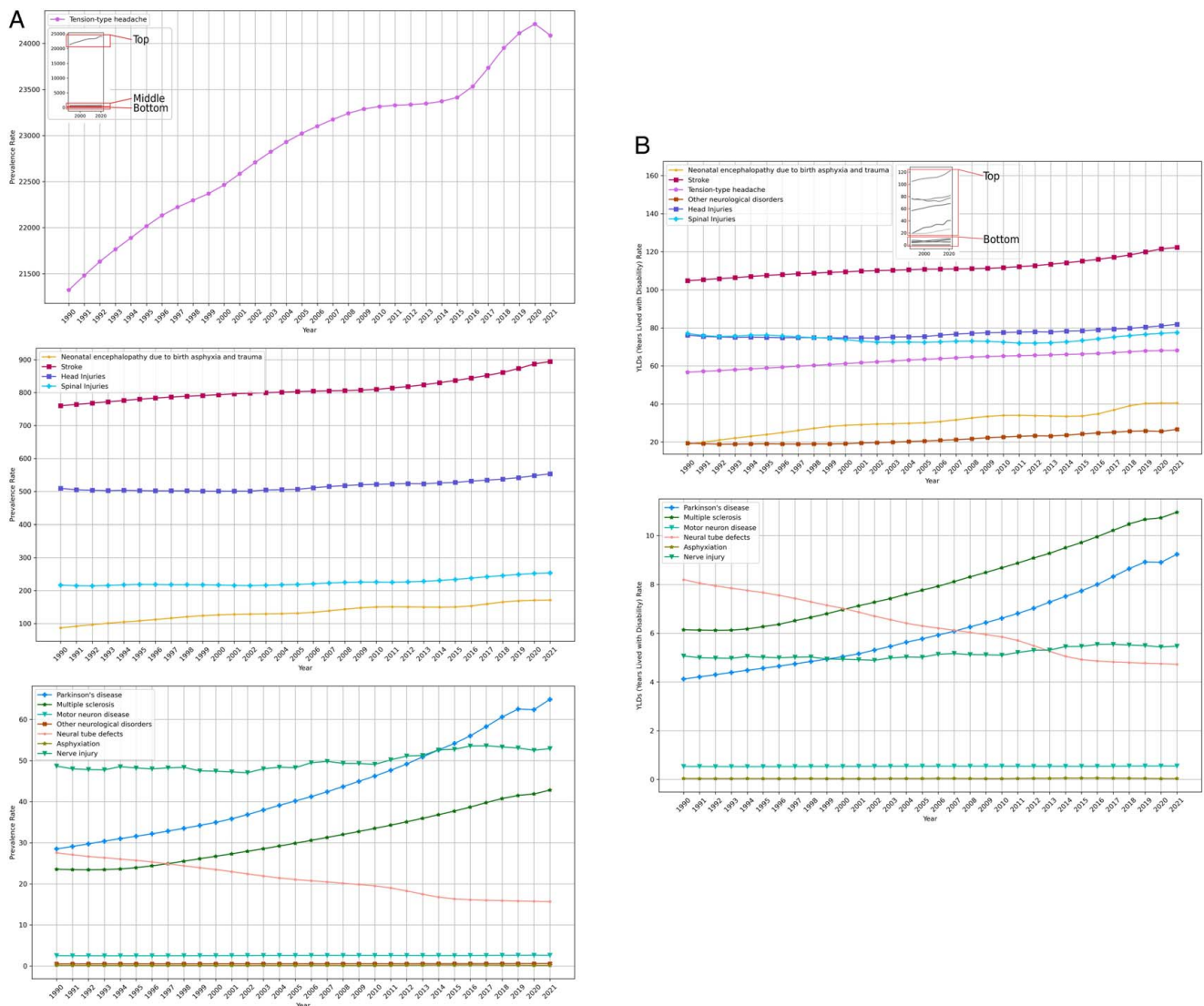


Figure 1. Trends in prevalence (A) and YLD (B) rates of disorders needing neurorehabilitation in the Middle East and North Africa. YLD, years of healthy life lost due to disability.

> head injuries > stroke), Palestine, and Syria (both tension-type headaches > stroke > spinal injuries).

We also reported the YLD rates of disorders needing neurorehabilitation in 1990 and 2021, as shown in Figure 5. In 1990, the countries with the most need for neurorehabilitation included Afghanistan, Lebanon, and Iraq, whereas the top three countries in 2021 were as follows: Syria, Saudi Arabia, and the United Arab Emirates. Comparing the data of 1990 and 2021, the need for neurorehabilitation by YLD rates increased in all MENA countries. The exceptions included Qatar, Iraq, Lebanon, and Afghanistan, in which YLD was reduced (−2.06%, −4.66%, −17.41%, and −29.92%, respectively). Among the MENA countries, Syria (+107.71%), Libya (+58.49%), and Saudi Arabia (+53.33%) had the most dramatic increases in the need for neurorehabilitation comparing 1990 and 2021.

In 2021, stroke made up the main cause of the need for neurorehabilitation in all MENA countries except for six countries. In Afghanistan, Iraq, Palestine, Syria, and Yemen, spinal injuries

were the disorders with the highest YLD rates. Meanwhile, head injuries were the main cause of the need for neurorehabilitation in Saudi Arabia. Finally, Table 3 shows the percentage of YLD rates attributable to disorders needing neurorehabilitation. In 2021, Afghanistan (5.27%), Saudi Arabia (5.22%), and Syria (5.16%) had the highest percentages mentioned in MENA.

Associations with socioeconomic profiles

Finally, the association between the YLD rate and SDI is presented in Figure 6. The expected line shows a downward slope until an SDI of about 0.4, after which it has an upward slope.

Discussion

This study, to the best of our knowledge, is the first one providing a comprehensive overview of the need for neurorehabilitation in MENA; it can guide the policies for tertiary prevention and help

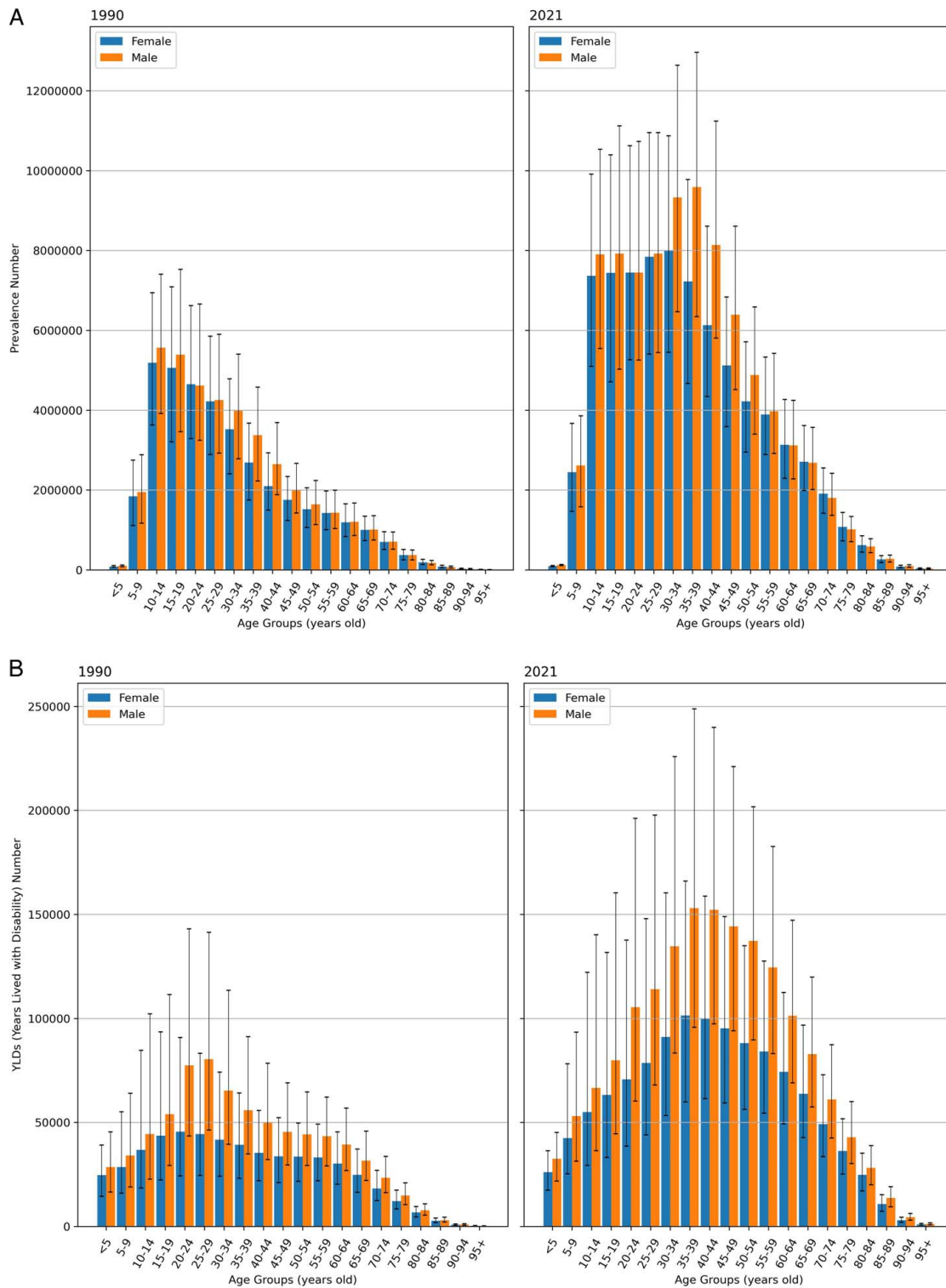


Figure 2. Comparison of prevalence (A) and YLD counts (B) of conditions needing neurorehabilitation across age groups and genders in the Middle East and North Africa in 1990 and 2021. MENA, the Middle East and North Africa; YLD, years of healthy life lost due to disability.

provide rehabilitation services for neurological conditions. Our findings indicated an increasing trend in the need for neurorehabilitation in the region and stroke was the main condition needing neurorehabilitation.

We found that the YLD rate of neurological conditions needing neurorehabilitation increased by 21.6% from 408.1 in 1990 to 496.2 per 100 000 people in MENA in 2021. Previous studies using the GBD database on the need for rehabilitation have not

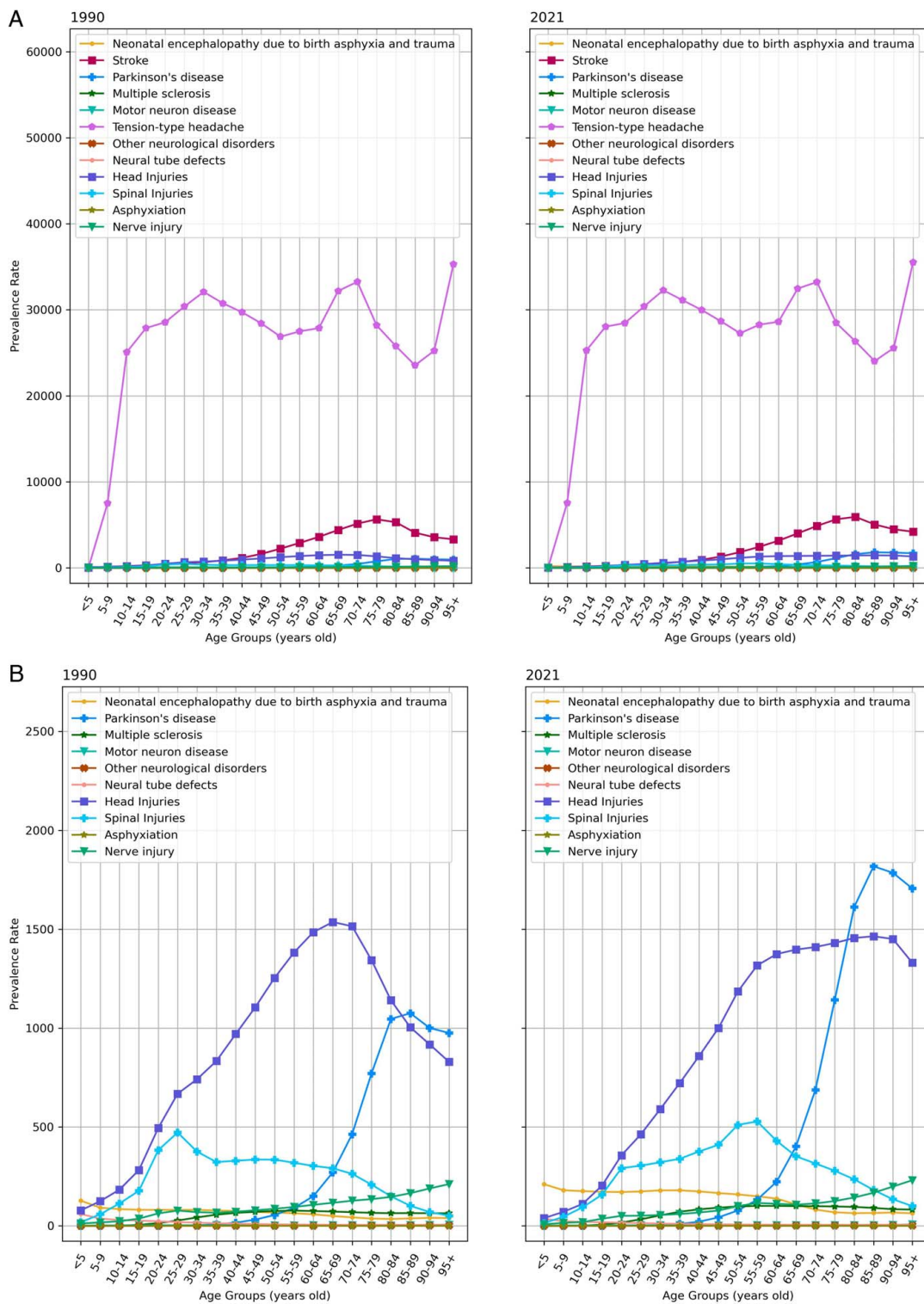


Figure 3. Comparison of prevalence rates of disorders requiring neurorehabilitation (A) and the same disorders excluding stroke and tension-type headache (B) across age groups in 1990 and 2021.

explicitly focused on neurological conditions. Instead, they have assessed these conditions within the broader context of disorders requiring physical rehabilitation. Jesus *et al.*^[15] found that the YLD rate of neurological conditions needing rehabilitation

increased by 31.1% from 441 in 1990 to 578 per 100 000 in 2017. In another study, Cieza *et al.*^[16] estimated the age-standardized YLD rate of neurological conditions to be 6.4 per 1000 people in 2019, indicating an 11% increase compared to

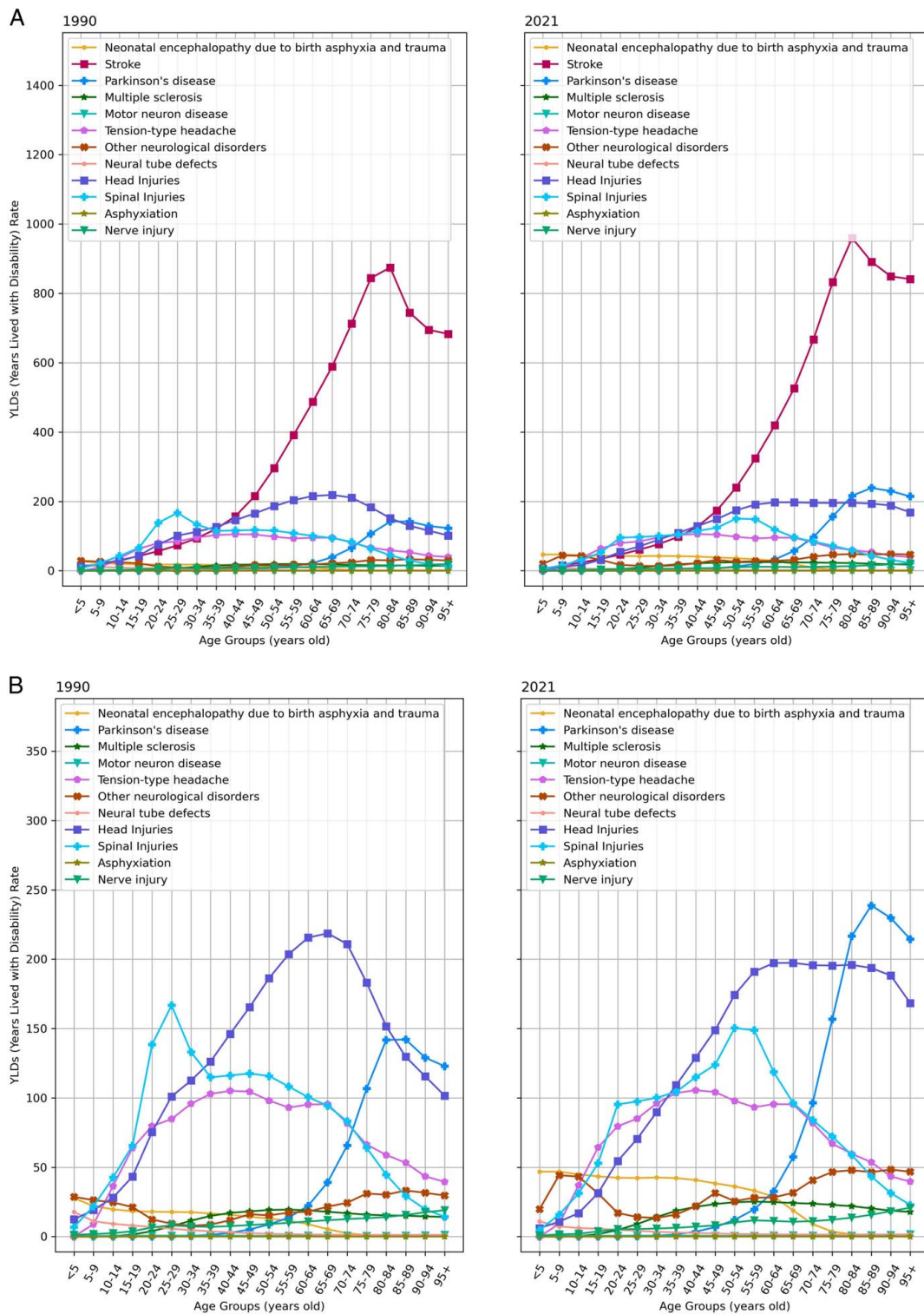


Figure 4. Comparison of YLD rates of disorders requiring neurorehabilitation (A) and the same disorders excluding stroke (B) across age groups in 1990 and 2021. YLD, years of healthy life lost due to disability.

1990. Overall, despite regional differences in the rate of increase, it appears there is an increasing trend in the need for rehabilitation in MENA, which aligns with global trends. Differences in identifying conditions needing neurorehabilitation and the

metrics reported in various studies may also contribute to the discrepancies across studies. The increasing need for neurorehabilitation is likely due to improved health conditions in MENA and increased life expectancy in recent years, resulting in a higher

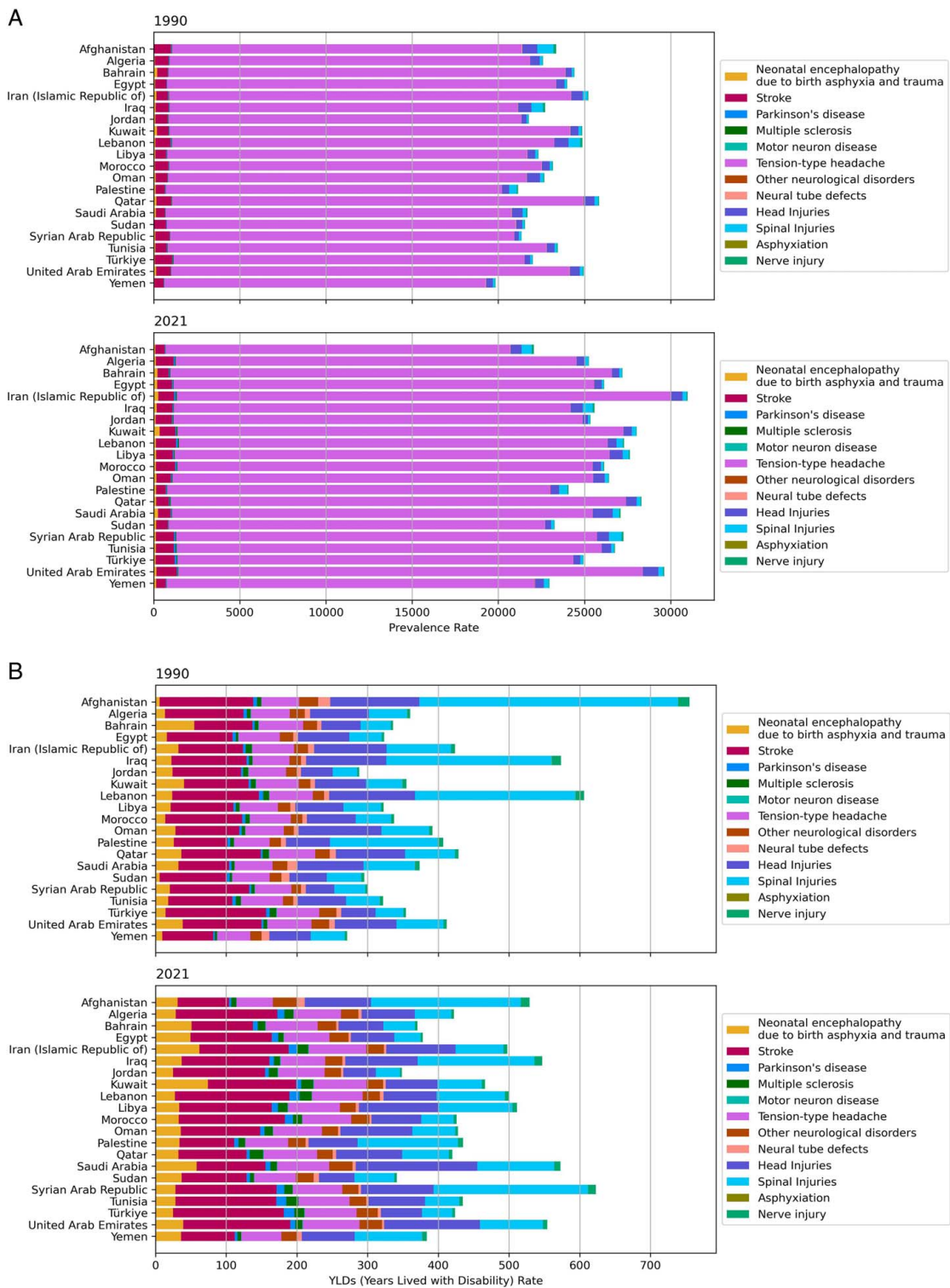


Figure 5. Prevalence (A) and YLD (B) rates of causes requiring neurorehabilitation across MENA countries in 1990 and 2021. MENA, the Middle East and North Africa; YLD, years of healthy life lost due to disability.

prevalence of chronic neurological conditions that require physical rehabilitation^[17–20]. Despite the increasing need for physical rehabilitation, including neurorehabilitation, in the MENA region, studies have found a significant shortage of rehabilitation services^[21]. This may be attributed to several factors, such as a

lack of rehabilitation facilities and equipment, a shortage of trained staff and specialists, and insufficient health budgets^[21,22]. Considering the ongoing challenges in implementing neurorehabilitation facilities in MENA countries and the increasing demand for these services, this imbalance between supply and

Table 3
Percentage of YLD rates attributable to conditions needing neurorehabilitation across the Middle East and North Africa countries

Location	1990	2021
Global	4.02%	4.32%
Middle East and North Africa	4.03%	4.08%
Afghanistan	6.44%	5.27%
Algeria	4.12%	4.01%
Bahrain	3.71%	3.36%
Egypt	3.52%	3.89%
Iran	4.56%	4.06%
Iraq	5.99%	5.07%
Jordan	3.53%	3.43%
Kuwait	4.13%	4.07%
Lebanon	5.66%	3.83%
Libya	3.82%	4.28%
Morocco	3.52%	3.55%
Oman	4.68%	4.39%
Palestine	4.68%	4.33%
Qatar	4.83%	4.12%
Saudi Arabia	4.24%	5.22%
Sudan	3.01%	3.54%
Syrian Arab Republic	3.51%	5.16%
Tunisia	3.49%	3.41%
Türkiye	3.74%	3.56%
United Arab Emirates	4.64%	4.84%
Yemen	2.62%	3.56%

demand can have severe consequences for individuals with neurological conditions and related disabilities, impacting their function, quality of life, and life expectancy in the coming years.

In both 1990 and 2021, stroke, head injuries, and spinal injuries were the main causes of YLD in MENA. This finding aligns with a previous study on the burden of neurological disorders in MENA, which identified stroke as having the highest YLD count compared to other neurological conditions^[23]. Therefore, programs aimed at promoting neurorehabilitation services in the MENA region should particularly focus on stroke rehabilitation services. A survey of 34 hospitals in 19 countries, including 15 in the MENA region, found that rehabilitation services were available in 88.2% of the hospitals^[24]. However, because some countries, such as Syria and Palestine, were affected by conflicts in the region, they were not included in the study; the actual situation may be worse and the findings may not fully capture the state of stroke rehabilitation services in the region. Telerehabilitation is one of the proposed interventions to enhance access to care and long-term care support for poststroke survivors^[25]. However, stroke tele rehabilitation remains an understudied area in the MENA region, and such services are not widely available in MENA^[22]. Therefore, considering that about 34% of the MENA population lives in rural areas, enhancing telerehabilitation services for stroke survivors, despite the possible challenges and barriers, can be an effective strategy to improve access to care for people in rural and underserved areas^[26–28].

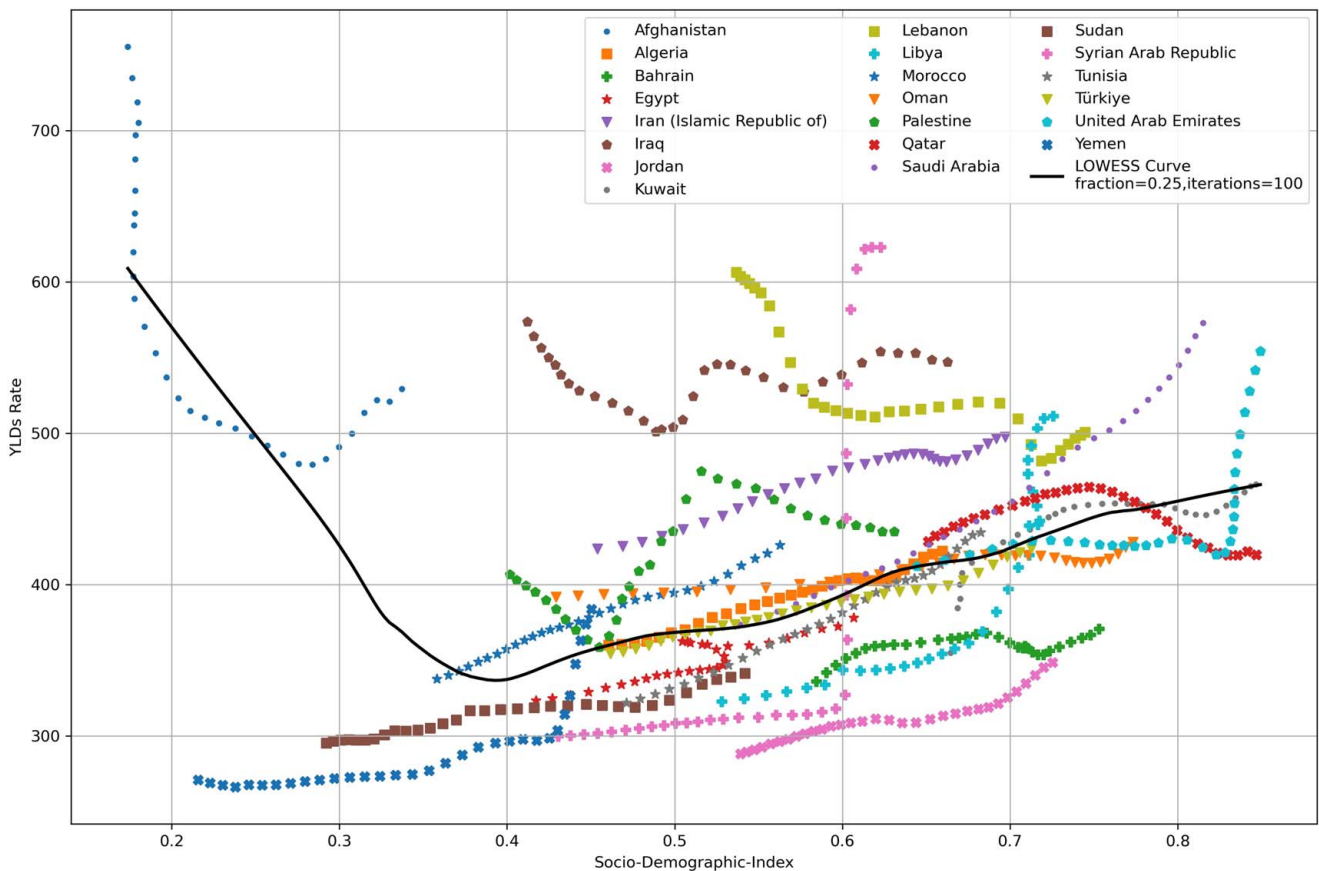


Figure 6. Association between YLD rates and SDI values in MENA countries from 1990 to 2021. MENA, the Middle East and North Africa; SDI, sociodemographic index; YLD, years of healthy life lost due to disability.

We found that Afghanistan, Syria, and Iraq were among the top five countries in the MENA region requiring neurorehabilitation. While stroke was the main condition requiring neurorehabilitation in most MENA countries, spinal injuries were the primary cause of YLD in Afghanistan, Syria, and Iraq. This may be due to the wars and conflicts in these countries, which result in injuries such as spinal and head injuries, making it more challenging to meet the neurorehabilitation needs of patients. On the one hand, wars lead to disabilities and increase the need for neurorehabilitation and medical services. On the other hand, they impact the availability of rehabilitation facilities, and with more budget allocated to military purposes, there are further shortages in the healthcare budget^[21]. Therefore, these countries have unique conditions in the region, warranting particular attention from international organizations, as they may not be able to address their neurorehabilitation needs without external assistance.

We found an inverse association between the YLD rate and SDI values up to an SDI value of about 0.4. However, a positive association was observed between these two indices beyond that point. One possible explanation for this observation is the advances and availability of prenatal screening tests for neural tube defects in more developed areas and raised awareness among people with better socioeconomic status, which reduces the burden of these conditions in populations^[29,30]. However, as further improvements in socioeconomic status enhance healthcare and increase life expectancy, neurological conditions associated with aging may rise, leading to a positive association between SDI and the need for neurorehabilitation^[31,32].

This study had several limitations worth mentioning. First, the GBD study relies on estimations and models to determine the burden of diseases, which may not be entirely accurate in some cases. Second, we calculated the total prevalence of conditions needing neurorehabilitation by summing the prevalence of individual conditions. However, since some individuals may be affected by multiple conditions simultaneously, this approach may overestimate the total prevalence. Third, to enhance the accuracy of our work, we used the conservative approach recommended by Jesus *et al.*^[14], which includes a list of conditions traditionally deemed to benefit from physical rehabilitation. However, some other neurological conditions, such as meningitis and encephalitis, that might also benefit from physical rehabilitation may have been omitted from our list, leading to the underestimation of the need for neurorehabilitation^[14,33,34].

Conclusions

This study provided the most comprehensive overview of neurorehabilitation in MENA, which can be a basis to guide the policies in the region. Considering the growing demand for neurorehabilitation with the aging of populations and the historical shortage of rehabilitation services in the region, the gap between the demand and supply may further increase in the coming years, which may lead to consequences for people living with neurological conditions in the region. Considering the impacts of conflicts on the conditions needing neurorehabilitation, the availability of services, the lack of infrastructure, and the shortage of specialists, collective, and international collaborations may be a more effective approach than individual, separate efforts to address the neurorehabilitation need in the region.

Ethical approval

Ethical approval was not required for this paper as it did not include any human participants and utilized the GBD study's publicly available data.

Consent

Informed consent was not required for this study as it did not include any human participants and utilized the GBD study's publicly available data.

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This study was not funded.

Author contribution

F.H., H.S., and A.N.A.: conceptualization; S.R.D., A.N.A., H.S., and F.H.: formal analysis; S.R.D.: visualization; H.S. and A.N.A.: supervision. All authors contributed in methodology, investigation, writing – original draft preparation, writing – review and editing, and project administration. F.H. and A.M. contributed equally to this work.

Conflicts of interest disclosure

The authors declare no conflicts of interest.

Research registration unique identifying number (UIN)

This study did not require registration as it did not involve any human participants.

Guarantor

Homa Seyedmirzaei.

Data availability statement

The original data presented in the study are openly available in GBD results tool (<https://vizhub.healthdata.org/gbd-results/>).

Provenance and peer review

Not commissioned, externally peer-reviewed.

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