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Burden of neurological diseases in Asia from 1990 to 2019: a systematic analysis using the Global Burden of Disease Study data

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ABSTRACT

Objectives The burden of neurological disorders is increasing worldwide, including Asia. The purpose of this study was to determine the burden of neurological disorders between 1990 and 2019 in Asia using the Global Burden of Disease (GBD) Sociodemographic Index.

Design, setting, outcome and participants The GBD Study is updated every year and the most recent version provides the burden of diseases according to age, gender and region from 1990 to 2019. The burden of neurological disorders was evaluated as incidence, prevalence, mortality, disability-adjusted life-years (DALYs), years of life lost and years lived with disability.

Results In 2019, DALYs of neurological diseases were 64.4 million in South-East Asia (95% uncertainty interval (UI) 45.2 to 94.2) and 85.0 million in Western Pacific regions (95% UI 63.0 to 118.5). Stroke, migraine, Alzheimer's disease and other dementias had the highest DALYs in the WHO South-East Asia and WHO Western Pacific regions in 2019. DALYs of stroke, Alzheimer's disease and other dementias, Parkinson's disease, brain and central nervous system cancer, multiple sclerosis, migraine and tension-type headache increased in both regions in 2019 compared with 1990. Infectious diseases such as tetanus, meningitis and encephalitis decreased in both regions. DALYs of idiopathic epilepsy and motor neuron disease increased in the WHO South-East Asia region and decreased in the WHO Western Pacific region.

Conclusions This study demonstrated the burden of neurological diseases in Asia. To reduce the burden of neurological diseases, strategies suitable for each country's real healthcare needs and challenges are needed; this study can serve as the cornerstone of these strategies.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Our study showed the disability-adjusted life-years of 13 key neurological diseases in the Asian region in 2019 and compared the difference in disease patterns with those reported in 1990.
⇒ The Global Burden of Disease methodology offers standardised statistical approaches that are comparable across countries and time, which can reduce the challenges of trying to estimate disease burdens in terms of incidence, prevalence, mortality, years of life lost or years lived with disability, diminishing potential biases.
⇒ The quality of the information varies in the countries and there may be incomplete data.

INTRODUCTION

Neurological disorders are among the major causes of death and permanent or transient disabilities in human beings.[1] Globally, the burden of neurological disorders is increasing.[2] According to the 2016 Global Burden of Disease (GBD), it was the second most common cause of death and the leading cause of disability-adjusted life-years (DALYs).[2] In addition, the incidence, prevalence and DALYs of neurological disorders are expected to increase with the increasing ageing population across the world. The ageing population is increasing in many countries, including the Asian countries.[3 4] In Asia, the gap between the rich and the poor is also large and varies across countries.[5] Notably, the prevalence and mortality of neurological diseases vary according to age and socioeconomic status[6 7]; and in Asia, these characteristics are likely to directly or indirectly affect the burden of neurological disorders. Moreover, different characteristics of the Asian population, including genetic, climatic, cultural and economic conditions, may present differences in the burden of neurological disorders between the Asian countries. Therefore, evaluating the burden of neurological diseases in the individual Asian countries is essential for health policymaking.

The GBD Study is a collaborative study of diseases worldwide, providing systematic information on 369 diseases in 204 countries each year.[8] According to the recent GBD Study,[9 10] neurological diseases are increasing worldwide including in Asia, but studies

analysing each neurological disease in detail in Asia are lacking.

The purpose of this study was to determine the burden of neurological disorders, including incidence, prevalence, death, DALYs, years lived with disability (YLDs) and years of life lost (YLLs) between 1990 and 2019 in the Asian region and each Asian country using estimates from the GBD Study website.

METHODS

Overview

Our data were extracted from GBD's publicly provided website; all GBD's research results can be freely accessed and downloaded from the GBD Compare and the Global Health Data Exchange websites (GBD Compare available at https://vizhub.healthdata.org/gbd-compare/; Global Health Data Exchange available at http://ghdx.healthdata.org/).[8] The GBD 2019 methods are described in detail on the GBD website and in a previous study.[9] The GBD 2019 is a worldwide multinational collaborative study. The GBD Study is updated every year and the most recent version provides the burden of diseases according to age, gender and region (369 diseases and injuries in 204 countries and territories) from 1990 to 2019. Our study data acquisition and analysis followed the methodology provided on the GBD website. Our study included 13 neurological diseases (the International Classification of Diseases (ICD) -10 codes) including stroke (I63), Alzheimer's disease and other dementias (F01~03), Parkinson's disease (G20), brain and central nervous system cancer (C71~72), idiopathic epilepsy (G40), motor neuron disease (G12.2), multiple sclerosis (G35), migraine (G43), tension-type headache (G44.2), meningitis (G00~03), encephalitis (G04~05), tetanus (A33~35) and other neurological disorders.

DALYs, YLDs and YLLs

The burden of each neurological disorder was separately evaluated as incidence, prevalence, death, DALYs, YLDs and YLLs.[11] DALYs are defined as the sum of YLDs and YLLs. YLD is the individual sequela prevalence of each disease multiplied by disability weight, quantifying the severity of the sequela as a number between 0 (indicating full health) and 1 (indicating death).[12] YLL is the number of deaths multiplied by the standard life expectancy at the time of death. Standard life expectancy is obtained from the lowest observed age-specific mortality rate among a world population of over 5 million.[11] Disability weights were estimated from nine US population surveys and an open internet survey that asked respondents to choose the healthier option among random pairs of health conditions provided with brief descriptions of key characteristics.[12]

Detailed methods for obtaining non-fatal estimates and death information have been described in a previous research study.[9] Considering DALYs, YLDs and YLLs, the neurological disorder estimates were acquired from disease surveillance systems, registries, survey microdata, health claims data and systematic reviews of reports.[9] These datasets are repositioned to the Global Health Data Exchange, and data of different characteristics are analysed using DisMod-MR V.2.1, a Bayesian meta-regression tool.[13 14] Age-standardised rate, which is a weighted average of the age-specific rates, was calculated to remove the confounding effect of age (standard age structure: a population structure used in the GBD Study to provide a constant distribution of covariates). Data were described using 95% uncertainty intervals (UIs) and changes from 1990 to 2019 as a percentage (95% UIs) provided by the GBD website.

Asian countries

In our study, the Asian region was analysed by dividing it into WHO South-East Asia region (11 countries) and WHO Western Pacific region (31 countries) according to the range of locations provided by GBD, and the burden of diseases calculated as an age-standardised rate per 100 000 was converted and compared with global data. Age-standardised rate of incidence, prevalence, death, DALYs, YLDs and YLLs, the total number for 1990 and 2019 and changes between 1990 and 2019 were investigated in WHO South-East Asia region and WHO Western Pacific Region. The WHO South-East Asia region countries were Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Indonesia, Maldives, Myanmar, Nepal, Sri Lanka, Thailand and Timor-Leste. The WHO Western Pacific region countries were American Samoa, Australia, Brunei Darussalam, Cambodia, China, Cook Islands, Fiji, Guam, Japan, Kiribati, Lao People's Democratic Republic, Malaysia, Marshall Islands, Micronesia, Federated States of Mongolia, Nauru, New Zealand, Niue, Northern Mariana Islands, Palau, Papua New Guinea, Philippines, Republic of Korea, Samoa, Singapore, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu and Viet Nam (online supplemental figure 1).

In Asia, the GBD Study separates high-income regions (Australasia: Australia and New Zealand; Asia Pacific countries: Brunei Darussalam, Japan, Republic of Korea and Singapore). Because the income level of the region may have influence on the mortality and prevalence of neurological diseases,[15–17] our study investigated changes in DALYs between 1990 and 2019 in neurological disorders in Australasia and high-income Asia and Pacific regions.

Sociodemographic Index

Sociodemographic Index (SDI) is an index developed by GBD researchers, which measures the degree of socioeconomic development.[18] It is a composite of the ranking of incomes per capita, educational attainment and fertility rates. SDI of 0 means the lowest level of development, while SDI of 1 means the theoretical maximal level. SDI was a predictor of the health-related indexes,[19] and widely used in predicting health outcomes and comparing different regions.[20 21] The limitations of other GBD

indicators also apply to this index, including measurement bias of different sources.[22 23]

Patient and public involvement

Patients and the public were not involved in our research's design, conduct, reporting or dissemination plans.

RESULTS

The 2019 burden of neurological diseases in Asia

The 2019 DALYs of neurological diseases in WHO South-East Asia and WHO Western Pacific regions are shown in table 1. In 2019, there were 821.8 million cases of newly diagnosed neurological diseases worldwide: 227 million in the WHO South-East Asia region and 178.6 million in the WHO Western Pacific region. The total number of DALYs of neurological diseases was 64.4 million in South-East Asia region (95% UI 45.2 to 94.2) and 85.0 million in Western Pacific region (95% UI 63.0 to 118.5). Stroke, migraine, and Alzheimer's disease and other dementias had the highest DALYs in WHO South-East Asia and WHO Western Pacific regions. This pattern was identical to the global trend of neurological diseases. When the incidence, prevalence and mortality of each neurological disease were compared in the two regions, stroke, Alzheimer's disease and other dementias, Parkinson's disease, brain and central nervous system cancer and motor neuron disease were higher in the WHO Western Pacific region, while multiple sclerosis, migraine, tension-type headache, meningitis, encephalitis and tetanus were higher in the WHO South-East Asia region (online supplemental table 1).

Figure 1 shows age-standardised DALYs in the WHO South-East Asia and WHO Western Pacific regions. The burden of age-standardised DALYs was highest in both regions in the order of stroke, Alzheimer's disease and other dementias, and migraine. The age-standardised DALYs of stroke, Alzheimer's disease and other dementias, and brain and central nervous system cancer were higher in the WHO Western Pacific region. On the other hand, DALYs of multiple sclerosis, idiopathic epilepsy, migraine, meningitis and encephalitis were higher in the WHO South-East Asia region (figure 1).

Figure 2 shows DALYs of neurological diseases in the Asian region by age. The total number of DALYs of stroke, Alzheimer's disease and other dementias was higher in old age in both areas, and the age-standardised rate of stroke and dementia increased with age (figure 2A). However, the total number of DALYs of migraine was relatively higher in the younger generation. The highest DALYs of stroke were in the ages between 60 and 64 years in the WHO South-East Asia region and 70 and 74 years in the WHO Western Pacific region (figure 2B). When compared according to sex, the trend of DALYs in neurological diseases showed a similar pattern in the WHO South-East Asia and the WHO Western Pacific regions. The number of DALYs of stroke was higher in men, while DALYs of dementia and migraine were higher in women. DALYs according to age and sex are described in the online supplemental tables 2 and 3.

The difference of neurological diseases in Asia from 1990 to 2019

In the WHO South-East Asia region, stroke, tetanus and meningitis had the highest age-standardised DALYs in 1990, which changed to stroke, migraine, Alzheimer's disease and other dementias in 2019. Age-standardised DALYs in the Western Pacific region showed a similar trend between 1990 and 2019, in the order of stroke, Alzheimer's disease and other dementias, and migraine (table 2). The DALYs of stroke and Alzheimer's disease and other dementias, Parkinson's disease, brain and central nervous system cancer, multiple sclerosis, migraine and tension-type headache increased in both regions in 2019 compared with 1990. Infectious diseases such as tetanus, meningitis and encephalitis decreased in both regions. The number of DALYs of idiopathic epilepsy and motor neuron disease increased in the WHO South-East Asia region and decreased in the WHO Western Pacific region. The age-standardised rate of stroke incidence (−10%, 157 to 141 in South-East Asia; −12%, 211 to 186 in Western Pacific) and mortality (−30%, 135 to 95 in South-East Asia; −42%, 180 to 104 in Western Pacific) decreased markedly in both regions. The age-standardised incidence of dementia declined in South-East Asia (−3%, 71 to 69) and increased in Western Pacific regions (14%, 92 to 105). Mortality of dementia was increased in both regions. The age-standardised incidence and prevalence of migraine and tension-type headache in the WHO South-East Asia region have not changed since 1990, but these increased in the WHO Western Pacific region (online supplemental table 4).

When age-standardised DALYs for each region were compared by income classification, motor neuron disease, multiple sclerosis and encephalitis increased in the Australasia region, in contrast to a decrease in the high-income Asia Pacific region. DALYs for Parkinson's disease increased in the Australasia and the high-income Asia-Pacific regions, but DALYs for stroke, idiopathic epilepsy, meningitis and tetanus decreased (table 3). The age-standardised DALYs of stroke, Alzheimer's disease and other dementias, and migraine according to SDI by country are presented in figures 3–5.

When analysed by country, DALYs of stroke increased in China and India and decreased in Australia, Japan, the Republic of Korea and Singapore. Stroke mortality was raised in Australia, China, India and Japan, and dropped in the Republic of Korea and Singapore. Age-standardised rates of incidence, prevalence, death, DALYs, YLDs and YLLs burden by country are described in the online supplemental table 5. DALYs of Alzheimer's disease and other dementias, and Parkinson's disease increased in most countries, but decreased in Nauru, Niue and Tokelau. DALYs of

Table 1 Disability-adjusted life-years of neurological diseases, comparison of South-East Asia and Western Pacific regions

	WHO South-East Asia region		WHO Western Pacific region		Global	
	Age-standardised rate per 100 000	Total	Age-standardised rate per 100 000	Total	Age-standardised rate per 100 000	Total
All neurological disorders	3634 (2610 to 5245)	64 373 789 (45 229 328 to 94 249 122)	3432 (2486 to 4891)	85 008 645 (63 024 027 to 118 461 528)	3464 (2521 to 4945)	273 063 453 (199 632 801 to 388 511 035)
Stroke	2008 (1811 to 2193)	34 460 498 (31 035 171 to 37 670 399)	2121 (1891 to 2369)	56 185 166 (49 950 162 to 62 813 530)	1768 (1641 to 1889)	143 232 184 (133 095 809 to 153 241 824)
Alzheimer's disease and other dementias	278 (114 to 644)	3 485 650 (1 444 595 to 8 150 443)	377 (170 to 797)	9 195 842 (4 102 641 to 19 647 700)	339 (151 to 731)	25 276 989 (11 204 523 to 54 558 243)
Parkinson's disease	81 (72 to 91)	1 197 394 (1 057 423 to 1 339 100)	79 (70 to 89)	2 090 741 (1 839 874 to 2 355 241)	80 (73 to 87)	6 292 616 (5 769 210 to 6 827 207)
Brain and central nervous system cancer	80 (60 to 93)	1 532 948 (1 153 447 to 1 796 140)	112 (86 to 132)	2 470 092 (1 887 397 to 2 919 034)	109 (85 to 121)	8 659 871 (6 718 029 to 9 574 458)
Idiopathic epilepsy	187 (146 to 237)	3 721 812 (2 894 671 to 4 718 264)	102 (73 to 137)	1 909 337 (1 365 698 to 2 534 086)	171 (130 to 218)	13 077 624 (9 986 730 to 16 734 086)
Motor neuron disease	4 (3 to 5)	78 631 (64 804 to 93 556)	8 (8 to 9)	195 642 (178 225 to 213 956)	13 (12 to 13)	1 034 607 (979 911 to 1 085 401)
Multiple sclerosis	7 (6 to 9)	147 786 (124 902 to 179 583)	4 (4 to 6)	113 019 (95 485 to 141 751)	14 (12 to 17)	1 159 832 (1 001 180 to 1 381 870)
Migraine	543 (67 to 1250)	11 496 964 (1 378 922 to 26 551 209)	456 (66 to 1047)	9 804 347 (1 563 046 to 22 190 876)	526 (79 to 1194)	42 077 666 (6 418 383 to 95 645 211)
Tension-type headache	52 (15 to 193)	1 079 949 (299 851 to 4 031 993)	47 (14 to 160)	1 041 113 (336 537 to 3 331 809)	56 (17 to 189)	4 541 689 (1 395 546 to 14 981 336)
Meningitis	157 (136 to 181)	2 853 048 (2 491 747 to 3 283 248)	45 (40 to 51)	638 116 (570 390 to 710 280)	234 (196 to 283)	16 333 198 (13 775 122 to 19 609 767)
Encephalitis	149 (119 to 231)	2 734 495 (2 187 604 to 4 270 395)	37 (31 to 42)	551 783 (478 145 to 627 604)	65 (55 to 87)	4 797 407 (4 059 493 to 6 418 088)
Tetanus	44 (28 to 62)	741 167 (478 331 to 1 059 882)	4 (3 to 5)	68 690 (43 256 to 82 825)	34 (26 to 48)	2 316 381 (1 770 002 to 3 279 408)
Other neurological disorders	43 (31 to 56)	843 447 (617 859 to 1 104 911)	39 (31 to 48)	744 757 (613 170 to 892 837)	56 (45 to 68)	4 263 390 (3 458 864 to 5 174 136)

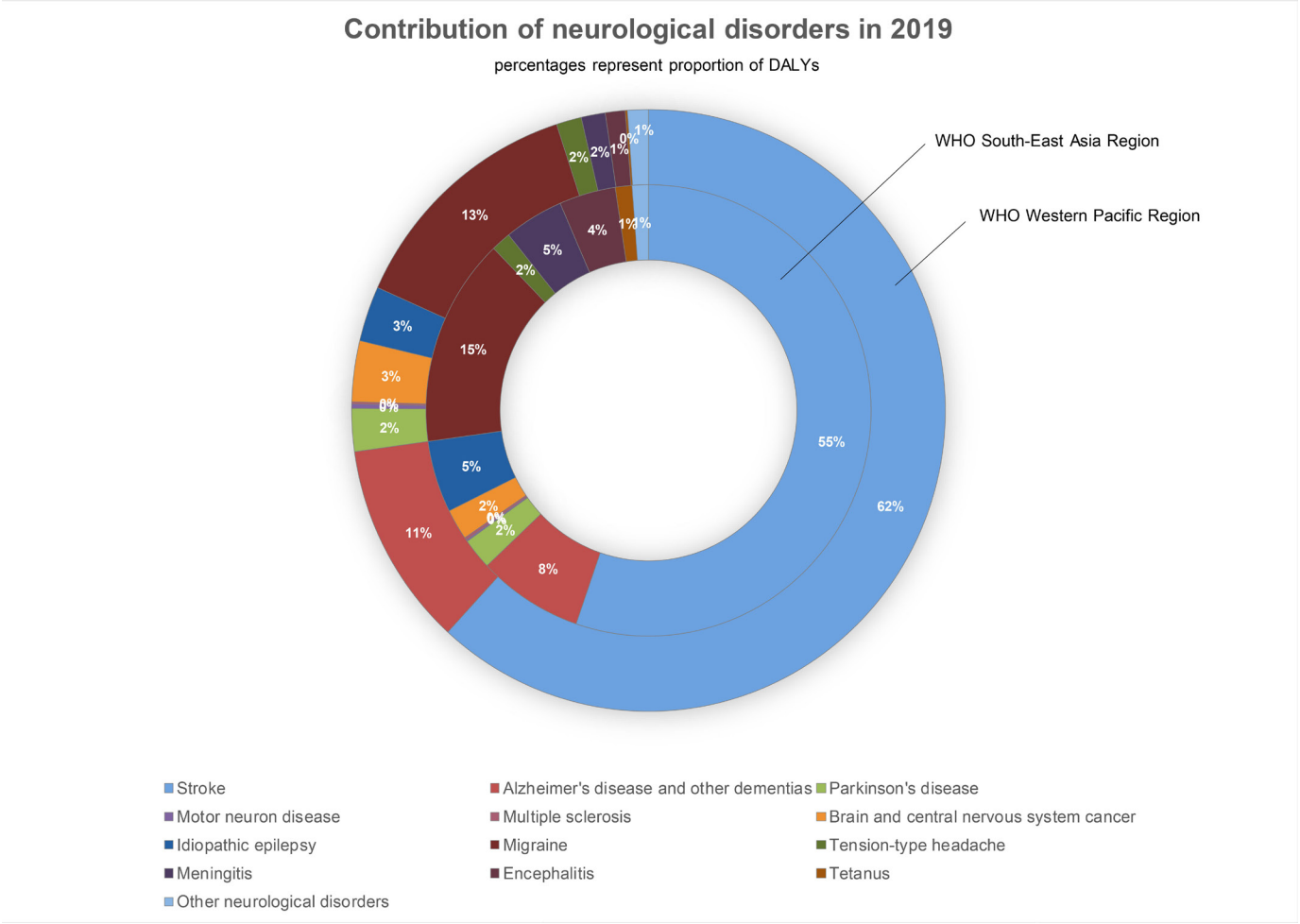

Figure 1 2019 Contribution of DALYs in the WHO South-East Asia and WHO Western Pacific regions. DALYs, disability-adjusted life-years.

motor neuron disease increased in Australia, Singapore and Japan, and decreased in China and the Republic of Korea. Mortality increased in Australia, China, Singapore and Japan, but decreased in the Republic of Korea. The DALYs of multiple sclerosis rose in all countries except Niue and Sri Lanka. Brain and central nervous system cancer decreased in Armenia, Niue and Tokelau, but increased in other countries. DALYs of idiopathic epilepsy increased in Australia and Singapore, and decreased in China and the Republic of Korea. Mortality decreased in Japan, the Republic of Korea and Singapore. Migraine's DALYs increased in all the Asian countries apart from Armenia, Georgia, Niue, Northern Mariana Islands and Tokelau. DALYs of tension-type headaches increased in most countries except for Georgia, Niue and Tokelau. Meningitis decreased in all countries except Vanuatu, and mortality decreased in all countries except Guam and Vanuatu. DALYs of encephalitis increased in Australia, the Republic of Korea and Singapore, and decreased in China, Japan and India. Mortality increased in Australia, China, Japan, the Republic of Korea and Singapore. Tetanus increased in Guam, Kiribati, Papua New Guinea, Tajikistan and Vanuatu, but decreased in other countries.

DISCUSSION

In the WHO South-East Asia and WHO Western Pacific regions, neurological diseases accounted for 3% and 5% of age-standardised DALYs in 2019.[9] Among the leading causes of the global burden of disease all-age DALYs, stroke ranked 3rd and headache ranked 15th. Stroke, migraine and dementia accounted for the highest number of DALYs in the WHO South-East Asia and WHO Western Pacific regions, which did not differ significantly from the global trend. High DALYs of neurological diseases in the Asian region are thought to be due to increased life expectancy, as DALYs of neurological diseases were higher in the elderly. In particular, stroke and dementia have a higher incidence with advancing age, and the long life expectancy of these patients increases as medical technology advances. Headache frequently occurred in the young population. The increase in the burden of headaches might be due to changes in recognition of the disease and diagnostic criteria.

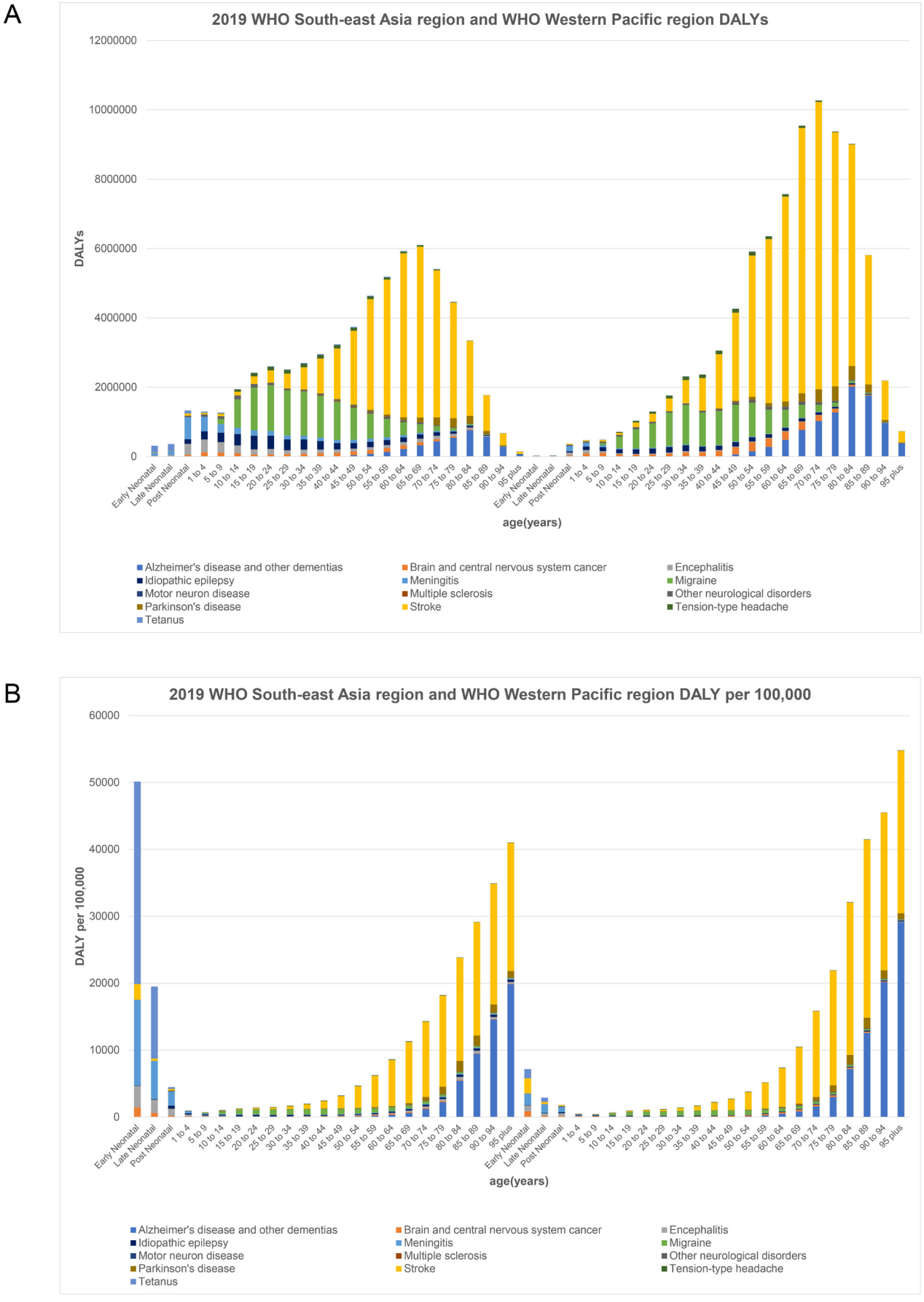

Figure 2 DALYs of neurological diseases in the Asian regions by age: (A) DALYs and (B) rate. DALYs, disability-adjusted life-years.

Table 2 Trends of neurological diseases in South-East Asia and Western Pacific regions between 1990 and 2019

	WHO South-East Asia region						WHO Western Pacific region					
	Age-standardised rate 1990	Age-standardised rate 2019	Change from 1990 to 2019	Total, 1990	Total, 2019	Change from 1990 to 2019	Age-standardised rate 1990	Age-standardised rate 2019	Change from 1990 to 2019	Total, 1990	Total, 2019	Change from 1990 to 2019
Stroke												
DALYs	2839 (2594 to 3097)	2008 (1811 to 2193)	−29% (−38% to −21%)	20 183 896 (18 482 460 to 21 850 550)	34 460 498 (31 035 171 to 37 670 399)	71% (51% to 90%)	3584 (3250 to 3984)	2121 (1891 to 2369)	−41% (−49% to −32%)	40 811 727 (36 975 527 to 45 349 220)	56 185 166 (49 950 162 to 62 813 530)	38% (18% to 60%)
Alzheimer's disease and other dementias												
DALYs	260 (108 to 623)	278 (114 to 644)	7% (−1% to 16%)	990 724 (415 186 to 2 337 548)	3 485 650 (1 444 595 to 8 150 443)	252% (222% to 284%)	345 (145 to 784)	377 (170 to 797)	9% (−1% to 21%)	2 711 166 (1 136 067 to 6 270 660)	9 195 842 (4 102 641 to 19 647 700)	239% (202% to 284%)
Parkinson's disease												
DALYs	82 (71 to 100)	81 (72 to 91)	−1% (−17% to 13%)	417 460 (358 716 to 506 514)	1 197 394 (1 057 423 to 1 339 100)	187% (140% to 229%)	86 (78 to 95)	79 (70 to 89)	−8% (−18% to 3%)	854 035 (768 070 to 944 762)	2 090 741 (1 839 874 to 2 355 241)	145% (117% to 176%)
Brain and central nervous system cancer												
DALYs	84 (59 to 129)	80 (60 to 93)	−6% (−44% to 28%)	1 103 726 (707 940 to 1 781 878)	1 532 948 (1 153 447 to 1 796 140)	39% (−21% to 101%)	138 (104 to 189)	112 (86 to 132)	−19% (−48% to 8%)	2 033 299 (1 521 466 to 2 779 444)	2 470 092 (1 887 397 to 2 919 034)	21% (−21% to 61%)
Idiopathic epilepsy												
DALYs	259 (186 to 322)	187 (146 to 237)	−28% (−41% to 0%)	3 545 290 (2 494 855 to 4 454 038)	3 721 812 (2 894 671 to 4 718 264)	5% (−16% to 48%)	144 (114 to 178)	102 (73 to 137)	−29% (−44% to −9%)	2 301 988 (1 834 995 to 2 835 846)	1 909 337 (1 365 698 to 2 534 086)	−17% (−35% to 7%)
Motor neuron disease												
DALYs	3 (3 to 4)	4 (3 to 5)	27% (5% to 49%)	34 733 (28 437 to 41 104)	78 631 (64 804 to 93 556)	126% (89% to 164%)	14 (13 to 15)	8 (8 to 9)	−40% (−46% to −31%)	199 306 (181 271 to 217 406)	195 642 (178 225 to 213 956)	−2% (−13% to 13%)
Multiple sclerosis												
DALYs	7 (5 to 10)	7 (6 to 9)	5% (−17% to 38%)	69 126 (51 225 to 96 038)	147 786 (124 902 to 179 583)	114% (67% to 179%)	5 (5 to 6)	4 (4 to 6)	−19% (−34% to 5%)	77 463 (63 701 to 91 450)	113 019 (95 485 to 141 751)	46% (19% to 92%)
Migraine												
DALYs	545 (67 to 1258)	543 (67 to 1250)	0% (−3% to 3%)	6 637 060 (720 531 to 15 495 588)	11 496 964 (1 378 922 to 26 551 209)	73% (66% to 93%)	423 (69 to 949)	456 (66 to 1047)	8% (−5% to 13%)	6 768 009 (1 059 137 to 15 293 657)	9 804 347 (1 563 046 to 22 190 876)	45% (36% to 55%)
Tension-type headache												
DALYs	51 (14 to 194)	52 (15 to 193)	1% (−5% to 8%)	589 905 (155 480 to 2 406 405)	1 079 949 (299 851 to 4 031 993)	83% (60% to 99%)	47 (15 to 163)	47 (14 to 160)	0% (−7% to 10%)	719 450 (222 679 to 2 586 630)	1 041 113 (336 537 to 3 331 809)	45% (21% to 63%)
Meningitis												
DALYs	632 (546 to 727)	157 (136 to 181)	−75% (−80% to −70%)	10 288 577 (8 807 057 to 11 946 290)	2 853 048 (2 491 747 to 3 283 248)	−72% (−77% to −66%)	247 (217 to 279)	45 (40 to 51)	−82% (−85% to −78%)	3 808 929 (3 340 387 to 4 298 041)	638 116 (570 390 to 710 280)	−83% (−86% to −80%)
Encephalitis												

Continued

Table 2 Continued

	WHO South-East Asia region						WHO Western Pacific region					
	Age-standardised rate 1990	Age-standardised rate 2019	Change from 1990 to 2019	Total, 1990	Total, 2019	Change from 1990 to 2019	Age-standardised rate 1990	Age-standardised rate 2019	Change from 1990 to 2019	Total, 1990	Total, 2019	Change from 1990 to 2019
DALYs	400 (319 to 493)	149 (119 to 231)	−63% (−72% to −38%)	6 110 657 (4 667 671 to 7 761 085)	2 734 495 (2 187 604 to 4 270 395)	−55% (−68% to −23%)	75 (51 to 90)	37 (31 to 42)	−51% (−61% to −31%)	1 165 784 (795 140 to 1 399 876)	551 783 (478 145 to 627 604)	−53% (−62% to −31%)
Tetanus												
DALYs	808 (681 to 945)	44 (28 to 62)	−95% (−96% to −92%)	14 068 396 (11 826 744 to 16 609 293)	741 167 (478 331 to 1 059 882)	−95% (−97% to −92%)	130 (102 to 156)	4 (3 to 5)	−97% (−98% to −95%)	1 980 966 (1 551 335 to 2 373 157)	68 690 (43 256 to 82 825)	−97% (−98% to −95%)
Other neurological disorders												
DALYs	39 (28 to 49)	43 (31 to 56)	9% (−7% to 37%)	552 728 (368 319 to 701 791)	843 447 (617 859 to 1 104 911)	53% (30% to 98%)	35 (30 to 41)	39 (31 to 48)	10% (−5% to 30%)	538 294 (454 920 to 639 130)	744 757 (613 170 to 892 837)	38% (21% to 60%)

DALYs, disability-adjusted life-years.

Stroke was the most common neurological disease in 1990 and 2019; compared with 1990, the total DALYs of stroke increased in both regions, but the age-standardised incidence and mortality rate decreased. Risk factors included hypertension, diabetes, dyslipidaemia, atrial fibrillation, smoking, alcohol, obstructive sleep apnea and other minor elements.[24 25] The mortality attributed to hypertension and diabetes significantly reduced between 1990 and 2019.[26 27] As awareness of the effects of these diseases on stroke has increased and the change of public health policies implemented, there is a possibility that it may have had the effect of reducing the burden. In addition, with the gradual development of medical treatment methods for each disease, the preventive effect of a stroke may have increased. Medications for hypertension, diabetes and dyslipidaemia have been continuously developed for decades, and researchers are focusing on the impact of these drugs on cardiovascular risk reduction.[28–30] For atrial fibrillation, non-vitamin K antagonist oral anticoagulants, which have lower haemorrhagic complication rates than warfarin,[31] are being widely used. Treatment methods for stroke have also made great strides. Intravenous thrombolytic therapy and endovascular thrombectomy are widely used and can effectively reduce mortality and disability after stroke.[32 33] Furthermore, it is possible to maximise the treatment effect by educating the general public about the importance of the time window, developing a patient transport system and using stroke units. When the age-standardised DALYs according to SDI for each country were plotted, high-income countries showed lower DALYs. This suggests that there may be differences in access to medical care and preventive medicine depending on economic status. Therefore, it is necessary to develop prevention and treatment strategies for stroke in low-income countries.

DALYs of Alzheimer's disease and other dementias were increased in both the WHO South-East Asia and WHO Western Pacific regions, which may be the consequence of an increased ageing population. However, the age-standardised rate of dementia in the WHO South-East Asia and WHO Western Pacific regions showed somewhat different patterns. In the WHO South-East Asia region, the change of dementia incidence was −3%, prevalence did not change and mortality and DALYs were increased by 10% and 7% each. In the WHO Western Pacific region, the incidence, prevalence, mortality and DALYs of dementia were increased by 14%, 25%, 7% and 9%, respectively. In the 2019 GBD report, DALYs of Alzheimer's disease and other dementias were slightly increased from 1990.[9] The exact cause of these differences is unknown, but nutrition, physical activity, genetic influence and access to healthcare may have affected the results.[34 35] As for dementia, there seems to be no significant improvement compared with 1990, which could be attributed to the lack of development of new powerful preventive and therapeutic drugs.[36 37] Considering the current global change into an ageing society, medical research and social support for dementia are essential.

Table 3 Trends of neurological diseases in high-income Asia and Pacific regions between 1990 and 2019

	High-income Asia and Pacific					
	Australasia			High-income Asia-Pacific		
	1990	2019	Change	1990	2019	Change
Stroke	1076 (1005 to 1132)	461 (414 to 503)	–57% (–60% to –55%)	1936 (1815 to 2030)	739 (659 to 814)	–62% (–64% to –59%)
Alzheimer's disease and other dementias	327 (147 to 726)	320 (146 to 682)	–2% (–6% to 3%)	323 (144 to 711)	385 (179 to 792)	19% (11% to 26%)
Parkinson's disease	80 (73 to 86)	84 (75 to 93)	6% (0% to 12%)	53 (49 to 57)	58 (51 to 63)	10% (–2% to 15%)
Brain and central nervous system cancer	174 (152 to 217)	145 (110 to 161)	–17% (–46% to –7%)	59 (52 to 82)	59 (36 to 67)	0% (–56% to 16%)
Idiopathic epilepsy	138 (83 to 221)	116 (66 to 198)	–16% (–53% to 49%)	103 (70 to 146)	80 (51 to 125)	–22% (–44% to 7%)
Motor neuron disease	46 (44 to 48)	55 (50 to 60)	20% (8% to 32%)	21 (19 to 23)	15 (13 to 16)	–30% (–39% to –22%)
Multiple sclerosis	25 (20 to 31)	29 (23 to 35)	18% (–10% to 33%)	6 (5 to 8)	6 (4 to 8)	–9% (–23% to 5%)
Migraine	495 (85 to 1112)	496 (84 to 1113)	0% (–3% to 3%)	410 (83 to 928)	410 (82 to 923)	0% (–3% to 3%)
Tension-type headache	60 (18 to 190)	60 (18 to 188)	0% (–6% to 8%)	63 (18 to 214)	64 (18 to 213)	1% (–4% to 5%)
Meningitis	50 (45 to 55)	14 (13 to 16)	–71% (–75% to –67%)	49 (45 to 54)	10 (8 to 11)	–80% (–83% to –77%)
Encephalitis	4 (4 to 6)	6 (5 to 7)	51% (–8% to 87%)	14 (12 to 17)	11 (10 to 13)	–18% (–29% to –9%)
Tetanus	0 (0 to 0)	0 (0 to 0)	–63% (–83% to –43%)	2 (1 to 2)	0 (0 to 0)	–86% (–89% to –81%)
Other neurological disorders	66 (56 to 80)	72 (59 to 92)	9% (–12% to 36%)	47 (41 to 55)	51 (43 to 63)	8% (–5% to 25%)

Age-standardised incidence and prevalence of epilepsy increased, but YLL and mortality were markedly decreased, and YLD did not show significant change. It is estimated that there will be an impact from the development of various anti-epileptic drugs and advances in critical care medicine.[38] The incidence of infectious diseases such as meningitis and encephalitis is decreasing worldwide,[9] but that of encephalitis has increased in the Australasia region. Further investigations are needed to determine the exact cause of the increase in encephalitis in this region.

The neurological diseases show various patterns in each country, which is in line with previous reports.[6 15–17 39 40] Environmental and geographical factors may have influenced these results. A rural area in Europe showed a higher prevalence of untreated hypertension, alcohol abuse, and higher incidence of stroke and cerebral haemorrhage compared with an urban area.[41] A study in China also showed a geographical difference in hypertension and stroke between the north and south regions.[42] Latitude gradient is reported to be influencing the prevalence of multiple sclerosis.[43] In a systematic review, air pollution

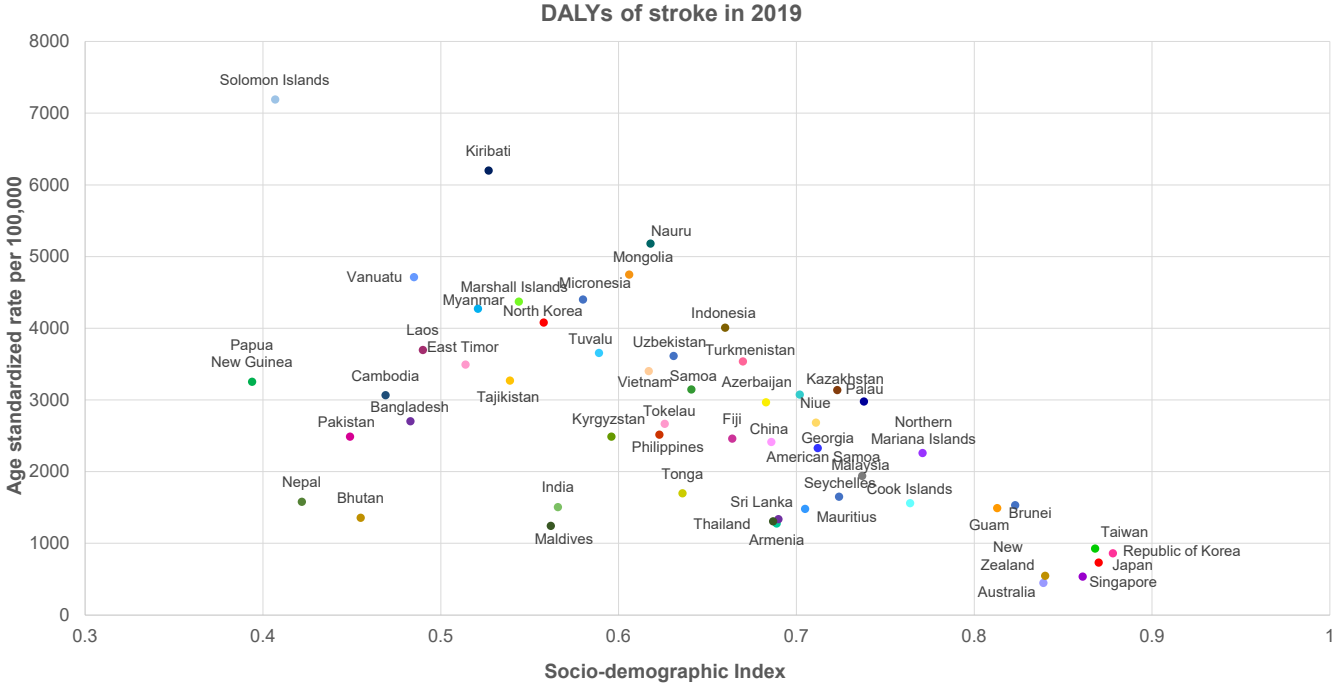

Figure 3 DALYs of stroke according to country-specific Sociodemographic Index. DALYs, disability-adjusted life-years.

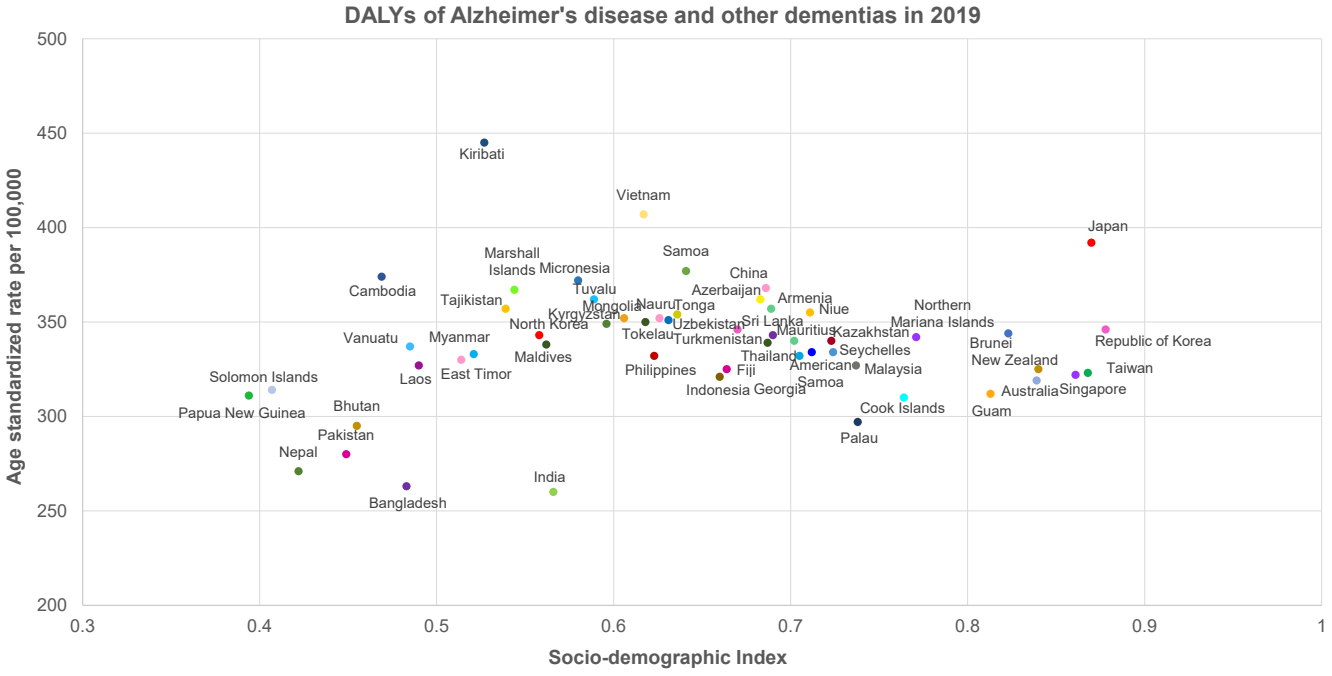

Figure 4 DALYs of Alzheimer's disease and other dementias according to country-specific Sociodemographic Index. DALYs, disability-adjusted life-years.

exposures were related to an increased risk of dementia.[44] Thus, individual healthcare strategies should be applied according to the characteristics of each country.

LIMITATION

General limitations of the GBD Study also apply to this report. First, the quality of the information varies across the countries, and there may be incomplete data. Because we do not have access to the original dataset, we could not conduct further statistical analysis to reduce bias. Second, the definition of cause of death may vary across different medical data sources; a study in India reported that there is marked heterogeneity in reporting of deaths across states of India.[45] These restrictions apply to other Asian countries as well. The results of this study should be interpreted with caution, due to limited access to

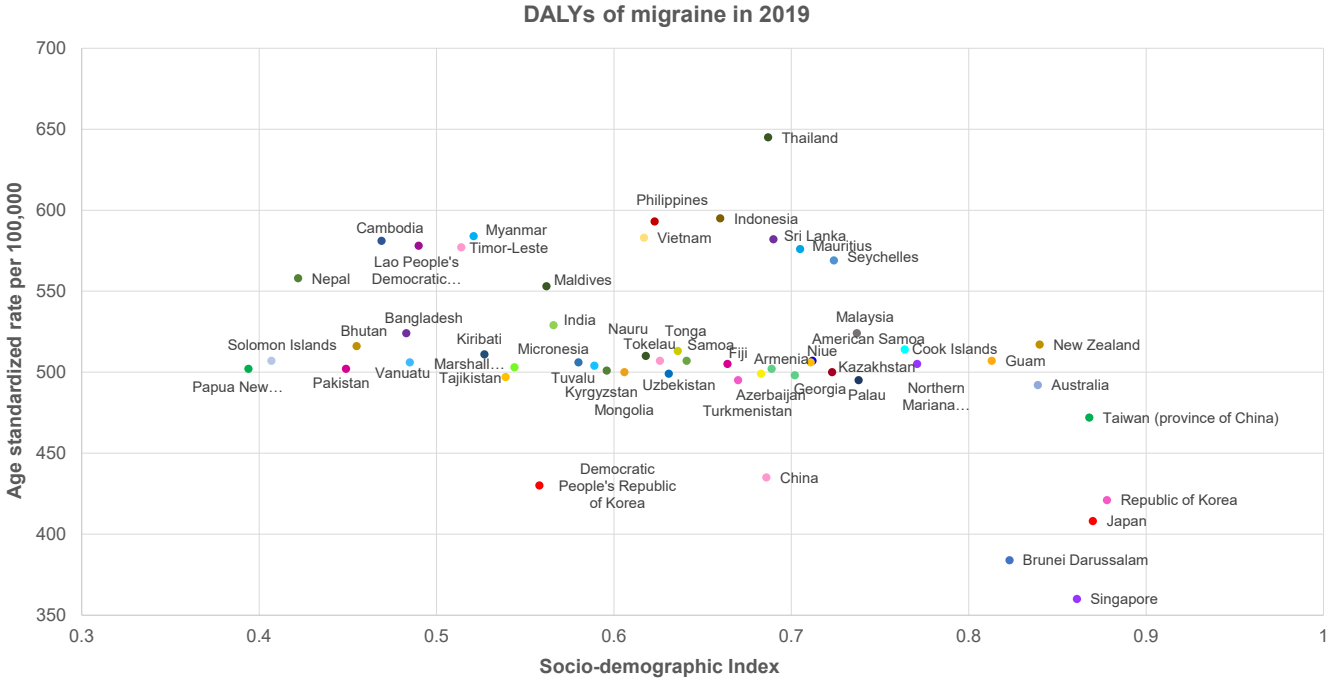

Figure 5 DALYs of migraine according to country-specific Sociodemographic Index. DALYs, disability-adjusted life-years.

original data, and most of the results are derived from the computation of a large dataset. However, the GBD Study takes these differences into account to make standard definitions and standard health indicators that can be compared among regions, countries and subnational settings. Third, the disability weights used to calculate YLD may vary across the countries. Fourth, a wide 95% UI is frequently noted, which implies the low precision of the estimate. Fifth, other neurological diseases, including peripheral neuropathy, tremor, dizziness and sleep disorders, were not included in the analysis because the GBD dataset does not have information on these diseases. Sixth, we could not suggest genetic epidemiological evidence for the Asian regions, which is a major limitation of our study. In a further study, information on the financial burden of neurological diseases will be helpful in making health policy decisions in Asia.

Conclusion

This study described the burden of neurological diseases in Asia. Although the DALYs of some neurological diseases are decreasing, it is necessary to pay attention to the diseases that are increasing. To reduce the burden of neurological disease, strategies suited to the reality of each country's healthcare needs and challenges are needed, and this study can serve as the cornerstone of such effective strategies. Also, as COVID-19 became a pandemic in 2019, further research will help identify changes in disease burden before and after COVID-19. Due to the possible bias resulting from the limitations of the GBD research method, additional research is needed for accurate statistics for each country.

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