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.

INTRODUCTION

Neurological disorders are among the major causes of death and permanent or transient disabilities in human beings.1,2 Globally, the burden of neurological disorders is increasing.3 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).3 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 neurological diseases are increasing worldwide including in Asia, but studies

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.
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/). The GBD 2019 methods are described in detail on the GBD website and in a previous study. 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. 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). 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. 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.

Detailed methods for obtaining non-fatal estimates and death information have been described in a previous research study. 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. 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.

**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 100000 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 from 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, 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. 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, and widely used in predicting health outcomes and comparing different regions. The limitations of other GBD
indicators also apply to this index, including measurement bias of different sources.\textsuperscript{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, migraine, meningitis and encephalitis 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 (1614 to 1889) | 143 232 184 (133 095 809 to 153 241 824) |
| Alzheimer's disease and other dementias                       | 278 (114 to 644) | 3485 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) | 252 769 899 (11 204 523 to 54 558 243) |
| Parkinson’s disease                                           | 81 (72 to 91) | 11 979 394 (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) | 15 322 948 (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) | 37 218 122 (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 (6 to 9) | 195 642 (1 782 255 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) | 9 804 437 (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) | 28 533 048 (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) | 273 495 (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) | 686 960 (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) |
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. 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 1990** | **Change from 1990 to 2019** | **Age-standardised rate 2019** | **Change from 1990 to 2019** | **Total, 1990** | **Total, 2019** | **Change from 1990 to 2019** | **Total, 1990** | **Total, 2019** | **Change from 1990 to 2019** |
| Stroke | Stroke |
| DALYs | 2839 (2594 to 3097) | 2008 (1811 to 2193) | -29% ( -38% to -21%) | 20183896 (18482460 to 21850550) | 34460498 (31035171 to 37670399) | 71% (51% to 90%) | 3584 (3250 to 3994) | -41% ( -49% to -32%) | 2121 (1891 to 2369) | -41% ( -49% to -32%) | 40811727 (3697531 to 52724349) | 20 016 (19 016 to 21 016) | 38% (18% to 60%) |
| Alzheimer’s disease and other dementias | Alzheimer’s disease and other dementias |
| DALYs | 260 (108 to 623) | 278 (114 to 644) | 7% (-1% to 16%) | 990724 (415186 to 2337548) | 3485650 (444595 to 8 150 443) | 252% (222% to 284%) | 345 (145 to 784) | 377 (170 to 797) | 9% (-1% to 21%) | 2711166 (138 067 to 6 270 660) | 9 195 842 (4 102 641 to 19 647 700) | 239% (202% to 284%) |
| Parkinson’s disease | Parkinson’s disease |
| DALYs | 82 (71 to 100) | 81 (72 to 91) | -1% (-17% to 13%) | 417460 (358716 to 506514) | 1197394 (1 057 423 to 1 339 100) | 187% (140% to 229%) | 86 (78 to 95) | 79 (70 to 89) | -8% (-18% to 3%) | 854035 (768070 to 944 782) | 2 090 741 (1 839 874 to 2 355 241) | 145% (117% to 176%) |
| Brain and central nervous system cancer | Brain and central nervous system cancer |
| DALYs | 84 (59 to 129) | 80 (60 to 93) | -6% (-44% to 28%) | 1103726 (709940 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%) | 2033299 (1 521 466 to 2 779 444) | 2 470 092 (1 887 397 to 2 919 034) | 21% (-21% to 61%) |
| Idiopathic epilepsy | Idiopathic epilepsy |
| DALYs | 259 (186 to 322) | 187 (146 to 237) | -28% (-41% to 0%) | 3545290 (2 494 855 to 4 454 038) | 3721812 (2 894 671 to 4 718 264) | 5% (-16% to 48%) | 144 (114 to 178) | 102 (73 to 137) | -29% (-44% to 9%) | 2301988 (1 834 995 to 2 835 846) | 1 909 337 (1 365 698 to 2 534 066) | -17% (-35% to 7%) |
| Motor neuron disease | Motor neuron disease |
| DALYs | 3 (3 to 4) | 4 (3 to 5) | 27% (5% to 49%) | 34733 (28437 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 | 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 175 983) | 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 | 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) | 456 866 (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 | 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 (222 627 to 2 586 630) | 1 041 113 (336 537 to 3 331 809) | 45% (21% to 63%) |
| Meningitis | Meningitis |
| DALYs | 632 (546 to 727) | 157 (136 to 181) | -75% (-80% to -70%) | 10 288 577 (8 807 057 to 11 946 290) | 285 3048 (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 | 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 | Age-standardised rate 1990 | Age-standardised rate 2019 | Change from 1990 to 2019 | Total, 1990 | Total, 2019 | Change from 1990 to 2019 |
|---------------------------|---------------------------|--------------------------|---------|---------|---------------------------|---------------------------|--------------------------|---------|---------|--------------------------|
| DALYs                     |                           | -63% (−72% to −38%)      | 6110657 (4 667 671 to 7 761 085) | 11 106 454 (2 187 064 to 4 270 395) | -55% (−68% to −23%)      | 37 (31 to 42) | -51% (−61% to −31%)      | 11 157 843 (795 140 to 1 399 876) | 551 783 (4 781 145 to 6 276 604) | -53% (−62% to −31%)      |
| Tetanus                   |                           | -95% (−96% to −92%)      | 14 068 396 (11 826 744 to 16 609 293) | 74 116 751 (47 833 156 to 1 059 882) | -95% (−97% to −92%)      | 130 (102 to 156) | -97% (−98% to −95%)      | 1 980 966 (1 551 335 to 2 373 157) | 68 690 (432 256 to 82 825) | -97% (−98% to −95%)      |
| Other neurological disorders |                          | 10% (−7% to 37%)         | 552 728 (368 319 to 7 017 791) | 843 447 (617 859 to 1 041 911) | 53% (30% to 98%)         | 35 (30 to 41) | 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.
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.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

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

| Disease                        | 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  | 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      | 174 (152 to 217)      | 145 (110 to 161)      | −17% (−46% to −7%) | 59 (52 to 82)         | 59 (36 to 67)         | 0% (−56% to 16%) |
| system cancer                  |                       |                       |                 |                       |                       |                 |
| 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 (8 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%)   |

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Figure 3  DALYs of stroke according to country-specific Socio-demographic Index. DALYs, disability-adjusted life-years.
exposures were related to an increased risk of dementia. 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. 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 4  DALYs of Alzheimer’s disease and other dementias according to country-specific Sociodemographic Index. DALYs, disability-adjusted life-years.

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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